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EGYPT IRRIGATION IMPROVEMENT PROJECT

TECHNICAL PROGRESS REPORT

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TECHNICAL PROGRESS REPORT

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1. INTRODUCTION

1.1 NATIONAL IRRIGATION IMPROVEMENT AND REHABILITATION PROJECT

Recognizing that agricultural production is the most important part of Egypt's national wealth, and recognizing the pressures of increasing population, the Government of Egypt (GOE) has initiated a National Irrigation Improvement and Rehabilitation Project (NIIP) to implement efficient use of all available water resources for irrigation. Despite significant progress in the development of irrigation systems in the Nile valley, irrigation efficiency remains very low, on average, below 50 percent. The Ministry of Irrigation (MOI) is determined to achieve higher efficiency through better control of water flowing in the distribution systems and improvement of on-farm irrigation practices.

1.2 REGIONAL IRRIGATION IMPROVEMENT PROJECT

The National Irrigation and Improvement and Rehabilitation Project is directed to the new reclaimed agricultural lands as well as the old lands. The USAID sponsored work centers on old lands through a Regional Irrigation Improvement Project (RIIP). The purpose of the project is to develop methodologies by which distribution systems including mesqas can be improved and rehabilitated effectively and economically. The MOI is receiving support for improvement projects from within the GOE and donor nations. Work is presently underway on cooperative projects with the United States Agency for International Development (USAID) and with the Canadian International Development Agency (CIDA). Participation by the International Bank for Reconstruction and Development (IBRD) will begin in later this year. The improvement projects are also being coordinated with the Structural Replacement Project (USAID) which targets large irrigation structures on major canals in the network.

1.3 ORGANIZATION OF NIIP

The National Irrigation Improvement and Rehabilitation Project (NIIP) has a central directorate in Cairo under the direction of Under Secretary of State, Engineer Farouk Shahin. NIIP presently operates under the Horizontal Expansion and

Improvement Projects Sector, which is headed by a Senior Under Secretary in the Irrigation Department. There is a National Irrigation Improvement Committee, which in addition to it's advisory role, is responsible for planning and budgeting each year of the first 5-year plan. Under the central directorate there are 11 Regional Directorates, each headed by a General Director and supported by a staff of engineers and technicians. The central directorate staff and the staff at the El Minya regional directorate is supported by an advisory staff from the Consortium for International Development (CID) and Colorado State University (CSU). Designers in the various regional directorates are responsible for field investigations, data collection, planning, designing, construction, and implementation of the overall plan. The central directorate establishes policies and standards by which the work is to be accomplished, and reviews all plans and designs completed by the regional staff.

1.4 SELECTED COMMAND AREAS

There is a total of 857,000 feddans in 33 canal commands that are targeted for improvement in RIIP. The division by regions is 224,000 feddans in East Delta, 236,000 in Middle Delta, 83,000 in West Delta, 244,000 in Middle Egypt, and 70,000 in Upper Egypt. Among the 33 commands, the largest is the Serry Bacha in El Minya governorate in Middle Egypt which comprises 130,000 feddans. Other project canals in RIIP are listed in Table A-1 in the Appendix A.

The Serry canal is being rehabilitated and improved with cooperation by USAID. Baheig, El Gharak, and Abou El Managa have been recently included in the USAID program. The following 8 commands is expected to be improved with the cooperation of the United Nations Development Program (UNDP): Boloktor in West Delta; El Bahr El Saidi and Awagi in Middle Delta; Sadia in East Delta; Keman and El Arous in Middle Egypt; Shamia and Okal, Khour El Sahel, and Redissa and Abadi in Upper Egypt. Dekernes in East Delta is being rehabilitated and improved in cooperation with the Canadian International Development Agency (CIDA).

2. PROBLEMS IN THE COMMAND AREAS

2.1 GENERAL PROBLEMS

The Committee for Irrigation Improvement[1] cites inequitable distribution of water and excessive flow to drains as the greatest general problems of irrigation systems in Egypt. The causes for poor distribution and waste of irrigation water are:

- The farmers have installed illegal outlets from the canals to divert more water onto their farms;
- Old methods of flood irrigation by gravity that is commonly used, results in irrigation efficiency between 45 and 50 percent;
- There is a common belief that increasing irrigation will result in increased crop yields;
- Deterioration of control gates and structures result in ineffective control and poor distribution within the system;
- High rates of seepage from canals where they flow through sandy soils;
- Lack of maintenance in mesqas resulting in poor water distribution along the mesqas;
- Water delivery is based on a restricted cropping calendar which does not coincide with planting dates for most crops;
- Peak demands cannot be salified by only daytime irrigation in a system designed for 24-hour irrigation;
- Because of free water there is no economic incentive to irrigate efficiently;
- Cultivation onto the banks of canals by farmers inhibit inspection, control, and maintenance of the canal network;
- Uneven surfaces of agricultural lands generally result in poor irrigation;

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1 Liberal interpretation of the paper on irrigation strategy prepared by the Committee for Irrigation Improvement.

- Irrigation methods to suit the crops and soil conditions are not generally practiced. Where there is over irrigation, the water table rises, there is poor drainage and salinization follows. Where there is too little water crop yields are poor;
- Lack of respect for laws which apply to irrigation systems makes it difficult to operate the systems properly.

2.2 SPECIFIC PROBLEMS

2.2.1 Serry Command

The Serry canal command is located in Middle Egypt in the Minya governorate. It is a main branch of the major Ibrahimiya canal system, and serves about 130,000 feddans in both Minya and Beni Suef governorates.

Briefly, the major problems of the Serry canal system are:

- maldistribution of water among the distributaries and within the distributaries;
- large quantities of irrigation water flows to the drains from the ends of mesqas and distributary canals;
- inability to control flows according to crop water requirements;
- aging control structures, and non-existing controls in many needed locations;
- irregular canal sections and excessive widths resulting from maintenance practices;
- high water table and localized areas of water logging and salinization;
- uneven agricultural lands;
- low on-farm irrigation efficiencies;
- poor weed control and inadequate maintenance, particularly at the mesqa level.

2.2.2 Baheig Canal

The Baheig canal has a command area of 30,000 feddans, and is supplied by the Mariut canal which is a branch of the Nubariya canal in Alexandria governorate in West Delta. Major problems of this canal system are:

- serious shortage of water in terms of planned irrigated areas;
- excessive seepage from the canal;
- water logging in the lower areas below the canal;
- poor drainage;
- crusting of surface following irrigation;
- low productivity and poor farming performance.

2.2.3 El Gharak

The El Gharak canal serves an area about 50,000 feddans in Fayoum governorate. The principal problems of this system are:

- lack of flow control, resulting in shortage of water at the tail of the system;
- excessive flow of water to the drains at the head of the canal.

2.2.4 Abou El Managa

The Abou El Managa canal is located in Kalubia governorate and serves an area of 52,000 feddans. Significant problems within the command are:

- seepage from the canal with water logging adjacent to the canal;
- high water table with increasing salinity;
- aging canal infrastructure including the pump station on the Nile with operating difficulties and increasing maintenance requirements.

3. SUMMARY OF THE NIIP PLAN FOR IRRIGATION IMPROVEMENT

The Ministry of Irrigation considers improvement and rehabilitation of irrigation systems to consist of two parts:

(1) improvement and rehabilitation of the distribution system of canals for better control in the delivery of water; and

(2) improvement of farm channels and on-farm irrigation practices by farmers, including land leveling and modernized agricultural practices.

3.1 IMPROVEMENT AND REHABILITATION OF CHANNEL NETWORKS

Principal improvements are to be made by:

- o installing new control gates at main and branch canals;
- o installing weirs at the heads of canals and distributaries to enable flow control in accordance with irrigation needs;
- o provide continuous discharge measuring capability to transfer accurate information to operating control centers for improved water distribution and management;
- o reduce waste and losses within the network.

3.2 IMPROVEMENT AND REHABILITATION OF MESQA NETWORKS

Principal improvements will consist of:

- o reconstructing the mesqas to accommodate the required discharges;
- o providing single point lifts with gravity irrigation to individual farms;
- o installing outlet and check structures on the improved mesqas;
- o scheduling rotations on the mesqas and training farmers in better water management practices.

4. TECHNICAL PROGRESS DURING THE REPORTING PERIOD

Except for a brief visit to the Baheig canal, the technical effort of the CID team in RIIP has concentrated on the Serry canal system. Personnel from the Salt River Project (SRP) have provided consultation service on installation of radial gates and on lining in the Baheig canal.

4.1 SERRY CANAL

4.1.1 Identification of Problems

The Research Institute for Ground Water (RIGW) of the Water Research Center, with the assistance IWACO of the Netherlands, has been investigating the ground water problems of Middle Egypt. The results of their studies indicate that since construction of the High Aswan Dam (HAD) and the advent of perennial irrigation, the ground water table has been gradually rising. Seepage from canals and irrigated land surfaces in the development of new lands along the edges of the valley have also contributed to the build-up of the water table. In selected regions of the valley lands below expanded areas have become water logged and are no longer in production.

On the valley floor, the relatively impervious clay layer functions as a cap over the underlying aquifer. The piezometric head in the aquifer, in some locations, is above the level of the water table in the clay layer, while in other locations the piezometric head is above the land surface and water flows from the aquifer through the clay layer to the surface. Where tile drains are functioning the upward flow is intercepted, but where the tile drains are not functioning, water logging results with gradual buildup of salt concentrations on the land surface. Surface drains wash some of the salts into open drains, but under-ground drainage and leaching is necessary to reduce present high salt concentrations in the root zone.

Activities have been initiated to identify the extent of water-logging, high water table, and salinization in the Serry

command. Two approaches are being examined at this time. Th first involves use of aerial photography and Landsat imagery with extensive field surveys in selected areas, and the othe involves exclusive use of field surveys and extensive sampling The first approach will be used by a team comprised of Mr. T Martin (TDY) from Colorado State University (CSU), a soil scientist and specialist in Landsat imagery and the Remote Sensing Center (RSC) of the Egyptian Academy of Science. Dr. Younis, Professor of Agronomy and Soil Science, at Ein Shams University will be the senior technical person on the RSC staff. The second approach will be utilized by the Soil and Water Institute of the Agricultural Research Center in the Ministry of Agriculture.

