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REPORT OF THE

EGYPTIAN IRRIGATION MANAGEMENT SYSTEMS

BY THE

USAID DESIGN TEAM

MAIN REPORT

Egyptian Irrigation Systems Operation, Maintenance, and Structural Replacement

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HILL
INTERNATIONAL
engineers
planners
economists
scientists

Requirements Contract No. AID/OTR-C-1618

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Ministry of Irrigation
Cairo, Egypt
and
USAID/Egypt

It has been a pleasure to work with the officials and staff of the Ministry and AID during the course of the Irrigation Management Systems design study. The team members: Richard V. Haapala, Robert B. Conklin, and M. J. Morgan wish to thank everyone involved with the project for the support that has been given. The assistance with transportation arrangements, data collection, and scheduling meetings has made the task possible to accomplish within the short time available.

With a continuation of the sincere efforts that have been demonstrated and many years of extremely hard work, the Design Team feels that Egypt has a very good chance of meeting its long term goals.

Sincerely yours,

R. V. Haapala

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IRRIGATION MANAGEMENT SYSTEMS

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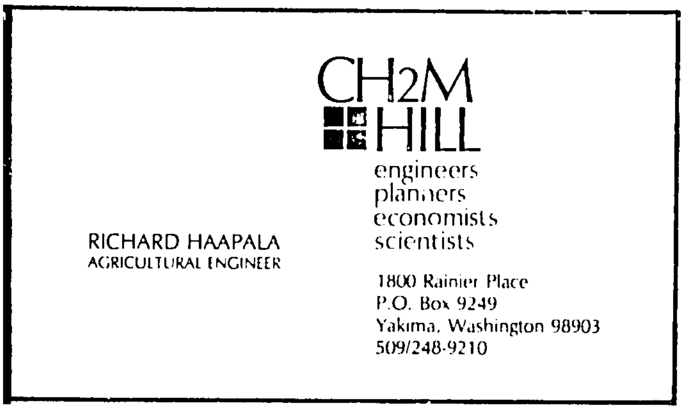

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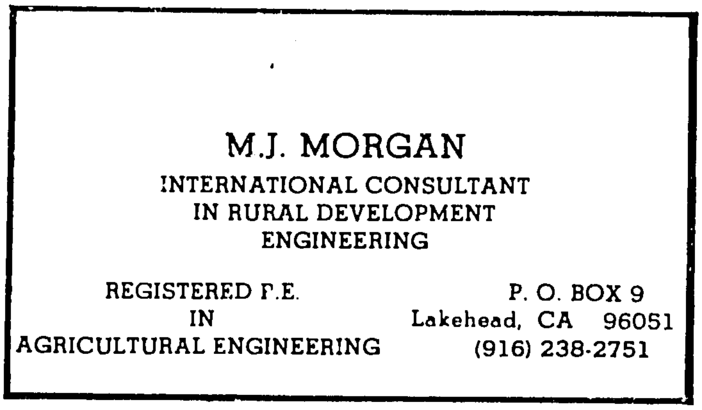

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EXECUTIVE SUMMARY

It is the objective of the Irrigation Management Systems program to identify and improve conditions that hinder efficient water resource utilization in the old lands irrigated area of Egypt. Only moderately sized structures are covered by the project. The Ministry of Irrigation (MOI) has had recent staffing deficiencies but has a significant engineering and management capability. A large backlog of deferred structural replacement is growing each year because levels of funding are not keeping up with the rate of deterioration. To eliminate the backlog and reverse the trend of deterioration approximately $100 million US are needed over the next five years. Manpower resources must be developed to implement current and future projects. Salary levels within the MOI need to be raised two to four times the current rates to attract and retain the needed additional staff. The project should be implemented slowly at first and build to higher rates rapidly as the staff can handle the load. Manpower must be utilized efficiently.

Projects within the Structural Replacement project must be prioritized to achieve maximum benefits. Current levels of expenditure need to be raised dramatically over the next five years so that the reconstructed system will not immediatel begin to deteriorate. The systems now used for fiscal control are applicable to the proposed project.

Designs developed by MOI are reasonable but could be modernized to take advantage of new materials and construction techniques. Alternative designs could save money. Egyptian engineers and technicians need more modern reference materials, survey equipment, drafting equipment, and office facilities. Standard design models for often used structures could improve design efficiency. Cost estimates prepared by the Design Team corresponded very closely with average costs developed by MOI. However, standards of construction do not meet Egyptian specifications in terms of quality. Therefore, the actual costs anticipated for acceptable levels of quality are approximately 50% higher than prices currently used by MOI.

Quality control at the job site needs to be monitored and enforced by competent engineers and technicians. At higher levels, an organization can be developed within the Planning Department to monitor both quality and progress of work.

Maintenance of the existing system is deficient. An internal capability to perform a limited amount of repair work must be developed. Water management suffers because of poorly maintained structures and canals.

Operational control of the existing system is achieved by monitoring water surface elevations. Better control could be achieved by controlling flow with respect to irrigated service area. A need for better communications at all levels within the MOI exists. A radio network should be established from the Districts to the Directorates. The existing network from Directorate to Cairo should be expanded.

A need for up to date aerial photographs of all of the irrigated service area exists and should be included in the program.

Studies in Gharbia Directorate and the North Zifta District will produce data that can be utilized throughout Egypt to improve water management and system improvements.

It is recommended that the project be funded at a large enough scale to remedy the current problems. It should be implemented as soon as possible with a commitment from MOI for continuing future maintenance. Programs of radio communications and aerial photography should be added to the project.

INTRODUCTION

It is the objective of the current Irrigation Management Systems program to rapidly identify and improve facilities and methods that impair efficient water management in the presently irrigated old lands of Egypt. The program is targeted toward currently operating organizations and replacement of badly deteriorated moderately sized structures that are dispersed throughout Egypt. Large irrigation water control structures such as the Nile Barrages and main canal regulators and facilities to serve new lands are anticipated to be funded under other programs by various agencies and will be evaluated in separate studies.

By concentrating the current project's structural rehabilitation and replacement component upon the mid-sized facilities, large benefits can be obtained over a short period of time. Increased agricultural productivity and better utilization of the water resource will result.