Two sociologists (agriculturalists) have been added to the RIIP staff in El Minya. They are being trained on the job by Dr. Abdulla Saber, a staff member of WRC stationed in Abyuha. Their task is to inform the village leaders and farmers about the project, obtain baseline data on the conditions of the farms, and ultimately to assist in organizing water users associations. Questionnaires developed by Dr. Jim Layton (TDY from CSU) and Abdulla Saber will be used to collect baseline information about the agronomic, sociologic, and some limited economic information of farms in selected subcommands of the Serry canal.

4.1.2 Selection of Subcommands

Three subcommands, thus far, have been identified for rehabilitation and improvement in this pilot program. They are consecutive subcommands at the head of the Serry canal, the Wasselet-Herz-Numania (WHN), Beni Ibeid, and Montout canals, totaling about 21,000 feddans. Two additional areas are to be selected within the work plan for the project (see first semi-annual report).

The first three subcommands have problems of channel irregularity, over-sized canal cross-sections, lack of flow control with maldistribution of water, and high water table and salinization. Although the problems are similar, variations in the solutions are contemplated for the three areas.

Of the two additional areas that are planned to be included in the present program, one will be selected from the middle reaches of the Serry canal and the other will be selected near the end of the system. Variances in the types of problems are expected which will necessitate different packages of solutions to be applied from those adopted at the head end of the command. Where there is shortage of water from the Serry canal, augmentation from ground water will be included in the plan.

4.1.3 Designs

The hydraulic design of the Serry canal was completed in May. The concept of continuous flow, with 24-hour irrigation has been adopted for selecting channel capacities. Cross regulators in the Serry canal are required only for the off-peak periods when reduced flows in the canal necessitate closing of gates to raise the water levels. Accordingly, backwater calculations for the low flows indicate the need for five cross-regulators. However, operational conditions are being examined to determine if additional regulators may be desirable.

Canal and control gate designs for the WHN subcommand have been checked subsequent to completing the hydraulic design of the Serry canal. The discharges used in the initial design were twice that used in the final design, hence the canals and gates in the plans used for awarding construction contracts are too large. It has been decided, however, not to make changes in the contract because any savings in cost by adopting changes could be offset by claims for additional payment by the contractor for making changes after the award. Three of four radial gates will be reduced in size; canal dimensions will remain the same.

A design committee for the WHN subcommand met in May, 1985 and decided to adopt raised mesqas as a part of the improvement program. Two types of raised mesqas will be implemented in the WHN subcommand. One type will be formed from precast concrete sections, and the other will be compacted earth fill. Turnouts will be standardized. Mesqa headgates are to be the same type of

slide gates used by EWUP in the Abyuha system. These gates are manufactured in Egypt.

With the assistance of the RIGW and Dr. Sunada (TDY from CSU), it was decided to place at least three test wells in the Serry command area. Each well will be accompanied by six pairs of deep and shallow observation wells to establish the drawdown curve in the aquifer and to monitor the water table in the clay layer. Measurement of yields from the wells will provide data to plan wells for conjunctive use in other areas of the system. One of the test wells will be in the WHN subcommand where the water table is generally high (50 cm below ground surface) and salinization is visibly evident. One well will be located in the Montout subcommand, near the tail of the system, and the third will be in the central region of the Serry command.

Only the distributary channels and structural designs have been completed for the Beni Ibeid subsystem. Bidding plans and specifications are being prepared for earthwork and the control structures.

4.1.4 Construction

Major sections of the first 8.4 km of the Serry canal have been under construction since the closure in January. The channel has been widened and straightened from the Ibrahimiya to the weir downstream from the WHN turnout, pitching has been added around bends and on the banks where the canal passes through villages, and wide sections have been filled to form uniform sections.

There are four radial gate structures in the WHN system, and only the intake structure has been completed. Construction of the other three structures are expected to be completed during the next three months. Tenders for the radial gates will be requested in July.

4.2 BAHEIG CANAL

4.2.1 Identification of Problems

The Baheig command has recently been added to the scope of the CID/CSU contract. One trip was made to this canal by a member of the CID/CSU team in April, which focused primarily on canal linings. However there have been discussions about the problems of the system with headquarters staff.

The Baheig canal is over 70 km in length and because of seepage there is no flow beyond 50 km. Although the command area is about 30,000 feddans, only 14,000 is currently under controlled irrigation. Through illegal withdrawals along the left bank of the canal, an additional 9,000 feddans of sandy soils are under irrigation.

There has been a significant change in the cropping of this command which has resulted in higher water demands than originally planned. Where olive orchards, and grape vines, along with barley were considered in the original design of the system, there is now considerable areas of berseem for livestock and milk production, and half of the area is in vegetables for both summer and winter seasons.

4.2.2 Design

Design of the system is presently underway by the NIIP staff in Alexandria, with the advice of a design engineer in Cairo. Two engineers from the Salt River Project (SRP) have been consulted concerning the type of canal lining and method of construction most suitable for the conditions prevalent at the site.

4.3 EL GHARAK

The canal intake has been redesigned with a Neyrtec distributor to limit the maximum discharge in the canal. Weirs have been designed at other locations along the canal to measure flow rates throughout the system. The concrete work at the intake has been completed and an order needs to be placed for the distributor.

4.4 ABOU EL MENAGA

This project site is north of Cairo near NIIP headquarters in Shoubra. Meeting have been held with engineers from the Kalubia governorate office to examine the problems and to review preliminary designs.

5. WATER RESEARCH CENTER

5.1 FIELD RESEARCH STATIONS

The data, methodology, and reports of the Field Research Stations were reviewed. The main goal of these sites is to obtain crop water requirements. A report containing recommendations on staffing, procedures, and new instruments for the stations was submitted for review by Institute[2] Engineers (Appendix B). Computer data banks and analysis were begun on crop water requirement data from Shebin El-Kom and lake evaporation from Shakshouk stations.

5.2 IRRIGATION SCHEDULING FOR PIPELINE

A method of operation of two asbestos-cement buried pipeline systems was developed for management in Egypt (Appendix C). The pipeline consists of two pipe systems (50-60 cm diameters) each with three supply pumps. A branch line connects the two pipeline systems and will allow water from either pump stand to flow throughout both pipelines. To prevent sedimentation, only six or seven of the thirty-one outlets on each pipeline can be operated at one time. The computer model uses field data of crop areas, crop consumptive use, ground water, application efficiency, conveyance efficiency, available moisture, and hydraulic characteristics to produce an operating schedule to satisfy irrigation demands for any time during the year. The valves at each outlet are fully opened and will remain open until the required volume of water has been delivered for the area served. The energy of

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2 Water Distribution and Irrigation Systems Research Institute.

the system is balanced between supply canal, pumps, corner stands, different pipe sizes, and outlets to farm watercourses for each change in outlet number setting. The following four computer programs were completed:

1. Operation of pipeline 1 from pump stand 1,
2. Operation of pipeline 2 from pump stand 2,
3. Operation of pipelines 1 and 2 from pump stand 1, and
4. Operation of pipelines 1 and 2 from pump stand 2.

6. TRAINING

The training activities consist of academic degree and non-degree programs, short-courses on specialized topics, invitational travel for tours of a specialized nature, in-country short courses, and on-the-job training.

6.1 ACADEMIC

The following persons were approved for advanced degree training and have been enrolled in U.S. universities:

6.1.1 Degree Programs

Master of Science:

None

Doctor of Philosophy:

1. Mohammed Ragy Salah Darwish - Economics, CSU, Jan 1986-
2. Abdel Fattah Metawie - Engineering, CSU, Sept 1985 -
3. Tarek A. Toufik - Engineering, CSU,

The following persons have been approved for academic training and will be enrolling in U.S. Universities or they are in the process of seeking admission to U.S. universities starting in the fall of 1986:

Master of Science:

1. Fatma Hassan Hassan- Ground water, CSU, Sept 1986 -

Doctor of Philosophy:

1. Mohamed Nagiib Mohamed - Sociology, CSU, Sept 1986
2. Azza Nasr - Engineering, UCD, Applied for Sept 1986
3. Maha El-Hakim - Engineering, UCD, Applied for Sept 1986
4. Farida Abdel Meguid El-Fessy, Engineering, CSU/UCD, Sept 1986

6.1.2 Non-Degree Programs

Post Doctoral Studies:

1. Dr. Mona El Khadi - Engineering and Management, CSU, July 1986.

6.2 SALT RIVER PROJECT

There are three types of training programs with the Salt River Project (SRP). They are (1) the professional exchange program, (2) student training, and (3) senior management training.

6.2.1. Professional Exchange Program

a. Completed during the reporting period:

From the USA to Egypt:

1. Mr. Ron Merkley - Radial gate construction and installation, and canal lining.
2. Mr. Herb Mattingly - Radial gate construction and installation and canal lining.
3. Mr. Ron Johnson - Radial gate construction and installation.

From Egypt to USA:

1. Hussein Soliman Elman - System operation and management.
2. Wadie Ragy Kelada - System operation and management.
3. Ahmed Habib Allah El Raiys - System operation and management.
4. Shawki Habib Tawadors - System operation and management.

b. Approved for exchange after July 1, 1986.

From Egypt to USA:

1. Hanaa Raismy Fahmy, System design and operation.
2. Nadia Aziz Welson, System design and operation.

6.2.2. Students Training, Summer, 1986

1. Khalid Abu-Zeid - University of Cairo
2. Yehia - Ein Shams University ?

6.3 SHORT COURSES

The following persons have attended or are attending short courses during the reporting period:

1. Course Title: Organization and Management of Agricultural Extension System.
   Location: University of Illinois, Urbana
   Dates: June 16 - July 11, 1986
   Attendee: Sohair Kamal Youssef, WRC
2. Course Title: Social and Technical Aspects of Irrigation Organization.
   Location: Colorado State University
   Dates: June 16 - July 19, 1986
   Attendees: Hassan Hussein Shouman, NIIP
   Aatif Mohammed Abd El Kader, NIIP
3. Course Title: Image Processing of Satellite Data for Natural Resources Applications.
   Location: University of New Mexico
   Dates: June 30 - July 18, 1986
   Attendees: Salwa Mohammed Bakir Khaloussi, WRC
   Ahmed Mohammed Sayed, WRC
   Sayed Mohamed Aly El Sayed, WRC
4. Course Title: Water Management and Runoff Farming for Small Scale Agriculture.
   Location: University of Arizona
   Dates: July 14 - Aug 8, 1986
   Attendees: Mohamed El Korany Gouda Moussa, WRC

5. Course title: Engineering, Management, and Economics of Irrigation Rehabilitation Projects.

Location: Colorado State University

Dates: Aug 11-Sep 5, 1986

Attendees: Loucy Helmi Boulos, Project Preparation Dept.
Essam Abdellatif Ahmed Samanudi, PPD
Ghada Khalil Barakat, PPD
Ramses Bakhoum, NIIP
Essam El Din Fawzi Barakat, NIIP

6.4 INVITATIONAL TRAVEL

The following persons were approved for invitational travel and have completed their tour or are on tour during the reporting period:

1. Mohamed Naser Ezzat - Director, Project Preparation Department, SRP.
2. Abdel Hamid Fahim - Director, Training and Manpower Development Institute, SRP.

The following persons have been approved for invitational travel and will embark on their trips in July, 1986.

1. Undersecretary, Farouk Shahin - Director, National Irrigation Improvement Project.
2. Abdel Raouf Salahi - General Director, NIIP, El Minya Governorate.

6.5 IN-COUNTRY SHORT COURSES

The CID/CSU staff participated in teaching two short courses during the reporting period which were organized by the Training and Manpower Development Institute of WRC. One is a course titled "Engineering for Irrigation Improvement" and the other is an on-going course for "On-farm water management". Participants for both courses included NIIP staff from various governorate offices, as well as district engineers responsible for operation and maintenance of irrigation systems.

6.6 ON-THE-JOB TRAINING

A five week course in the use of microcomputers and elementary BASIC language was prepared and conducted for the engineers at NIIP headquarters in February and March. A similar, but abbreviated course was conducted for the engineering staff at El. Minya. Following the introductory course, development and use of computer programs in hydraulic analysis, and design of irrigation systems is being undertaken on a one-on-one and one-on-two basis. Teaching the engineers at NIIP the fundamentals of irrigation system design is planned during the next six months.

7. PROCUREMENT

7.1 PROCURED TO DATE

The major equipment procured to date consists of 10 vehicles and 5 PC computers. The computers were delivered in November, 1985. Five of the 10 vehicles have been delivered to date, 2 vans and 3 pickups. Three station wagons and 2 suburbans are still in custody of customs in Alexandria. The last word from Customs is that non-working vehicles can be imported only as project property and only if there is a promise to re-export the vehicles. Efforts are presently being made through the Prime Minister to secure release of the vehicles. Other procurements are listed on the following page.

7.2 FUTURE PROCUREMENT

Specifications for competitive procurement of float-controlled radial gates for the Baheig canal and Herz-Numania subcommand are being prepared. In addition, specifications for a discharge limiting device at the intake to El Gharak canal is also being prepared. Specifications for other equipment urgently needed for data collection and design of improvements for the Serry command are being assembled.

7.3 SUPPLEMENTARY PROCUREMENT LIST

Two Chevrolet Suburbans, three Chevrolet S-10 Pickups and three Chevrolet Celebrity Station Wagons were received. The vehicles were road tested and the only problems discovered were with the two Suburbans. These problems were corrected by the local Chevrolet dealer. The vehicles were shipped on April 7, 1986.

Two sets of mechanics' tools with tool boxes were purchased for maintenance of the project vehicles. These tools will be shipped soon

One Epson FX-85 printer was purchased to replace an Epson FX-85 printer with an inoperative paper drive motor. The replacement printer was hand caried to Egypt by Dr. Richardson in July.

Two spare half-height disk drives and a 2400-Baud modem were purchased for the IBM Personal Computers. The modem and one disk drive was hand carried to Egypt by Dr. Richardson in July.

A replacement lid for one of the freezers, which was damaged in shipment, is on order. Considerable time was spent ordering this part due to the difficulty in obtaining the correct model number for the freezer.

Miscellaneous supplies and accessories for the IBM personal computer systems have been ordered. Most of thesse items have been sent and the balance will be sent in the next air shipment.

SHORT-TERM TRAVEL

Dan Sunada	May 16 - June 7	To assist in vertical drainage and groundwater projects in Cairo, Egypt for the Groundwater Research Institute.
James Layton	May 16 - June 30	To assist in vertical drainage and groundwater projects in Cairo and Minya, Egypt for the Groundwater Research Institute.
Timothy Martin	May 20 - July 23	To work with the Remote Sensing Center in Cairo in connection with Landsat data on soils cropping, physical boundaries, maps, and many related items for Serry, Baheig, Gharak, and Abu El Manaza Systems.

APPENDIX A

Table A-1 Selection of Commands in
The Regional Irrigation Improvement Plan

Governorates	Canals	Command Areas	Est. Costs
East Delta:			
Sharkia	Sadia	80,000	27,000
	El Dababra	5,000	1,500
	El Samaana	6,000	2,000
Kalubia	Abou El Managa	67,000	20,000
Ismalia	El Karwan	7,000	2,500
Dakahlia	Orman Talkaa	4,000	1,400
	El Masfa	5,000	1,500
	Dekernes	50,000	15,000
Middle Delta:			
Bahr El Seidi	Bahr el Saeidi	42,000	15,700
	Bahr el Saeidi	18,000	6,300
	Salma	20,000	7,000
	Youssef Afendi	11,000	3,850
Gharbia	Ahwagi	12,000	4,700
	El Ghafari	9,500	3,500
	El Batatonia	29,000	10,000
	El Malah	70,000	25,000
Menoufia	Rayah	7,000	2,500
	Derwet Madi	11,500	4,000
	Dia El Kom	6,000	2,000
West Delta:			
Behiera	Boloktor	11,000	3,850
	El Hamami	12,000	4,200
	West Behiera	30,000	10,000
Alexandria	Baheig	30,000	12,500
Middle Egypt:			
El Giza	El Mansouria	24,000	9,000
	El Hamami	1,000	750
Beni Suef	Keman,El Arous	5,000	1,500
El Fayoum	El Gharak	52,000	5,000
	Wahby	20,000	3,000
	Karoun	12,000	2,000

Table A-1 Selection of Commands in
The Regional Irrigation Improvement Plan (cont.)

Governorates	Canals	Command Areas	Est. Costs
Middle Egypt: (cont.)			
El Minya	Serry Bacha	130,000	45,500
Upper Egypt:			
Assuit	Shamia & Okal	25,000	7,850
	El Ibrahimiya	20,000	7,000
Sohag	Khour El Sahel	12,000	4,200
Kena and Aswan	Redissia,Abadi	13,000	11,300
Totals:			
East Delta		224,000	70,900
Middle Delta		236,000	8,455
West Delta		83,000	3,550
Middle Egypt		244,000	66,750
Upper Egypt		70,000	30,350
Grand Total		857,000	283,100
Area to be completed before the 1987/92 5-yr plan		76,000	25,300
Planned for completion during the 1987/92 5-yr plan		557,000	184,050
Completion during the following 5-yr plan		224,000	73,750
Grand Total		857,000	283,100

APPENDIX B

REPORT ON FIELD RESEARCH STATIONS

by

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March 26, 1986

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REPORT ON FIELD RESEARCH STATIONS

Consumptive use of water or evapotranspiration is one of the important elements of the hydrological cycle. Consumptive use includes evaporation of water from land and water surfaces and transpiration by vegetation. Refinement in water requirement technology is a major need in applying irrigation management to increase yields and reduce water logging and salinity problems.

Ten Field Research Stations and a Lake Evaporation Station are operated by the Water Requirement Discipline of the Water Distribution and Irrigation System Research Institute. These are used to study the following objectives:

1. Determine the water requirements to obtain maximum yield from crops grown throughout Egypt.

2. Determine the effect of water table level on water requirement for crops.

3. Determine the effect on yield when plants are stressed during critical periods of growth.

4. Determine the irrigation frequency for different crops and soils.

5. Study actual consumptive use versus theoretical formulas using climatic data.

6. Study the relationship of irrigation and drainage water requirements.

7. Determine the effect of water table level on yields of rice in the Delta region of Egypt.

8. Technical evaluation of the use of drip, sprinkler, and surface methods of irrigation of new lands development.

9. Economical evaluation of the use of drip, sprinkler, and surface methods of irrigation of new lands development.

Visits were made to each of the Field Research Stations except Kom Ombo. These visits are summarized in Appendix A. General recommendations for instruments are given in the following pages. Many of these practices are used at the Field Research Stations. They are given here in handbook form for use by field technicians.

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RECOMMENDATIONS

The staffing of the stations was usually sufficient except for engineers. Bahtim, Shebin El-Kom, King Osman and Shakshouk stations did not have resident engineers due to possible shortage of engineers. It is recommended that engineers be hired to fill the resident engineer position at these stations. Maryut and Kom Ombo have engineers who are or will be on maternity leave. It is recommended that temporary engineers be assigned to fill their positions during their leave of absence.

The procedure used to obtain field measurements appeared to be sound for the data recorded at present. However, recommendations on methodology are given in the section on Instruments. Measurement of air humidity, total run of wind, and solar radiation should be added to the parameters to be measured at all stations. Training of engineers and technicians to operate the equipment is recommended before installation of instruments. A data bank (computer) of past data would assist in the analysis and application of the data.

The recommendation on new instruments and apparatus for the Research Stations are listed in Table A. The numbers are tentative until review by Water Distribution and Irrigation System Research Institute Engineers. Yearly recalibration of instruments is recommended using a reference instrument kept in the laboratory and used only to check calibration. Therefore, one extra instrument is added to the list for their purpose.

Table A.__Recommendation on new instruments and apparatus for Research Stations.

Number	
	Air Temperature
12	A complete set (Weather Bureau pattern) of minimum and maximum thermometer mounted on stainless-steel back and approved Townsend support.
6	Extra Maximum thermometer less metal back -30 to +55 degree C.
6	Extra Minimum thermometer less metal back -45 to +50 degree C.
	Air Humidity
13	Hygrothermograph with spring-wound clock, 24-hour and 7-day drum rotation.
3	Replacement hair bundle.

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Table A. (continued) Recommendation on new instruments and apparatus for Research Stations.