Existing Systems

The Ministry of Irrigation (MOI) has the financial responsibility of maintaining all irrigation works down to the level of the intakes to the privately controlled meskas (small farmer operated canals). The system of irrigation canals and drains is complex and has evolved over a period of many years. It is functional, but in many aspects is not as efficient as it could be. With a relatively small expenditure in relation to the value of the irrigation system to Egypt, it is possible to restore the system to a more efficient state. Potentially, large quantities of water could be saved. Egypt has enjoyed an adequate supply of water that has far exceeded the demands. In the past, especially, since the construction of the High Aswan Dam, the excess water resources have not demanded or inspired diligent water management programs. Consequently, many of the irrigation and drainage facilities have not received the attention needed. The difficult years of turmoil resulting from the wars have also contributed to the system neglect and have been a drain on the available resources.

The facilities are in need of much work and a limited amount of system redesign may be in order. An imminent threat of total collapse, as suggested in the PID, does not appear to exist. Facilities in Egypt are of all ages. Many are now at the end of their useful life and quite expectedly are showing signs of severe deterioration. This is a process that has been occurring for years. Under the current levels of maintenance and replacement, the condition is declining. The rate of degradation is slow but progressive and although it poses no threat of immediate catastrophic failure, it must be reversed. The system is functioning, good crops are being produced, and an operating organization within the MOI exists.

MOI Capability

Over its long history, the Ministry of Irrigation has been staffed with some of the most competent engineers in Egypt. In recent years, situations affecting staffing and budget have developed which now threaten to reduce the MOI's technical capability. Inadequacy of staffing levels and the resulting backlog of deferred maintenance work indicate that a need for improvement exists if the National objectives of making more efficient use of the water resources of the Nile are to be met.

Needed Program

A long-term program of increased operational and maintenance awareness at high administrative levels is needed.

To be successful this program will have to receive budgetary and administrative support from those who establish National priorities at the highest levels of the Egyptian Government. Adequate long term funding and staffing must be provided.

Since much of the work to maintain and efficiently operate the facilities has been deferred in recent years, an agressive program is needed. By committing substantial efforts to irrigation and drainage at this point in time, serious food production short falls that have been predicted may be avoided.

Initially, investments of fairly large sums of money will control the country wide general degradation of quality of the facilities. Once the trend of deterioration has been reversed, continued maintenance funding at higher than present levels will result in improved operational efficiency of the system.

The currently proposed project will result in significant structural improvements coupled with efforts to improve operational control, improve system maintenance, and enhance training. Following this, efforts will be needed to continue the work indefinitely at much higher levels of funding than are now budgeted.

STRUCUTRAL REPLACEMENT

The 5-year program in the order of magnitude of $100 million of accelerated structural replacement of moderately sized facilities should be implemented to eliminate the backlog of deferred maintenance that has accumulated over the past years and raise the level of annual replacement to the required level for sustained operation. The MOI has prepared a prioritized program that has been judged by high level Ministry leaders to provide a solution to the deferred maintenance problem. The structural replacement component of this program as proposed by MOI is shown in Annex B, Table 1. Review of the proposed program by the USAID Design Team verified that the type and general nature of the structures that have been included in the program are needed. This program, if pursued aggressively and financed accordingly, should bring the system back to a stabilized condition. As indicators of the adequacy of the structural replacement program, the standard plans, cost, and proposed location of sample facilities were evaluated. Significant improvements in the system will result if the recommended program is followed. Staffing patterns and capabilities of the MOI to implement a major strucutral replacement program were investigated

Manpower Development

Serious deficiencies currently exist within the MOI in the area of manpower. The current level of staffing potentially will limit the implementation of the structural replacement program. Long term impacts upon other aspects of the Ministry's operation will also be felt unless changes are made in the effective utilization of engineers. However, the most immediate crises will occur in the structural replacement program because of the magnitude of the proposed project.

With a gradual implementation of the project, it will be possible and within the capability of the MOI to readjust and increase the engineering and technical staff levels. An active training program has been proposed by the USAID Design Team to serve as a catalyst to provide the needed qualified personnel and is presented as a separate document. This training program outlines the programs needed. The program proposed will offer long term solutions to some of the problems within the MOI. However, the rate at which the program can be implemented will limit the impact of the training upon the first part of the structural replacement work. To meet the overall objectives of enhanced irrigation management, it will be necessary to begin implementaiton of the structural replacement before a large number of trainees can complete the courses of instruction. Since some engineers are already highly skilled, they can be used during the project startup period. Lack of trained engineers cannot be accepted as justification to delay project implementation.

Coupled with the training program, a means to attract and retain competent employees is needed. Current salaries and incentives have not proved adequate to attract and keep sufficient numbers of employees. This is evidenced by the high vacancy rates. Of the authorized 1392 engineering positions within the Irrigation Department, only 707 are filled. Recent evaluation of future needs by MOI has indicated that the 1392 engineers will be adequate for the next five years. The increasing trend of engineers and technicians moving toward public and private sector companies as well as to overseas employers has left a void within the MOI. The salary structure within the Ministry is so unattractive that highly trained and qualified engineers have taken positions in the private sector in nonengineering occupations to substantially increase their income. These engineers indicate that would only return to the engineering field if the salaries were two to four times the present levels. Until that financial incentive becomes a reality, staffing will continue to be a problem. A similar deficiency exist at sub-professional levels. Again, the same remedy is needed. A large manpower resource exists in Egypt today. Therefore, with proper incentives the staffing needs can be met quite rapidly.

To be successful, the incentive program used to initially attract employees into the system must also serve to provide continuing motivation to old and new employees alike. It is suggested that a program of annual incentives based upon quantity and quality of performance be initiated as soon as possible. To provide maximum, continued long-term motivation the employee's performance must be rewarded each year independent of past history. The annual "bonus" payments should not become automatic since the motivational value will be lost.

Manpower Utilization

Qualified engineers and technicians currently working for the MOI should be used in positions for which they are best suited. For example, the extensive amount of time District Engineers spend surveying could better be spent in overseeing the operation and maintenance of the irrigation system, designing new facilities, or inspecting construction projects to assure quality control. Trained irrigation technicians should be utilized to relieve the engineer of many of the sub-professional duties.

The time spent by engineers in developing drawings for draftsmen to trace is not the most productive use of the engineer's or draftsmen's time. Trained drafting technicians should be used to complete the drawings from sketches developed by the engineer. The drafting technicians' efficiency and output could be increased by use of modern tools, equipment, and supplies.

Definite efforts must be made by all managers within the MOI to assure that all levels of employees are used at the highest skill level possible. Not only will better manpower utilization result, but the employees will be motivated by the challenge.