Number	Air Humidity (Continued)
36	Replacement Cartridge pen.
48 pkg.	Charts, Temperature -10 to +50 degree C; relative humidity 0 to 100%; 7-day rotation.
12	Sling Psychrometer (Weather Bureau type), two 9.5" thermometers mounted on stainless steel back. Furnished with hardwood swivel-type handle, wick and humidity table. Thermometers are etched with graduations over a range -10 to +50 degree C.
6	Replacement thermometers for Sling Psychrometer.
12 pkg.	Extra Wicks.
12	Pocket-type metric slide rule with relative humidity scale for use with psychrometer.
	Wind
13	Contact Anemometer totalizing 100 m, six digit to 99,999.9 km; includes 10 m of cable.
13	Event recorder with spring-wound clock 26-hr. and 176-hour drum rotation (100 event). Supplied with pen, ink, dash pot oil, and package of charts.
48 pkg.	Chart 176-hour rotation.
36	Silicone oil dash pot fluid, 0.5 oz. (15 ml).
	Solar Radiation
13	Mechanical Pyranograph with spring-wound 26-hour or 176-hour clock, pen, ink, and package of weekly charts.
6	Spare parts kit, includes cartridge pen, pen arm, rubber gasket, and spare glass dome.
48	Silica Gel, 4-oz.
48 pkg.	Charts, 176-hour rotation approx. 0 - 2.5 ly/min
	Evaporation
12	Evaporation Pan, Class A stainless steel.
12	Stilling Well 3 1/2"D x 10"H (89 mm D x 254 mm)

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Table A. (continued)__Recommendation on new instruments and apparatus for Research Stations.

Number	
	Evaporation (continued)
12	Hook gage, micrometer metric calibration.
18	Submersible maximum/minimum thermometer complete with thermometers -10 to 60 degree, and stainless steel rod handle.
	Precipitation
6	Standard 8-inch non-recording rain and snow gage, complete with overflow cylinder, funnel, inner measuring dip stick.
6	Gage stand for rain and snow gage.
6	Spare measuring dip stick, metric.
	Soil Moisture
22	Spiral screw type auger, 1.25-inch diameter by 6-inch length auger supplied with 36-inch extension and handle. Total length 42 inches.
22	Post hole auger, 2-inch diameter by 6-inch length supplied with 36-inch extension and a wooden cross handle.
22	Bucket auger, 3-inch diameter by 6-inch length cylinder supplied with extension shaft and handle. Total length 42 inches.
60 doz.	Sample can formed of aluminum, 2.5-inch diameter by 1.75-inch height with closely fitting telescoping lid that may be fitted to the bottom of the can as a single unit during the drying process.
2	Top pan precision balance, scale division (digital) 0.1 gram, weighing range 1000 grams, zero adjustment 100 grams.
or	
	Top pan precision balance, scale division (digital) 0.1 gram, weighing range 2000 grams.
3	Top pan precision balance, gross weighing range 0.1 to 249.9 grams, taring range 0.1 to 49.9 grams, 9 VDC power, sensitivity 0.1 grams.
11	Soil auger, 15 cm graduation for measuring depth, diameter of bit 3 cm, overall length 101 cm.

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Table A.(continued)__Recommendation on new instruments and apparatus for Research Stations.

Number	
	Soil Density
11	Soil core sampler set consisting of five brass core cylinders 2.25-inch outside diameter (5.715 cm); one 6 cm long, two 3 cm long, and two 1 cm long. The set contains an outer steel housing with a replaceable cutting edge, driving hammer, and core extractor. All steel parts are plated for corrosion resistance.
24	Replacement cutting edge
36	Extra brass cylinder 6 cm
36	Extra brass cylinder 3 cm
36	Extra brass cylinder 1 cm
14 doz.	Sample can formed of aluminum 3.5-inch diameter by 2-inch high with closely fitting telescoping lid that may be fitted to the bottom of the can as a single unit during the drying process.
	EC and PH Meters
12	The LaMotte Greenhouse Soil Testing Outfit, Model GS-01, Complete, self-contained soil laboratory which provides tests for pH using the LaMotte pH meter, soluble salts with the LaMotte conductivity meter, Octet comparators for nitrogen and phos phorus tests; the LaMotte turbidimetric method for potassium and micro burette titration procedures for calcium and magnesium.
24	Refill package for LaMotte Soil Testing Outfit.
12	Kelway Soil Acidity and Moisture Tester, no batteries, upper scale reads 3.5, 4, 5, 6, 7, 8 pH; lower scale 100, 70, 50, 0 % moisture. Carrying case with belt loop with complete instructions.
	Yield
10	Portable platform scale for general purpose weighing, 50 kg x 200 kg. Capacity 500 kg. Double beam.
10	Small Tractor SAE 17 H.P. 2-cylinder diesel with electrical starter and implements.

Table A.(continued)__Recommendation on new instruments and apparatus for Research Stations.

	Ground Water
24	Lufkin Fiberglass Measuring Tape; Metric gradua tions m, cm, 2mm; Tape leng'h 15 meters.
or	
	Chicago Symron Fiberglass measuring tape; Metric graduations m, cm, 2mm; Tape length 20 meters; closed case.
13	Microbarograph with spring-wound clock, 24-hour and 7-day rotation complete with pen, ink and 100 charts. Sensor: 14-cell 2.5" (64mm) diameter aneroid. Scales: 945 to 1045 mb. Accuracy: + or- 0.15 mb
48 pkg.	Chart for Microbarograph, 945 to 1045 mb, 7 day drum rotation.
11	Full-Range Mercurial Barometer complete with mounting panel, hanging bracket, centering ring, thermometer, and instruction manual; scales 20-31" and 508 to 790 mm.
24	Water-Level Recorder, Stevens Type F with 8-day spring wound clock drive, Time Scale 1.2 in./day, Gage Scale 1:1, Chart F4, Float Pulley 375 mm circumference for perforated tape, 3 meters stain less steel perforated and graduated float tape with set of end hooks and index bracket, 2.5-in. Float with counterweight, Guide pulley for float tape, Cover with viewing port.
50 pkg.	Chart F-4, boxes of 54, Ledger stock.
	Current Meter
6	Magnetic current meter; digital readout 0-3 meters/s or 0-10 ft./s; time averaging with switch settings of 2 sec., 10 sec., 20 sec., and 30 sec.
6	Top Setting Wading Rod, Metric.
10	50-Hertz 220V Electrical generators 21.9 KVA.
10	Portable Industrial Pump 4-inch
10	Suction hose, 4-inch rubber, fabric/wire reinforcement, length 20 ft.
10	Discharge hose, 4-inch rubber, fabric reinforcement, length 25 ft with water meter.
400	Sprinkler heads (to replace model ZE 30, 1-inch)

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INSTRUMENTS

Air Temperature

Separate liquid-in-glass minimum and maximum thermometers mounted on cross board of the shelter (U.S. Weather Bureau Pattern) with a thermometer support (Townsend). When released, a hinged locking mechanism permits whirling of the maximum thermometer to reset the mercury column. The minimum thermometer can be positioned vertically to reset the indicator index in the alcohol-filled column.

Maximum and minimum thermometers should be read daily, preferably about 0800 or 0900 hours. Readings should be recorded immediately on the form specified by the project. Both maximum and minimum thermometers should agree within 0.5 degree C after resetting the thermometers. A greater variation should be noted on the recording form.

Air Humidity

Besides the maximum and minimum thermometers, a recording hygrothermograph should be operated in the shelter house. This will furnish a continuous trace record of the air temperature and relative humidity. A weekly time scale is adequate. Temperature pen readings should be checked against maximum and minimum thermometer readings made in the same shelter. Adjustments are made to the pen setting whenever its error is more than 1 degree C. Recorded values of daily maximum and minimum temperature can be read from the chart when maximum and minimum thermometer readings are unavailable (non-workdays).

Chart recordings of relative humidity should be checked periodically against values obtained with a sling psychrometer. Checks should be made in early morning or after a rainy period when humidity is high. Checks should also be made in the middle of the afternoon when humidity is usually at its lowest point. These checks should be made when relative humidity is not changing, as a certain amount to lag exists in the hygrograph. Sling psychrometer should be ventilated by whirling in a shady location. Muslin used as a wick on the wet bulb thermometer must be clean with no dust or finger marks. Clean water should be used to moisten the wick when readings are made.

The shelter (U.S. Weather Bureau "cotton-region" pattern) should have louvered sides and a double roof to protect instruments from precipitation, condensation, and radiation. The floor of the shelter house should be level and approximately 1.2 m above ground. The door should face north. Rigid mounting of the shelter is necessary since wind-induced vibrations may displace the thermometer index for maximum and minimum readings.

Wind

A totalizing anemometer is sufficient for recording of wind velocities with a mechanical event recorder (7-day clock) for recording continuously so that a permanent record is available. The World Meteorological Organization standard height for wind measurement is 10 meters above ground. However, a height of 2 meters is recommended for use in calculating potential evapotranspiration methods. Therefore, for ease in reading the total run of wind and resetting the counter, a height of 2 meters is recommended. To estimate wind speeds at a second height, U_2, when wind speed at another height, U_1, is known use the formula:

$$U_2 = (\ln Z_2/\ln Z_1)\ U_1$$

where Z_2 and Z_1 are the heights in centimeters of estimated and measured wind speeds.

The anemometer should have a uniform fetch of 100 times the height of the uppermost obstruction. Day-to-day operation is simple. The recorder chart is inspected, and any time corrections are noted and made. The ink supply is checked and pen traces are checked to see if the pen needs cleaning. The total run of wind for the previous calendar day is noted on the observer's form.

Solar Radiation

Solar radiation is generally the most important factor in the evaporation and transpiration processes. Several methods for determining potential evapotranspiration use solar radiation data. Evaporation and transpiration are more closely related to net radiation than to solar radiation. However, instruments for measuring net radiation are subject to change and require frequent calibration and maintenance. Therefore, for remote field use a mechanical pyranograph (7-day drum rotation)is recommended.

A pyranograph must be installed so that the solar beam is not obstructed at any time of the day, nor during any season. In addition, glare or reflections should not be directed towards the instrument at any time. The pyranograph should be kept level at all times and cleanliness is very important. The glass hemisphere should be kept clean using a soft cloth or camel'shair brush or facial tissue. The desiccant chamber needs to be serviced periodically to prevent condensation of moisture inside the glass hemisphere. The gasket seal should be replaced when worn or deteriorated. Yearly recalibration is recommended using a reference instrument kept in the laboratory and used only to check calibration. The instrument should be mounted approximately 1 to 1.5 meters above ground.

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Evaporation

Evaporation of water from a pan or tank is influenced by solar radiation, air temperature, water temperature, humidity, and wind. These are some of the same factors that determine evaporation and evapotranspiration from land and plants. Thus, measurement of pan or tank evaporation provides an index of the integrated effect of meterological conditions of evaporation and potential evapotranspiration from land when water is not limiting.