Qualifications of Manpower

One comment frequently heard from engineers throughout the MOI was that they felt that there was a lack of practical experience and exposure to new engineering techniques after graduation from the University. To help overcome this problem, a short course of study in new design methods is being developed within the training component of this project. This course will ultimately be offered to engineers at all levels of the MOI. A program of establishing libraries with adequate reference material available to all levels of engineers within the MOI must be developed (see Annex A). There is very little evidence of adequate libraries of technical books, manufactures catalogs, technical society publications, or trade magazines in many of the MOI field offices. Without this reference information, the engineers find it difficult to be sufficiently informed and aware of the alternate design methods and recent engineering innovations. This problem extends to the University libraries where adequate reference materials are not always available to the students.

To overcome the lack of available information it is recommended the following steps be taken:

1. All engineers and technicians should be encouraged and if possible aided financially to join at least one technical society such as the Egyptian or American Society of Civil Engineers.

2. Provide technical libraries at the Inspectorate level containing the following types of material (see Annex A):

    a) Technical reference books
    b) ASCE publications and magazines
    c) Current manufactures catalogs describing types of materials and equipment used by the MOI
    d) Subscribe to Engineering New Record (ENR)
    e) Standard specifications

The above list is only a small sample of material available in the United States. Other countries have similar information available. Engineers at all levels in the MOI should be encouraged to provide input to help determine which materials should be obtained to update and improve the libraries.

Familiarity with the technical information mentioned above will make the engineers aware of new innovations in engineering design, materials selection, and quality control used construction projects. This data resource coupled with the courses presented in the proposed training program will give the engineers more practical exposure that they need and have requested.

The engineers in the District and Design offices appear to be well versed in the technical aspects of project design.

They seem to be very knowledgable of the engineering factors which are required to technically analyze the various components of a system. Selected MOI plans were reviewed by the USAID Design Team. They were found to be of reasonable quality and have adequate detail for construction. MOI specifications from the contract document for the Tender No. 8/1979-N.M.D. 3A for the Construction of the Nubaria Main Drain were reviewed. These represent the type of document from which quality construction could be achieved.

With the type of training proposed and the capability of the Egyptian engineer to design and produce high standard plans and specifications, there is no reason to believe that quality construction can not be achieved in Egypt if it is so directed and supported.

Prioritization of Projects

Since deficiencies exist throughout the entire distribution system, a logical system must be developed to assign higher priorities to work that will produce the greatest amount of benefit. Two factors of primary importance are the impact that each structure will have upon water management and the size of the service area affected by the structure. It becomes readily apparent that hydraulic control structures serving large areas should be assigned a high maintenance or replacement priority. Structures such as bridges that may have very little effect upon water management should be given lower priorities. It must however be recognized that certain non-hydraulic structures like bridges may have significant implications upon efficient water control. For example, a bridge that collapses may obstruct a canal for a period of time sufficient to cause crop damage. From another point of view, adequate bridges facilitate the movement of water operating personnel as they control the system.

The overall impact to water management must be considered when the criteria for establishing priorities are established.

By directing the system improvements to a "macro" level, the potential for greater benefits exists at the lowest unit cost for improved water management. Initiating a rehabilitation project under a "top-down" arrangement allows the system to continue functioning at an ever increasing efficiency with minimal disturbance to the water users. As each subordinate level of structures is improved, the water management capability in all of the area served increases. This has the effect of giving each water user better water service and more confidence as the system develops. Farmers with a reliable and controlled water supply are generally more productive and better disciplined. With definite schedules and flows, self instituted water user organizations are more likely to develop. Such an acceptance of organization is only possible when the members have something of value to gain from the association. Under these conditions, both the success of the irrigation discipline and the farmer unity become self perpetuating without external intervention.

Several field trips by the USAID Design Team covered the East Delta, Central Delta, West Delta, and Middle Egypt. Although the trips were of short duration, it is evident that the condition of facilities throughout the area is fairly uniform.

Data provided by the MOI which show the anticipated 1981 price level costs for the proposed structure replacement program was compared to the service area and canal length for each Directorate. The average cost of the project would be approximately LE 6 per feddan and approximately LE 1500 per kilometer of canal. There are very large variations in these costs from one Directorate to the next. The range is from LE 0.34 to LE 15.66 per feddan and from LE 62 to

LE 6203 per kilometer of canal. Although a certain amount of variability is anticipated, the magnitude of the cost differences would suggest the amount of work and possibly the nature of the projects throughout the area is not equally balanced. This would imply that the nationwide set of priorities should be evaluated for uniform application to all areas.

Budgets and Financial Control

Budgets of the Irrigation Department have been compared to the proposed strucutral replacement program. When the levels of previous spending are compared to the suggested annual capital replacement cost as shown in Table 7 of the Water Master Plan Technical Report 20, it becomes apparent that the previous levels of spending fall short of the needed levels. Basic data from MOI is contained in Annex B of this report.

Evaluation of the level of funding suggested by MOI for the proposed strucutral replacement program indicates that scope of work will meet the physical needs. However, the level of funding is likely to fall short of the actual costs. To obtain the quality of construction described in the MOI specificaitons it is estaimted that the costs should be increased approximately 50%. Additional increments should be added to account for contingencies (25%) and inflation (15% per year).

At the proposed rate of increase in construction within the MOI, the work probably could be undertaken by Egyptian private or public sector companies without any difficulty. If the work is undertaken too rapidly there is a possibility that the contractors' capability will be exceeded.

The currently operating system of financial control used by the MOI will adequately control the flow of funds. A monthly progress report is submitted by each Directorate to the Planning Department. After evaluation and consolidation, the data is presented to the Minister of Irrigation. With a report preparation time of about 10 days, the capability to monitor the financial aspects of projects is quite adequate. Members of the Planning Department staff have indicated that the structural replacement project will create no problems or excessive workload if it is managed through the existing financial control system.

Evaluation of Designs

Standard designs which are currently being used by the MOI were evaluated by the USAID Design Team. Representative structures which are similar to the ones that will be used in the strucutral replacement program were studied.

The basic designs were found to be substantiated by properly executed engineering calculations. Engineering assumptions made generally tend to be on the conservative side. Considering the long expected life of irrigation structures, it is not unrealistic to be somewhat conservative since many conditions will change over a period of years. It is because of certain conservative assumptions and reasonable factors of safety and high quality materials and workmanship that many of Egypt's older structures are still operating. Many structures have outlived any reasonable anticipated life; yet they are still functional. This presents a very strong argument for adequate design and good quality construction.

From the engineering work that was checked, the USAID Design Team is confident that the Egyptian engineers are capable of proper design techniques. It was found that the efficiency of the engineers could be increased if they had access to better reference libraries, better office working conditions, more specific standard design criteria, and technical support.

Alternative Analysis

Aside from the basic design talents of the engineers, it was found the MOI designs could be improved by placing more emphasis on alternate materials selection, and construction techniques. Creative new ways to solve problems are not always pursued and too often, new structures are designed just like the old ones.

The engineers should be encouraged to investigate alternatives in design. This will ultimately result in better quality structures at the least total cost.

Drawings and Designs

Drawings are presently prepared by the engineer and traced by the technicians. These drawings should be completed by draftsmen from sketches prepared by the engineer. This will increase the productivity of the engineers. The draftsmen desperately need more modern working spaces, tools, equipment, and supplies.

Drawings should be made on a more durable material such as mylar plastic film for good reproducibility and extended storage life. Drawing sheets should be standardized. The A-1 metric sheet size (594x841mm) has proven to be very workable.

Modern storage and retrieval systems are needed at all levels of the MOI for document and technical information.

Reproduction equipment for plans and documents is needed at all levels including the District Engineer's office.

Standard Designs

Model plans and specifications should be available in each District Engineer's office and MOI design office. These should include the criteria used in the development of the models and sample calculations. Guidelines for use of the standard models should be included with the documents to assure proper application.

The currently used designs have not been developed into drawings and instructions of standard format. To insure uniformity of application in all parts of Egypt the standards must be developed and distributed to each District Engineer and design office.

Cost Comparison

The costs developed by the MOI for the structural replacement program were checked by making a detailed cost analysis of a typical structure using current Egyptian construction costs. A standard bridge with a 7 meter span was used as the typical structure. Unit costs of construction were obtained from engineers in the field. A price of LE 50 per cubic meter for brick and plain unreinforced concrete in place and LE 150 per cubic meter for reinforced concrete in place were used. The total cost for this bridge, including excavation, backfill, and pitching, (erosion protection) was estimated to be approximately LE 14,000.

From the data in the Annex B table 1, "Cost of Rehabilitation/Replacement of Irrigation Structures by Directorate (1981 Prices)", developed by the MOI the average cost of

1736 bridges was about LE 14,000. Although there is a great amount of variability in the average costs for structures from one Directorate to the next as shown in this table, the calculations substantiate the nationwide average costs at the present qualities of materials and workmanship.

However, the plans and specifications presently being used by the MOI require qualities of materials and workmanship much greater than those being achieved on recently constructed projects observed by the USAID Design Team. If the unit costs of the cost estimate calcultions are increased by the appropriate amount to obtain the specified quality of brick and concrete, the total cost of the 7 meter span bridge would be increased about 60%. This increased cost and quality could be expected to develop the full design life of the bridge.

An alternate design suggested by one of the MOI design offices was also analyzed. In-lieu-of the brick and concrete abutments and wing walls, a reinforced concrete cantilevered retaining wall was investigated. The cost of this type of construction was found to be about equal to the brick and concrete abutment noted above. However, only approximately one-half the amount of concrete was used.

Approximately 25% of the items listed in the MOI table (Annex B, table 1) do not use extensive amounts of reinforced concrete. To raise the quality of all structures to the level indicated in the present specifications a 50% overall price increase is needed.

From the above analyses it is evident that significant long-term cost savings can be achieved by increasing the quality of construction to the currently prescribed levels and performing adequate investigations of alternative designs.

Computations of the cost comparison are shown in Annex C.

Evaluation of Contract Documents

In order to assess the suitability of contract documents that have been produced for projects in Egypt, two recently produced sets of documents were reviewed. Both sets were printed in English and were reported to be representative of typical Egyptian documents by the MOI. The first document reviewed was for the construction of the "Nubaria Main Drain," Tender No. 9/1979-N.M.D. 3A which was prepared by the MOI Drainage Authority. The other document was prepared by the Horizontal Expansion Sector of the MOI for the El Salam Canal Project.

Each of the documents contained sufficiently detailed specifications to require a contractor to construct a high quality project. It is the opinion of the USAID Design Team that this quality of specifications would be adequate for the structural replacement project.

Through a process of standardization it will be relatively easy to produce good specificaitons for all jobs. The standardization will facilitate project implementation by making it easier for the contractor as well as the engineer to know precisely what is to be done with fewer disputes.

A well developed system of bid advertising, evaluation of bids, and contract award exists. Although the mechanism is established and operating, it appears that some contractors are producing substandard work. This appears to be a contract administration or inspection problem rather than a defect in the documents. Engineers in the field indicated that it is difficult to find sufficient time to be on the job site during all critical operations. Staffing shortages and training deficiencies may contribute to the failure to fully execute the work with respect to the specifications. It is the opinion of the USAID Design Team that with direction from higher levels of authority in the MOI, that the specifications would be enforced.

Construction drawings were evaluated for several types of structures. They appeared to be complete enough to give the contractor the direction he needs to build the project. Most of the drawings were of nonstandard size and the originals were drawn on vellum paper. The use of standard A-1 metric sized sheets of mylar plastic film would produce better quality easier to use plans.

Facility Mapping

A need exists in the MOI for current, accurate maps which show detailed information describing the irrigation and drainage system of Egypt. The present 1:25,000 scale topographic maps were produced in the 1940's and are nearly useless for current detailed project planning. A program has been proposed to the Survey Authority to produce 1:10,000 scale aerial photography of the entire irrigated service area. This work would serve many purposes for Egypt and should be strongly supported.

The maps would enable the MOI to more accurately determine the irrigated service area, develop water management plans, and layout structural replacement programs.

Map sheets using photo imagery could be produced on mylar plastic film to yield a very useable and easily reproduceable planning tool.

Copies of the standard A-1 metric size sheets could be distributed to all levels of the MOI. Since the maps would be easily reproduced with a diazo process printer, they would be relatively inexpensive.

Project Construction and Management

Within the public and private sector, a fairly large capability for construction exists. Even though the MOI in its Irrigation Department organization does not have a construction branch, it does have engineers that can be used to supervise construction activities done under a contractual arrangement if properly trained, guided, and motivated. Many of the engineers within the MOI need more practical experience in the construction field. For that reason, the training program that is being developed will provide practically oriented construction management courses.

Both public and private sector companies have successful records of building structures similar to those proposed for the structural replacement program. Most moderate to large sized constructors have the capability to execute good quality work that would meet the MOI specifications and the Egyptian Code of Practice. However, no contractor can be expected to automatically follow the specifications unless there is an established process of follow up. It is the MOI responsibility to provide this follow-up and construction inspection.