The U. S. National Weather Service 4-foot (inside diameter 1207 mm, depth 254 mm) diameter Class A pan is recommended as a standard for pan evaporation. The pan is mounted in a level position on a wooden platform as described in National Weather Service Observation Handbook No. 2.[1] Soil under the platform is leveled and tamped to provide a standard air space of 1 1.5 cm.

A micrometer hook gage is used with a stilling well to measure the level in the pan. The stilling well (with a small hole in the base) provides an undisturbed water surface around the hook gage and a support for the gage. The stilling well is located in the pan about 30 cm from the north edge. Leveling screws and lock nuts are provided on the triangular base of the stilling well.

The site of a Class A evaporation pan should be fairly level and sodded. Obstructions should not be closer to the pan than four times the height of the object. Weeds and grass should be cut to keep growth below the level of the pan. Sites on downwind side of large swamps or reservoirs should be avoided. The site of the evaporation pan should be fenced to prevent animals or birds from drinking from pan.

Precipitation

The standard 8-inch (203 mm) non-recording precipitation gage is recommended. The top of the funnel should be 76 cm above the ground. A stand or support is required to raise the funnel to this height. The standard consists of an overflow can, measuring tube, rainfall funnel, and measuring stick. The measuring tube has a cross-sectional area that is one tenth the cross-sectional area of the funnel. Therefore, when 1 mm of rain falls into the funnel the tube is filled to a depth of 1 cm. Any overflow water should be poured into an empty measuring tube for

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[1] National Weather Service Observation Handbook No. 2 Substation Observation. U. S. Department of Commerce, National Weather Service, Washington DC (1972 or later edition).

direct measurement with the measuring stick. The total depth of precipitation, date, and time are recorded on the field data sheet after each occurrence of precipitation.

Soil Moisture

The gravimetric method of moisture determination is the standard method to which all other methods are compared. Samples are taken in the field with convenient tools such as shovels, spiral hand augers, bucket augers, or hand driven soil sampling tools like the Veihmeyer tube. The soil sample (100 to 200 grams) is placed immediately in a leak-proof tare weighted can suitable for transporting to the laboratory for drying in an electric oven at 105 degrees C to a constant weight (usually 16 to 24 hours). If a sample is dried at a lower temperature, all the water may not be removed, and if it is dried at a higher temperature, other volatile matter may be driven off in addition to the water. The minimum time required to bring soil samples to a constant weight will depend on sample size, number of samples placed in the oven, moisture content of the samples, and type of oven. It is best determined by trial and error under typical operating conditions. The moisture content is calculated by the following formula:

P = (loss of weight on drying) x 100/(weight of oven dry soil)

It is convenient to weigh samples on automatic balances that read to the nearest 0.1 gram.

Two general radiological methods are available for the measurement of soil moisture content. One is based on the interaction between high energy neutrons (fast neutrons) and nuclei of hydrogen atoms in the soil. The other method is based on the attenuation or back scattering of gamma rays as they pass through the soil. These methods have the advantage of being nondestructive and yielding data from the same location at each observation. However, both methods require careful calibration, preferably with soil in which the equipment is to be used. Also, the radiological methods have several common drawbacks. The equipment is expensive, requires considerable maintenance, the access tubing is difficult to install and maintain, and depth moisture probe readings are not consistent near the soil surface (top 25 cm). Therefore, gravimetric method of moisture determination is recommended.

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Soil Density

The weight per unit volume of soil is defined as soil bulk density, specific weight, or volume weight. Soil sampling rings are used to obtain undisturbed cores (100 to 200 cc) of know volume. The sampling rings are placed inside a outer steel housing that has a sharp cutting edge. Light blows should be used in forcing the rings into the soil. After the sampling ring has been driven into the soil, the ring is removed from the outer steel housing and the core is trimmed on each end to the exact length of the ring. Care must be exercised in extracting core samples to prevent either compaction or fragmentation of the core. Samples should not be taken when the soil is either too wet or too dry. Place sample in a tared drying pan and dry to a constant weight at 105 degrees C. The net dry weight is determined to the nearest 0.1 gram (g). The specific weight, soil bulk density is computed as follows:

Specific weight = [dry weight of sample (g)]/[sample volume (cc)]

Ground Water Measurements

Water level observations must be referred to a surface reference point, such as mean-sea-level (MSL), before comparison between different observation points can be made. Two methods for observing ground water are manual using a steel tape (non recording, periodic) and recording instrument (continuous) in an observation well.

The recommended method for non recording is to attach a inverted cup sounding "popper" to a steel tape and measure the depth from a reference point on top of the well to the water surface using the "popper" sound to determine when the cup comes in contact with the water. This "popper" can be made from a short (5 cm) piece of pipe (diameter 2.5 cm) filled with lead and fitted with a "eye" for attaching steel tape with a shallow depression (inverted cup) on the bottom.

An instrument house should be provided to protect the water level recording device on the well. All recorders should be maintained according to the manufacturer's instructions. The observer should familiarize with instruction manuals and should follow recommended maintenance and servicing procedures.

APPENDIX C

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IRRIGATION SCHEDULING FOR PIPELINE

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IRRIGATION SCHEDULING FOR PIPELINE

by
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INTRODUCTION

The El-Hammami pipeline system serves approximately 633 feddans using water from El-Mansuriya Canal of the Giza governorate, Upper Delta near Cairo, Egypt. The annual precipitation is approximately 7 mm. Therefore, the farmers depend on irrigation to supply the water needed for their crops of berseem (clover), wheat, maize, vegetables, and orchards of citrus and mango. The soil is mostly yellowish-brown sand or sandy loam and non-saline except for a few scattered sites. The water table is usually less than one meter from the ground surface with the average approximately 63.5 cm.

The pipeline system (see Fig. 1) consists of two identical pump stations with outlet valves 1 - 27 on the main and outlet valves 31 - 34 on the branch line of pipeline 1 and outlet valves 1 - 30 on the main line of pipeline 2. A gate stand separates the two systems and allows operation of both lines from either pump station. Each pump station is provided with three pumps having capacities of approximately 90, 180, and 90 liters per second (see Fig. 2). After completion of the hydraulic network, the next process is the operation plans or software to meet the crop-water requirements. The end products are irrigation time tables which present the amounts of water required and tell the irrigator when to open and shut certain valves, and what pumps are operating. This report covers irrigation scheduling for the El-Hammami pipeline.

CROP-WATER REQUIREMENTS

Consumptive use by crops includes transpiration by the plants and evaporation from soil and plant surfaces. Daily consumptive use varies as the factors that influence evaporation and transpiration. Average monthly values were computed using

[1] Professor, Colorado State University, Consortium for International Development, EGYPT IRRIGATION IMPROVEMENT PROJECT, Water Distribution and Irrigation Systems Research Institute, Water Research Center, Ministry of Irrigation, 22 El-Galaa St., Bulak, CAIRO, EGYPT

data from Technical Report 17.[2] The results are shown in Table 1. The monthly values were used to estimate 10-day periods using a linear interpolation of the monthly values. Each month is divided into three periods; first ten days, second ten days, and the remaining no of days in the month. The estimated 10-day values are shown in Table 1 and Figure 3.

In arid and semiarid regions, where all the moisture is supplied by irrigation, experience indicates the desirability of maintaining a minimum soil-moisture level of about 50 percent for most crops. Irrigation frequency refers to the number of days between water applications and requires data on the soil type and root depths of the crops. The average depth to water table in the El-Hammami area was determined by Field Team members to be 63.5 cm. Therefore, this becomes the approximate rooting depth. Also, most of the moisture will be supplied by this depth on most crops. The general range of available moisture-holding capacity for sands is 0.06 mm per mm of depth.[3] The net irrigation requirement at 50 percent moisture level is 0.06 multiplied times 635 mm multiplied times 0.5 equals 19 mm for the total depth. The irrigation frequency is computed by dividing 19 mm by the consumptive use in mm per day (Table 1). The results are shown in Table 2 and Fig. 4. Since all crops have to be irrigated at the same time, the minimum irrigation frequency in days was chosen as the time for each 10-day period. Therefore, when to irrigate is determined by adding the minimum irrigation frequency in days to the previous date irrigation began. The gross amount of water to be applied is the consumptive use by the crop multiplied times the irrigation frequency multiplied times the crop area to be irrigated and divided by the combined efficiency of the system. The efficiency of the system is composed of water application efficiency (farmer's field) and conveyance efficiency (meska). The application efficiency for computing irrigation requirements was recommended to be 60 percent by Dr. Mona El-Kady.[4] This value of 60 percent will be assumed in the computer

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[2] Technical Report 17, "Consumptive Use of Water By Major Field Crops In Egypt," Master Plan for Water Resources Development and Use, Ministry of Irrigation, Arab Republic of Egypt, UNDP-EGY/73/024, March, 1981

[3] Engineering Field Manual, Soil Conservation Service, U. S. Dept. of Agriculture, Washington DC, p. 15-18, Table 15-1, Forth Printing 1984

[4] El-Kady, Mona, and Hanson, Eldon, "El-Hammami Irrigation Delivery System and Actions for Improvement," Working Paper No. 111, The Egypt Water Use and Management Project, The Water Research Center, 22 El Galaa St., Bulaq, Cairo, Egypt, July 1983 pp. 55

program. The conveyance efficiency will vary depending on the length of the meska (watercourse) and the condition of the meska lining. The conveyance efficiency will be input along with the data on outlet number, crop number, and crop area to be irrigated. The default value for zero input will be set at 85 percent for the conveyance efficiency.

HYDRAULIC COMPUTATIONS

The pipe-friction loss computations were made using Darcy-Weisbach friction factor f in formula:

$$h_L = f\ L/D\ V^2/2g \quad . \ . \ . \ . \ . \ . \ . \ . \ (1)$$

where h_L = head loss due to pipe friction
f = Darch-Weisbach friction factor
L = length of pipe
D = Diameter of pipe
V = average fluid velocity of pipe
g = gravitational acceleration

An empirical Colebrook formula is used to solve for f and forms the basis for the standard Moody diagram. The diagram is solved using a iterative estimator (Newton's method) developed by Crowley[5]. A computer subroutine uses this estimator to solve for Darcy-Weisbach friction factor f. The pipe roughness was assumed to be 0.00006 m (0.0002 ft.) and the kinematic viscosity was assumed to be 0.0000013 m/s (water temperature 15.6 C).

The energy losses in a pipeline due to bends, elbows, joints, etc. (called "minor losses") are taken as being directly proportional to the velocity head in the pipe or

$$h_{ML} = K\ V^2/2g \quad . \ . \ . \ . \ . \ . \ . \ . \ (2)$$

where h_{ML} = minor loss
K = minor loss coefficient
$V^2/2g$ = velocity head of pipe

[5] Croley, Thomas E. II, "Hydrologic and Hydraulic Computations on Small Calculators,"p. 746, Iowa Institute of Hydraulic Research, University of Iowa, Iowa City, Iowa, pp. 837, 1977

The following were assumed in the program:

Location	Minor Loss Coefficient "K"	Remarks
entrance to pipe	0.5	flush entrance
exit flow from pipe	1.0	velocity head loss
flow past a tee	0.3	
flow through a venturi	0.375	loss assumed to be 10 percent of differential head
contraction (1.2 ratio)	0.07	velocity head of smaller pipe diameter
alfalfa valve	$\frac{0.12755}{x^2}$	assumes discharge coefficient C=0.7, diameter of valve same as pipe diameter x= valve opening/diameter $0 < x < 0.25$
elbow, 90 degree	0.9	
elbow, 45 degree	0.6	
swing check valve	2.5	

The pump discharge versus head are shown in the top part of Fig. 2. Pumps A and C discharge characteristics are nearly the same and are shown as one curve. Data values for both curves were fitted to the equations shown by the method of least squares. These two equations (top part of Fig. 2) were used to compute the estimated combination pump discharge rates versus total head (energy level in pump stand minus water surface elevation El-Mansuriya canal "ENLPS-ELM"). Four equations (see Fig. 2) were developed for the various combinations using the method of least square. These four equations were used to estimate pump discharge rates for the computer program.

The system of operation chosen was with the valves fully open or completely closed. This system depends on time control to assure the delivery of the correct water amount to the field. The design flow was set at approximately 60 l/s flow rate from each outlet valve to assure sediment removal from the pipeline. To maintain 60 l/s flow rate, only six or seven valves can be operated at one time. Therefore, some order of scheduling must be set. Priority was given to the outlet requiring the largest

volume of flow. The outlet numbers were sorted into a set with maximum volume first and minimum volume last and irrigation was begun with the top six outlets. As the time required to fulfill the gross amount of water is reached that valve is closed and the next valve is opened. For each group of valves, an energy balance between the water surface level versus outlet discharge rate in each meska, corner stand, pump stand, and water surface elevation El-Mansuriya canal versus pump discharge is obtained by the program. This process is continued until all water requirements for that period is met. The system is operated between 7 and 14 hours per day depending on the total time to complete the irrigation. A full 24 hour day of operation is required when operating both pipelines from one pumping station in an emergency situation.

The output from the program is a tabular listing of pumps operating, total pump discharge, outlet valve number, valve discharge, time, crop, and date of irrigation.

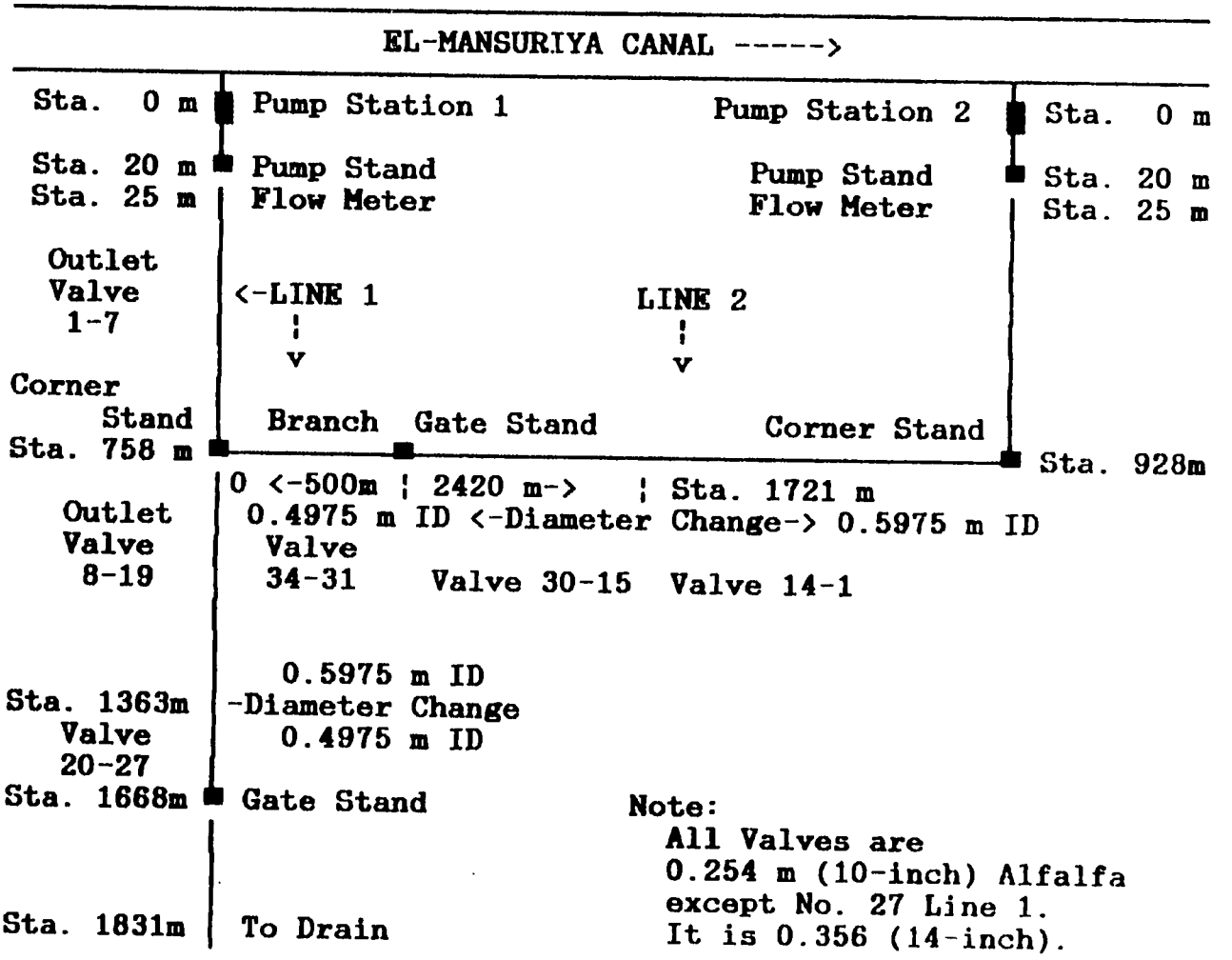
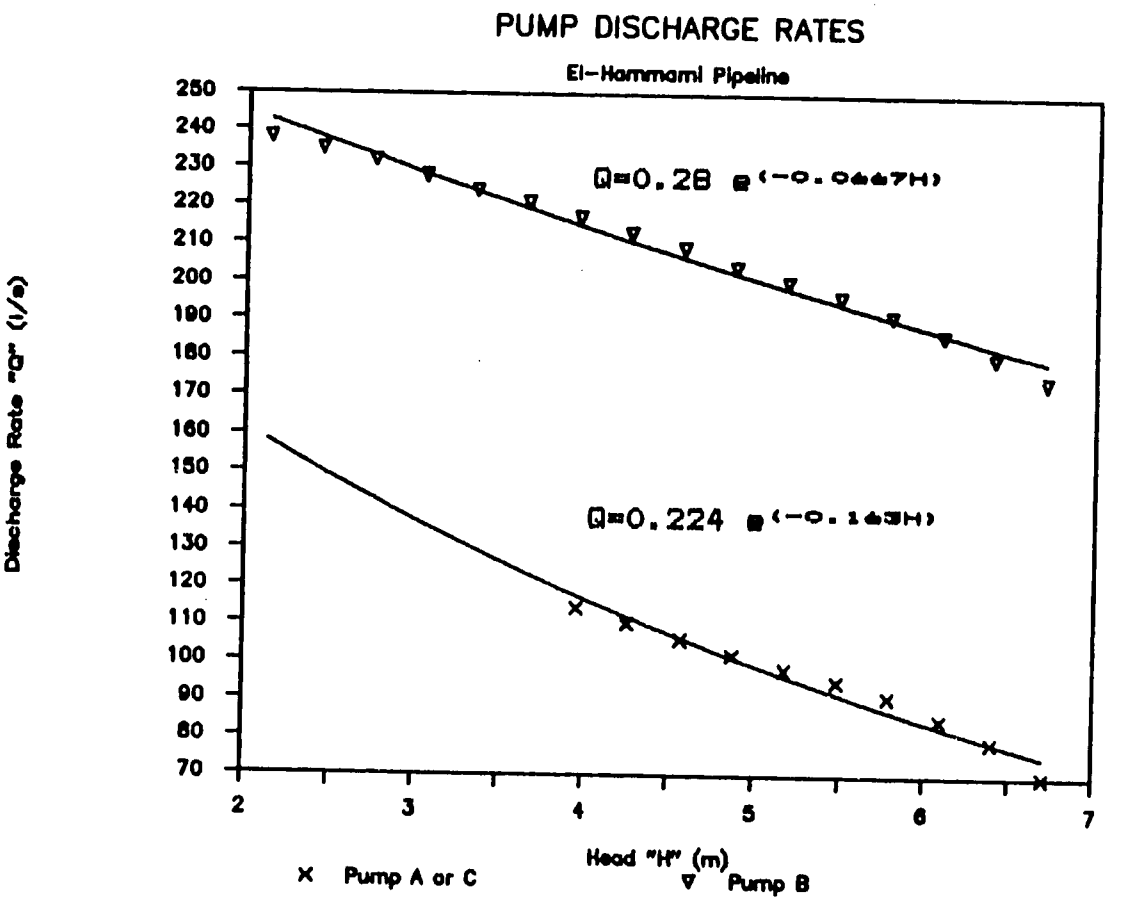