At the current time there is a large uncomitted contractor work force. Therefore, the structural replacement program could be implemented quite rapidly. Within realistic levels of project funding it does not appear that contractor related problems will be a constraint.

Construction Practices

The selection of materials for the irrigation facilities continues to follow the practices used for facilities installed over the past 50 years. Modern corrosion resistant materials and coatings are not being fully utilized. Engineers in the field have frequently expressed the feeling that Egypt cannot afford the new construction methods and materials. If the MOI wants a modern and long lasting system, as most economists claim is ultimately the least expensive alternative, the use of 20th century methods and materials is essential. Egypt is going into the 21st century with the rest of the world. The excuse that progress is too expensive or cannot be obtained is no longer acceptable or realistic. In fact, the use of good materials and quality control of construction could ultimately make the system costs lower than current costs due to the increased life and performance of the system. In many areas of Egypt, contractors are successfully producing high quality structures with the so called "new" methods and materials. Therefore, the capability is presently in-country. The MOI can no longer afford the old ways. New and improved materials and construction methods must be demanded. The MOI must maintain their present high standards and require the contractors to perform the work in accordance with the plans and specifications.

As a specific example, the continued use of the soft, poor quality, common brick by the MOI for the construction of facilities is questionable. These bricks are made from the clayey agricultural soils of Egypt. Each year the nation is robbed of many thousands of cubic meters of their non-replenishable precious topsoil by this practice. An agency of the government concerned with increased agricultural production can not continue to perpetuate this practice which causes the depleiton of such a precious commodity as the topsoil, especially when the use of these low grade bricks will result in inferior quality strucutres. As an alternative, more extensive use of good quality formed reinforced concrete structures could eliminate this practice completely. Some practices which should change the quantity and quality of structures are as follows:

- Proper concrete mixing, handling, and curing
- Reusable forms for concrete work
- Mechanical vibration of concrete
- Precast concrete
- Better gradation of concrete aggregate
- Culverts in-lieu-of bridges where hydraulically possible
- Multi-function structures
- Rubber gasketed joints for pipe (USBR type R-4 joint)
- Corrosion resistant coatings on metal products
- Materials selection to suit conditions
- Progress control and scheduling
- Quality control by inspection
- Alternative gate designs

Quality Control

Each engineer involved in the quality control of construction projects should have adequate equipment to assure that the contractor is in compliance with workmanship requirements of the plans and specifications. These should include at least the following:

- Concrete testing equipment
- Soils testing equipment
- Paint thickness gauge
- Measuring and leveling equipment
- Camera
- Copies of standard specifications (Egyptian Code of Practice, ASTM, AWWA, etc.)

In each Directorate, there are large cities where good quality construction using relatively modern methods is being done. Therefore, there is a well dispersed existing pool of contractors capable of doing the quality of work expected on this project. Contractors who have a proven record of quality workmanship and timely completion of projects should be prequalified from this pool. The prequalification of contractors should be updated every six months to a year. The cost of labor is relatively expensive when compared to the basic cost of engineering. Therefore, anything in the design of a project that will reduce the labor costs should also reduce the overall project cost. Inflation is increasing faster than the incremental costs incurred by increasing the quality and thereby reducing the number of times a facility will have to be replaced in a given period of time. Ultimately, the increased structure life achieved through quality control and high quality standards will save money.

Implementation of Quality and Progress Control

To assure the MOI that both quality and progress goals are met, a system of control is needed. This can be accomplished on a system wide basis with minimal outside assistance by an extension of the responsibilities of the "Planning and Follow-Up" division of the Planning Department. This unit presently audits the financial progress of each project. It is essential that an organization outside the channels of project identification and construction be used to impartially monitor the progress of the work. Two aspects of a project's progress should be controlled. The quantity of work accomplished can be easily observed by conventional fiscal accounting that is presently used. Quality control at an equivalent level of authority is also needed. Weaknesses currently exist in this area, at the construction site level, especially in the construction of smaller structures. By expanding the "Planning and Follow-Up" division's responsibility, both quality and quantity of work can be effectively controlled.

Most of the quality control is and should be performed by the project engineer who monitors the contractor at the job site on a daily basis. However, a need to check the inspector exists. It is proposed that the planning department assume an aggressive role of periodic spot check inspections to assure that the specifications are being met at the project site. This "inspection audit" is necessary to keep everyone following the rules.

Such a program of spot checking will not replace any of the present inspection by the project engineer and certification by the Director of Works that is now being done. Feedback from this high level monitoring should be used to redirect the field staff's emphasis as needed.

MAINTENANCE

Maintenance of irrigation systems in Egypt has been less than adequate during the past 25 years. A variety of causes such as shortage of funds, abundance of water, and international uncertainties have contributed to the lack of emphasis on system maintenance. An extensive program of evaluating improvements to system maintenance is proposed for the Gharbia Directorate. The program is intended to provide insight into the problems so that solutions can be implemented throughout Egypt. (see Future Investigations Section).

Impacts on Water Management

The deterioration of facilities in Egypt have progressed so far that inoperative structures are beginning to hamper water management operations. The problem has developed through a series of unique circumstances. During the 1800's, a rather efficient irrigation system was constructed to make maximum utilization of the available water resource. At that time there were shortages and it was important to manage the water. Since the structures were needed on a regular basis, they were operated and of necessity maintained. When the High Aswan Dam was completed, the water supply became very abundant. Little regulation of the canals was needed so long as there was water to waste. Consequently the structures were not operated and maintenance was neglected. Now, with an expanded agricultural economy, water is again in limited supply. The neglected facilities cannot be operated and water management suffers.

MOI Organization and Responsibility

The MOI has the responsibility to deliver water to all the land within the developed projects. Hence, there is a responsibility to maintain the facilities. Maintenance capabilities at the District level are very limited and usually require the services of a contractor. Progressing upward through the organization, each superior organization has an increasing maintenance obligation. Relative to the maintenance needs, the capabilities within the MOI to directly perform maintenance work are severely limited. More in house capability is needed. The work that is presently done on structural repairs is generally performed by a contractor and in only undertaken when a structure ceases to function.

A need exists to increase the maintenance skills of the MOI staff. This problem is addressed by the proposed training program. To increase the capabilities of the operating units a certain amount of workshop equipment is needed. (see Annex D).

Workshops

To perform manufacturing the maintenance work, the MOI has established a system of workshops. At the national level a very complete facility for manufacturing and repairing mechanical equipment and vehicles exists. The irrigation workshop located near Cairo has very complete design and production capabilities. The work being accomplished there is centered around metal products including: machine work, steel fabrication, foundry work, construction equipment rebuilding, and automotive repairs. Even though the workshop is a Ministry of Irrigation controlled public sector company, the staff are relatively highly paid and motivated. The atmosphere is very similar to that associated with a profit earning private enterprise. A large capacity to support the needs of the irrigation sector exists within the workshops of Egypt.

The MOI has established maintenance workshops with very limited capabilities at both the Directorate (400,000 feddans) and Inspectorate (200,000 feddans) levels. A combination of limited funding, inadequate equipment, and low levels of staffing have resulted in the operating units (Districts) going to the private sector for shop support. Utilization of the private sector for some work is reasonable. However, a moderately capable "in-house" shop has the advantage of permitting rapid response to minor and moderately sized mechanical and structural problems with the added benefit of immediate reaction to emergencies. Under the current limited capability, it appears that minor system maintenance problems are deferred until they become significant enough to warrant hiring a private shop or contractor to make the repairs. This is an inefficient process and appears to have allowed an excessive amount of relatively minor deferred repair work to accumulate. The magnitude of this work has risen to the point where it is having an effect upon efficient operation of the irrigation system.

Both equipment and staff supported by adequate levels of funding are needed to remedy the problem. The workshops should be equpped to handle projects in the following areas:

- Patch and replace concrete
- Repair and replace masonry (brick and rock)
- Repair, adjust and lubricate gates
- Restore small earthworks
- Repair and apply protective coatings
- Repair and replace steel work
- Repair and install pipe

To accomplish these tasks the workshops should have at least the equipment shown in Annex D. Each shop must be staffed by a competent foreman, skilled craftsmen, and skilled laborers. The work must be accomplished under the direction (part time basis) of an engineer who is qualified in canal systems operation and maintenance.

Depending upon the particular needs of each inspectorate and the unique problems encountered in specific areas, it may be justifiable to build a workshop capability into the District level organization. At the present time no District workshops exist.

Caution must be exercised in establishing workshop capability within the MOI organization. It should be realized that the function of these shops is to perform minor and emergency work. They are not to become major construction organizations. The large projects are better left to the construction industry.

OPERATIONS

With a long history of relatively successful irrigation system operation, the Ministry of Irrigation has developed an organizational structure and procedures by which water deliveries are currently made. In the recent, past, since the availability of water has far exceeded the demand for irrigation water, rather casual water management procedures have been used. The current and anticipated future conditions necessitate more efficient resource utilization.

A detailed analysis of operations and maintenance is proposed to be conducted in the Gharbia Directorate as part of this project (see the Future Investigations Section of this report).

Current Practices

Irrigation systems are operated by a staff of skilled laborers supervised by pyramidal organization of engineers. Generally the irrigation water is delivered to any particular area on a scheduled rotational basis for eleven months out of the year. Depending upon the time of year and crop water requirements the rotation may vary from four days on with four days off to five days on and ten days off. Many modifications are made to the scheduling to meet the farmers needs. Within any portion of the system, the adequacy of the water supply is judged entirely by the water stages in the canals. No attempt is made to relate the irrigated service area and its crop pattern to measured flows within the system. Critical control points are monitored on a regular basis by a gate keeper who has been instructed to maintain pre-selected elevations by operating his assigned gate. Other water stages are measured early each morning by laborers and relayed in person or by telephone to the District

Engineer. Based upon the data collected, the Engineer makes an analysis of the water situation and directs the appropriate changes to be made. A report summarizing the conditions is sent up to the Inspectorate level by courier or telephone. The necessary adjustments to the inflows are made by the Inspector and other higher authorities as needed.

Communications

Theoretically the reporting system is intended to relay information up through the organization so that flow adjustments can be made rapidly. In practice, the difficulty of communicating by telephone and the long distances to travel slow the response of the system. More effective communications in the form of reliable telephones and radios would increase the productivity of all levels of supervisory personnel. At the present time, many laborers must leave their posts and travel to the District Engineer's office to report data and receive instructions. Telephone communications at prearranged times might reduce the lost time. Although the District Engineer is responsible for an area of approximately 60,000 feddans, he is totally out of communication with his superiors and subordinates when he is away from his office. Radio communications down to the District Engineer level would significantly increase the Engineer's productivity. At higher levels, a radio communications network is currently being installed. This MOI system should be expanded to allow all General Directors to be able to communicate with each other and the Ministry headquarters in Cairo. Annex E shows a suggested communications network.

Water Distribution

Equitable distribution of water throughout Egypt is dependent upon the operating staff's ability to quickly react to the changing needs within the system. The irrigated area has enlarged to the point where it is impossible for every water user to irrigate simultaneously. Therefore, control of the system is essential to insure that all demands can be met on a timely basis.

Data provided to the water managers by the laborers and technicians is one of the key elements to successful operational control. The present flow of data supplies only part of the actual needs. Communications problems discussed earlier introduce an administrative lag into the system and often times cause much effort to be expended to collect data and transmit commands. Aside from the communications problem, there is an additional area of weakness in the data collection process. Accurate flow measurements made on a regular basis (at least once per day) are needed throughout the system. The measurements represent the only accurate method to assess the fairness of water distribution. At each point where the rate of flow can be modified a measurement is needed.

Before the flow data will be useable for effective water management, accurate and up-to-date service area measurements must be available. Currently available data is quite old and many recent, sigificant changes in land use have been made. The unit duty of water at any particular time of the season must be adjusted for such factors as: type of crops, temperature, cropping intensity, and time of year. Guidelines can be established over a period of years by keeping orderly written records summarized by a short annual report. Accurate service area measurements are not available in Egypt today. Efforts to obtain aerial photography at a scale of at least 1:10,000 must be supported as mentioned in the Facilities Mapping Section. Until such data becomes available, the water manager (usually a District Engineer) should continue to make the best possible estimate of the area served. Even though such estimates are not 100% accurate, they at least make an attempt at water distribution based upon scientific principles.

In practice the idealized concept of flow measurements and service area analysis carried down to the lowest level of control becomes extremely burdensome to implement. As a beginning program it is suggested that moderately sized command areas be selected for the basic water management units.

When the initial system begins to operate smoothly, the size of the management units can be reduced. Better control and greater system efficiency will result.