Figure 1.. Plan of the El-Hammami Pipe Line



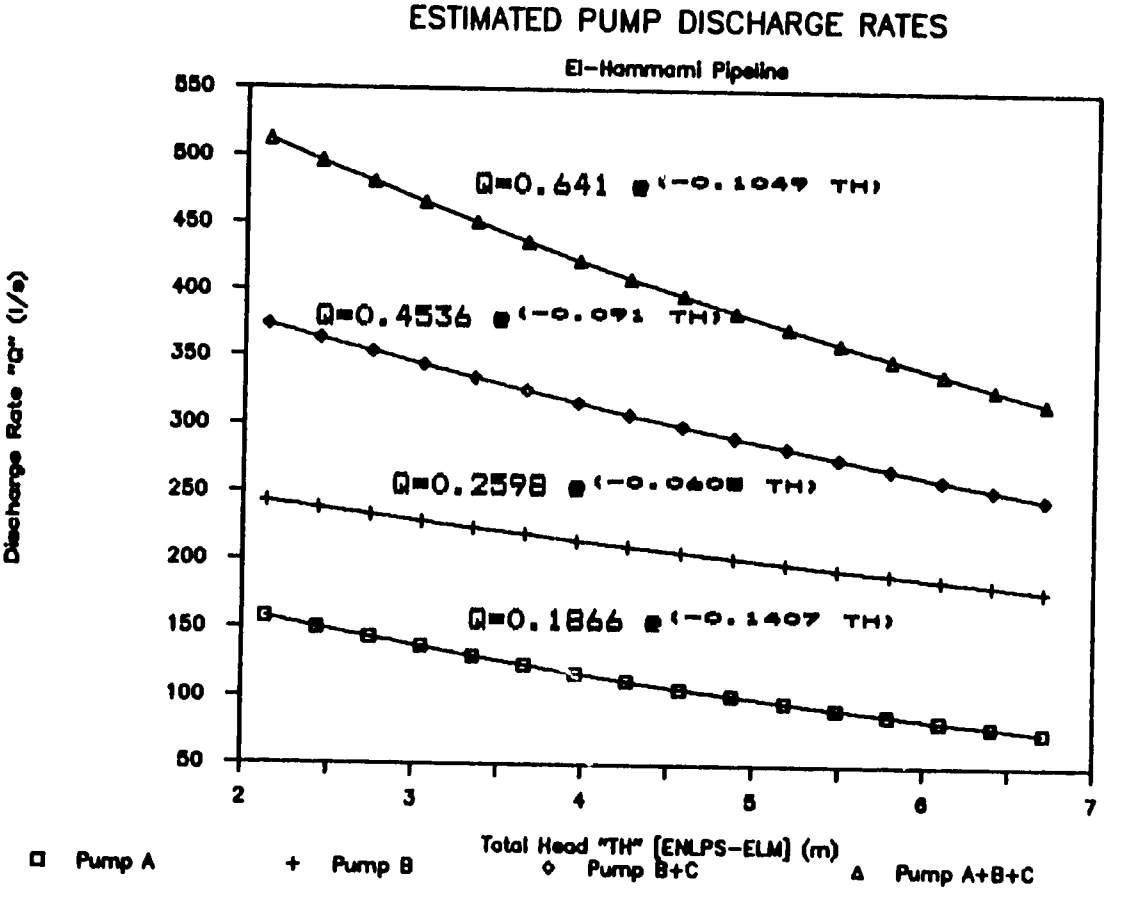


Figure 2._ El-Hammami Pump Discharge Characteristics

Table 1
Consumptive Use in mm/day, Giza, Egypt
Data from TR17 Water Master Plan

Crop	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.
Horse Bean	1.98	2.50	3.80	2.31							1.56	1.88
Citrus	1.16	1.71	2.31	2.84	3.81	4.40	4.28	3.77	3.27	2.62	1.78	1.30
Clover	1.79	2.88	4.12	4.99	4.04						1.70	1.97
Wheat	1.93	2.69	4.21	3.65	3.22						1.47	1.83
Nili Corn							4.17	5.10	5.68	3.98	2.07	
Summer Corn					3.07	5.17	7.48	5.24	2.72			
Cotton			1.90	2.92	4.87	6.61	7.24	3.31	2.37			
Average	1.72	2.69	3.27	3.34	3.80	5.40	5.79	4.35	3.51	3.30	1.72	1.75

Estimated 10-day Periods

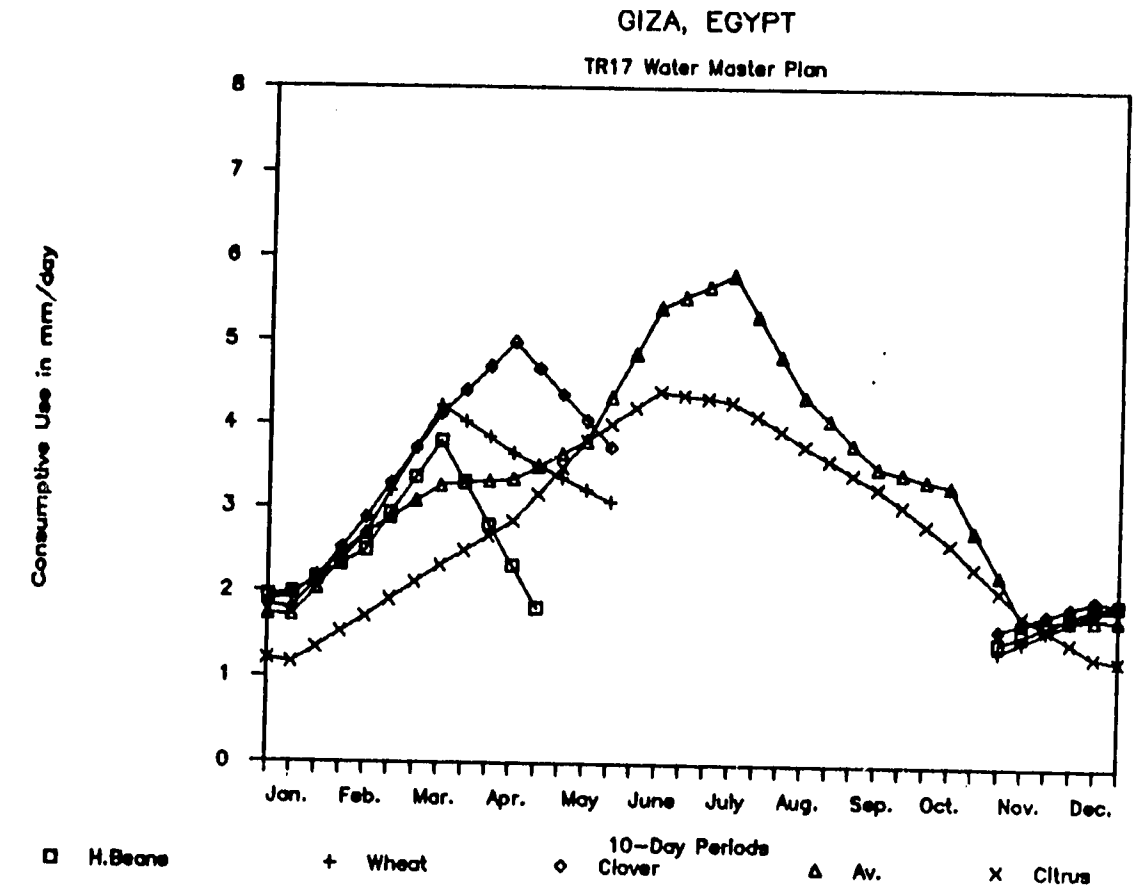
Month	Horse Bean	Citrus	Clover	Wheat	Corn Nili	Corn Summer	Cotton	Average
	1.95	1.21	1.85	1.90				1.73
Jan.	1.98	1.16	1.79	1.93				1.72
	2.15	1.34	2.15	2.18				2.04
	2.32	1.52	2.52	2.44				2.36
Feb.	2.50	1.71	2.88	2.69				2.69
	2.93	1.91	3.29	3.20				2.88
	3.36	2.11	3.71	3.70			1.56	3.07
Mar.	3.80	2.31	4.12	4.21			1.90	3.27
	3.30	2.49	4.41	4.02			2.24	3.29
	2.81	2.67	4.70	3.84			2.58	3.32
Apr.	2.31	2.84	4.99	3.65			2.92	3.34
	1.82	3.17	4.67	3.51			3.57	3.50
		3.49	4.36	3.36		2.37	4.22	3.65
May		3.81	4.04	3.22		3.07	4.87	3.80
		4.01	3.73	3.08		3.77	5.45	4.33
		4.20				4.47	6.03	4.86
June		4.40				5.17	6.61	5.40
		4.36				5.94	6.82	5.53
		4.32			3.86	6.71	7.03	5.66
July		4.28			4.17	7.48	7.24	5.79
		4.11			4.48	6.73	5.93	5.31
		3.94			4.79	5.98	4.62	4.83
Aug.		3.77			5.10	5.24	3.31	4.35
		3.60			5.29	4.40	2.99	4.07
		3.43			5.49	3.56	2.68	3.79
Sep.		3.27			5.68	2.72	2.37	3.51
		3.05			5.11	1.89	2.05	3.44
		2.83			4.55			3.37
Oct.		2.62			3.98			3.30
		2.34			3.34			2.77
	1.45	2.06	1.61	1.35	2.71			2.24
Nov.	1.56	1.78	1.70	1.47	2.07			1.72
	1.66	1.62	1.79	1.59	1.44			1.73
	1.77	1.46	1.88	1.71				1.74
Dec.	1.88	1.30	1.97	1.83				1.75
	1.91	1.25	1.91	1.87				1.74

Table 2

Irrigation Frequency In Days
Giza, Egypt

Average Depth to Water Table = 63.5cm
Average Available Water Holding Capacity (sand)=0.06/cm x 63.5=3.8 cm
Irrigate at 50% Available Water = 3.8/2 = 19 mm
Days = 19mm/(Consumptive use mm/Day)
Data from TR17 Water Master Plan

	Horse Bean	Citrus	Clover	Wheat	Corn Nili	Corn Summer	Cotton	Minimum	Averag
	10	16	10	10				10	11
January	10	16	11	10				10	11
	9	14	9	9				9	9
	8	12	8	8				8	8
February	8	11	7	7				7	7
	6	10	6	6				6	7
	6	9	5	5			12	5	6
March	5	8	5	5			10	5	6
	6	8	4	5			8	4	6
	7	7	4	5			7	4	6
April	8	7	4	5			7	4	6
	10	6	4	5			5	4	5
		5	4	6		8	5	4	5
May		5	5	6		6	4	4	5
		5	5	6		5	3	3	4
		5				4	3	3	4
June		4				4	3	3	4
		4				3	3	3	3
		4			5	3	3	3	3
July		4			5	3	3	3	3
		5			4	3	3	3	4
		5			4	3	4	3	4
August		5			4	4	6	4	4
		5			4	4	6	4	5
		6			3	5	7	3	5
September		6			3	7	8	3	5
		6			4	10	9	4	6
		7			4			4	6
October		7			5			5	6
		8			6			6	7
	13	9	12		14	7		7	8
November	12	11	11		13	9		9	11
	11	12	11		12	13		11	11
	11	13	10		11			10	11
December	10	15	10		10			10	11
	10	15	10		10			10	11