FUTURE INVESTIGATIONS

To improve the level of operations and maintenance in Egypt it will be necessary to continue to evaluate methods to optimize system management. A program of evaluating operations and maintenance is suggested for the Gharbia Directorate. To focus on problems that may not be soluable by increased management alone, a system redesign project is recommended for the North Zifta District which is part of the Gharbia Directorate. The findings of these investigations may be applicable to other parts of Egypt with similar problems.

Gharbia Project

The proposed project to evaluate water management practices in the Gharbia Directorate will provide a beneficial service to the area as well as develop techniques that can be applied in other areas. The project will be best accomplished by an engineering contractor outside the Ministry of Irrigation. Close coordination with the MOI and utilization of experienced Egyptian consultants will permit an outside contractor to develop a rational program.

Both system operation and maintenance must be evaluated. The social, cultural, economic and technical aspects of the area will influence the project. Selection of the prime contractor should be based upon his ability to evaluate all aspects of water management in the Egyptian context. There will be definite advantages in using one contractor to perform the entire Irrigation Management Systems Program with this Gharbia Project as one relatively small component.

North Zifta District

In a similar but more specific project, a contractor would be selected to study various alternative water distribution systems in the North Zifta District. Again, the same contractor that is performing work on the Gharbia Project could provide vitally needed continuity.

RECOMMENDATIONS

1. It is recommended that USAID provide adequate funding so that the project can proceed as fast as the MOI staff and Egyptian contractors can accomplish the work. Due to the critical nature of the work to be done, the constraint of inadequate funding must be eliminated.

2. Each of the Technical Assistance positions established for this project should be paralleled with an Egyptian counterpart oequivalent technical training.

3. The MOI should immediately begin a program of structure evaluation and prioritization measured against a Nationwide set of realistic quality, condition and performance standards.

4. The program should be started as soon as possible, but at a relatively slow rate to permit orderly start up. It can then be accelerated quite rapidly. Sufficient expatriate engineering staff must be available and have sufficient authority to provide the needed guidance. A single engineering contractor is recommended so that program continuity can be maintained.

5. A firm commitment from the MOI should be obtained to assure that the rehabilitated system will be properly maintained and adequately funded in the future.

6. As separate projects or as part of this project both Aerial Photography and Radio Communications should be provided. Both will complement the other aspects of this project.

7. Maintenance workshop equipment should be acquired as early in the program as possible.

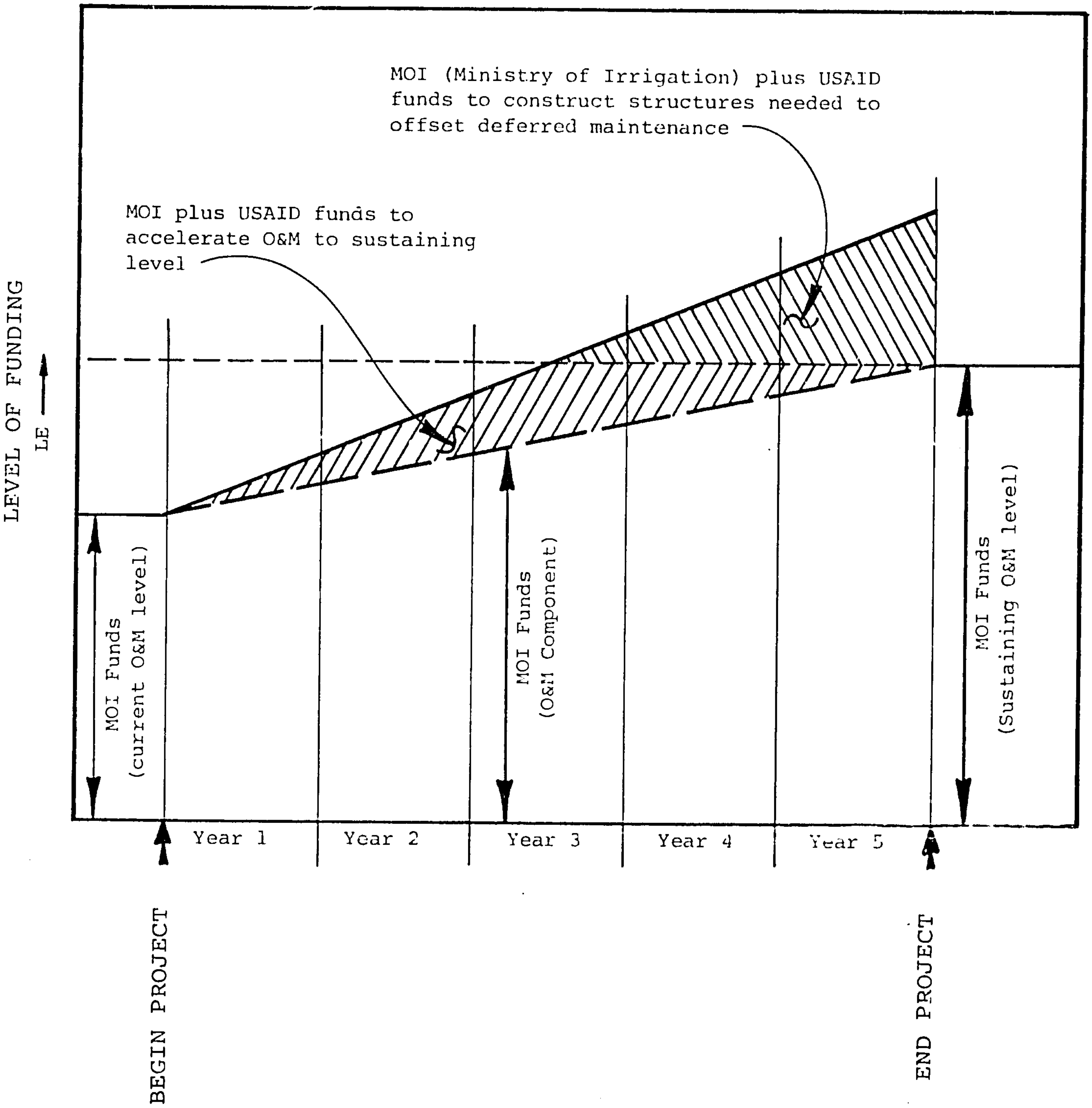
IMPLEMENTATION

The Irrigation Management Systems project should be implemented at the earliest practical date. Annex F describes the role of the expatriate consultant contractor and gives a proposed schedule. Annex F Tables 1, 2, and 3 were developed by the USAID Design Team for review by the MOI and USAID. After meetings with the MOI and USAID, held on May 11, 1981, several modifications were suggested and are incorporated into Table 4. No attempt to update Tables 2 and 3 was made since the organization shown in Table 4 may be further modified subsequent to additional meetings between USAID and MOI. The concept of a single contractor is supported by program continuity that would be difficult if not impossible to achieve with multiple contractors. There is a significant inter-relationship between the components of the project which will require continuous coordination and direction from a single project administrator. To maintain administrative control of the structural replacement component of the project it is necessary to limit the magnitude of the work in the early phases. This can be accomplished by starting work in one geographic area such as the Central Delta. By confining the USAID initial involvement in the structural replacement project to work within 3 to 5 Directorates in this area, it will be possible to start the project in a more orderly fashion. When the project is running smoothly, it can be expanded to additional Directorates and the level of funding increased. This is demonstrated in the following diagram showing a graphical representation of the rate of the funding proposed.