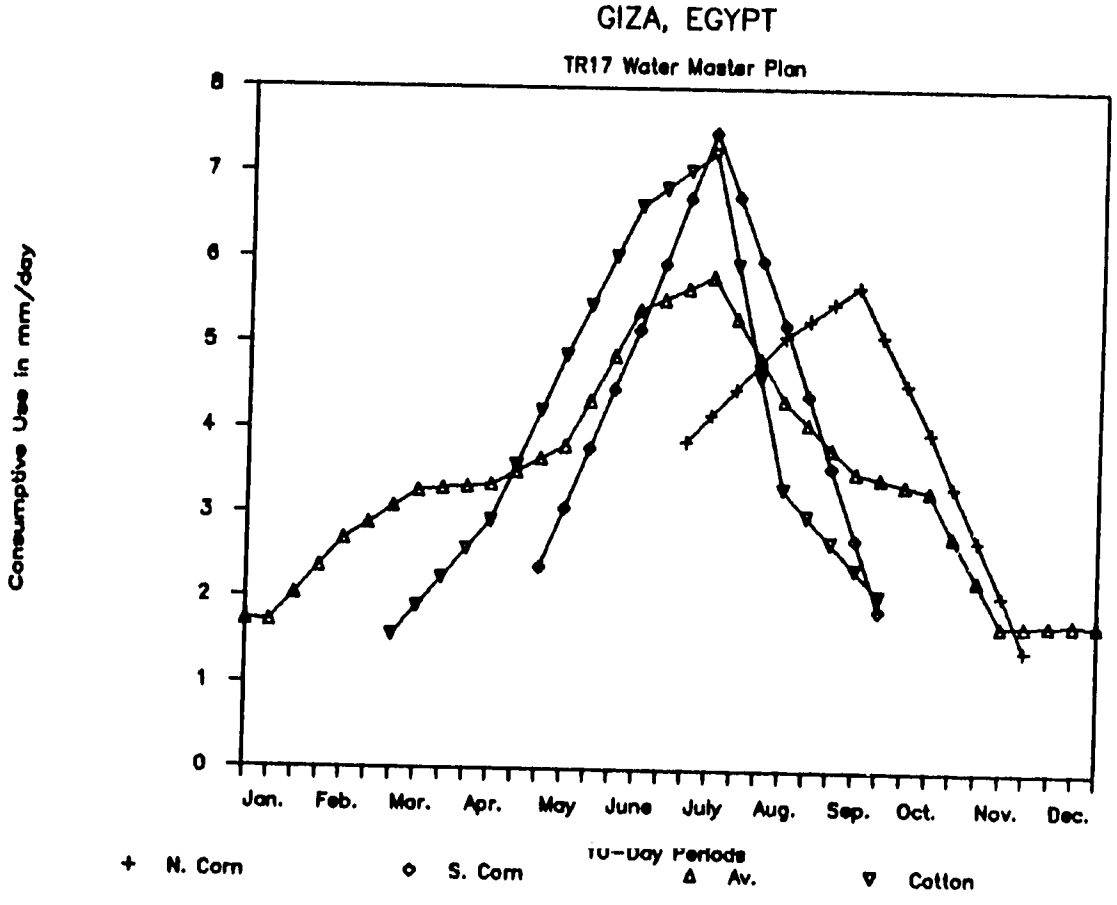
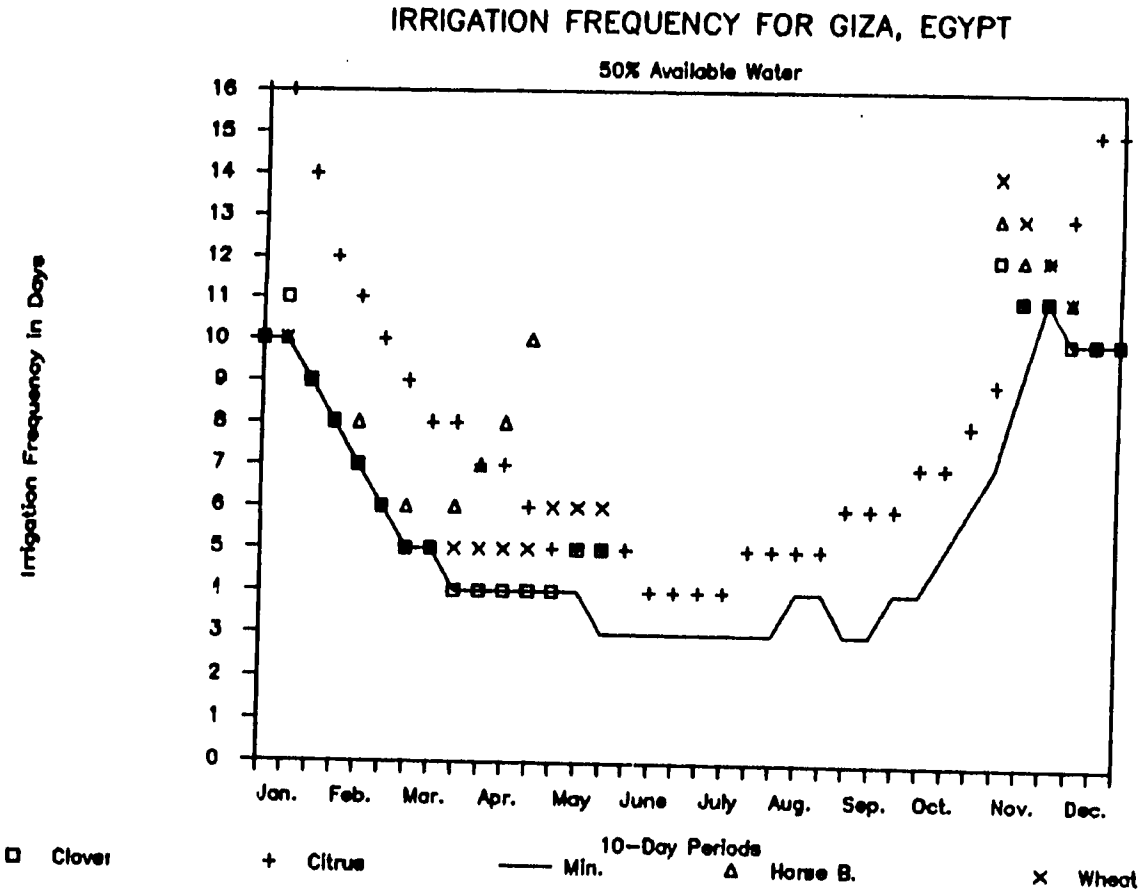


Figure 3.__ Estimated crop consumptive use for Giza, Egypt.



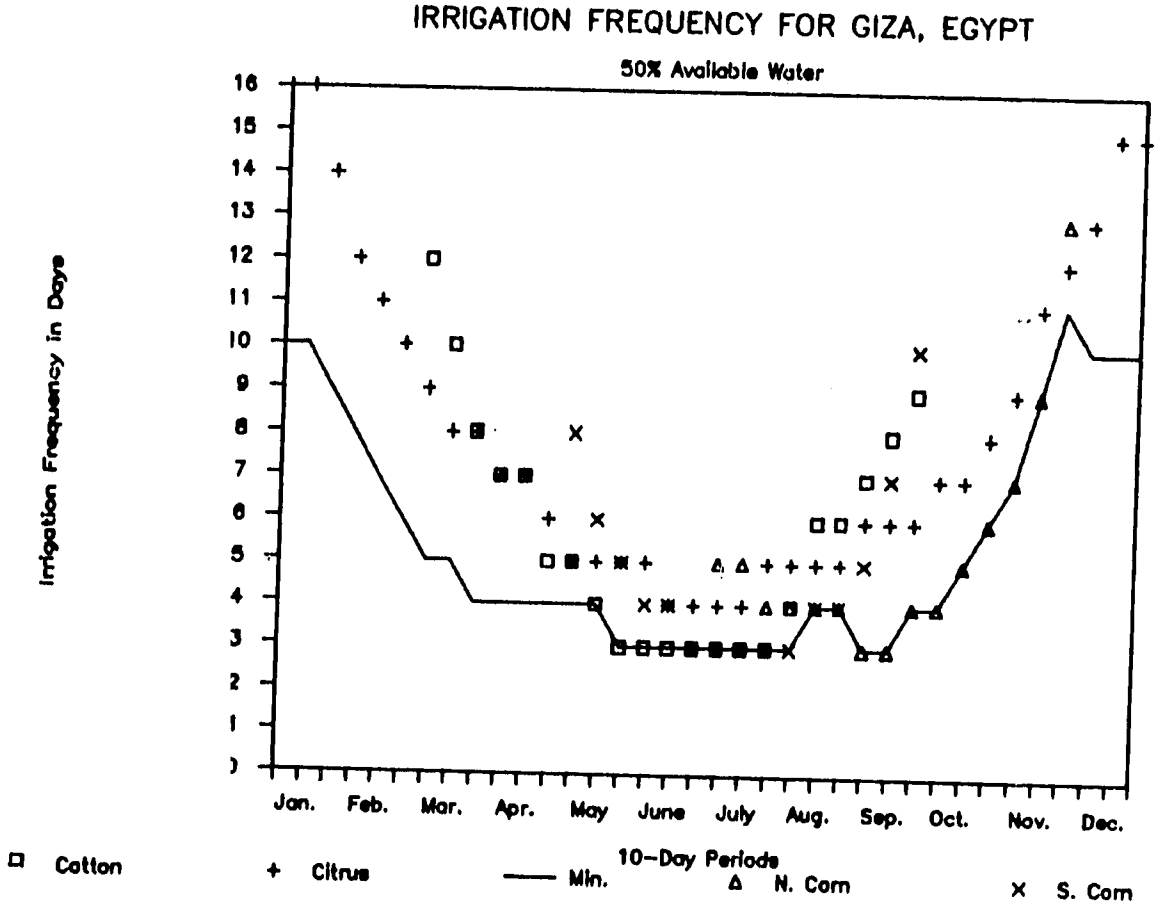


Figure 4.__ Crop irrigation frequency for sandy soil near Giza, Egypt.