The Technical Assistance (TA) team must be composed of the most experienced and capable personnel available. The Egyptians chosen to serve as counterparts to the TA team must be well qualified and must be actively working in the appropriate field at the time they are selected. At the time that the TA team and its counterpart team is established, the training staff described in the training program should begin to mobilize.

The primary objective of the MOI and TA staff, at the beginning of the project, will be to adapt standard plans and specifications to specific sites for the first year's structure replacement program. Intthe course of this effort, guidelines for future segments of the replacement program will be developed to insure uniformity of standards throughout Egypt. As a secondary objective the training staff working with the TA team will be able to identify the specific details and problems encountered during the initial phases of the project implementation. Instruction can then be centered around the critical areas to make later phases of the project run more smoothly by giving the necessary and appropriate training in the form of short courses and participant training.

Earlier implementation of the project can be achieved by the MOI if funds become available. It is essential that the procedures to establish uniform priorities and standards be followed. Should implementation begin prior to arrival of the TA team, the MOI will have to take on more responsibilities and possibly proceed slightly slower rate. Therefore, a strong case is made to mobilize the TA team as early as possible to help reduce project start up problems.



PROPOSED PROJECT
FUNDING CONCEPT

Tentative Project Implementation Schedule

	1981		1982				1983				1984	
	J A S	O N D	J F M	A M J	J A S	O N D	J F M	A M J	J A S	O N D	J F M	A M J
Project Paper Approval	*(7/30)											
Sign Project Agreement	*(9/1)											
Request for Tech. Proposal		*(10/1)										
Contractor Selected			*(2/1)									
Contract Signed			*(3/1)									
Tech. Assist. Team Arrive				*(4/15)								
Project Underway				* →	→	→	See →	Annex →	F →	→	→	→

ANNEX A

Technical Libraries

The following lists of technical reference materials have been assembled to give guidance in establishing libraries for engineers in Egypt. The material presented is mostly from American sources but similar material is available from other countries.

Manufacturers Catalogs

- Fiberglass Reinforced Plastic Pipe and fittings
- PVC pipe and fittings
- Concrete pipe and fittings
- Reinforced Concrete pipe and fittings
- Steel pipe and fittings
- Corrugated metal pipe and fittings
- Asbestos-Cement pipe and fittings
- Irrigation Gates
- Valves (all types)
- Grouts and Concrete Admixtures
- Protective Coatings (Epoxy, Enamel, Galvanizing, etc.)
- Water measuring equipment
- Monitoring and control equipment
- Telemetry equipment
- Communications equipment
- Pumps (all types)
- Electric Motors
- Gasoline and Diesel Engines

Magazines and Periodicals

- Egyptian Society of Civil Engineers
- Engineering New Record (ENR)
- American Society of Civil Engineers (Civil Engineer)

American Society of Agricultural Engineers
Irrigation Age
World Water
International Committee on Irrigation Development

Standard Specifications and Practices

Egyptian Code of Practice
American Society of Testing Materials (ASTM)
American Waterworks Association (AWWA)
Cast Iron Pipe Institute
American Concrete Pipe Association
American Concrete Institute (ACI)
American National Standards Institute (ANSI)
American Society of Agricultural Engineers (ASAE)
United States Bureau of Reclamation

Technical Reference Books

Design of Small Canal Structures (USBR)
Handbook of Hydraulics (King)
Open Channel Hydraulics (Chow)
Fluid Mechanics
Hydrology
Strength of Materials
Concrete Design
Steel Design
Structural Design
Materials Handbooks
Irrigation Principles and Practices
Journals and Manuals of ASCE
Irrigation Water Management
Irrigation Operations and Maintenance
Agronomy
Soil Mechanics
Soil Science
Concrete Manual (USBR and others)

Handbook of Civil Engineering
Handbook of Mechanical Engineering
Handbook of Electrical Engineering
Soil-Plant-Water Relationships

ANNEX B
Table I

COST OF REHABILITATION/REPLACEMENT OF IRRIGATION STRUCUTRES BY DIRECTORATE

(1981 Prices)

Thousands of Egyptian Pounds

DIRECTORATE	BRIDGES		INTAKE & HEAD REGULATOR		STEEL GATES		TAIL ESCAPES		WEIRS		SYPHONS & AQUEDUCTS		TOTAL COST
	No.	Cost	No.	Cost	No.	Cost	No.	Cost	No.	Cost	No.	Cost	
1. KALIOUBIA	50	280.0	3	28.0	64	256.0	5	15.0	-	-	9	13.5	592.5
2. ISMAILIA	17	161.0	19	319.0	-	-	12	54.0	-	-	-	-	534.0
3. SHARKIA	186	110.0	49	280.0	135	600.0	47	170.0	-	-	103	195.0	2345.0
4. EAST DAKAHLIA	245	3796.0	35	334.0	174	792.0	147	447.0	-	-	18	51.8	5120.8
5. WEST DAKAHLIA	155	2741.0	39	2550.0	72	380.0	71	673.0	-	-	48	169.0	6513.0
6. KAFR EL SHIEKH	66	1320.0	8	145.0	125	555.0	20	70.0	-	-	26	45.0	2135.0
7. GHARBIA	77	1889.0	43	1533.0	57	293.0	21	158.0	-	-	-	-	3870.0
8. MONOUFIA	167	2273.0	44	610.0	129	528.0	56	144.0	-	-	47	141.0	3696.0
9. BEHEIRA	244	2624.0	79	1800.0	261	1164.0	60	254.0	-	-	14	110.0	5952.0
10. NOUBARIA	106	1478.0	13	198.0	198	787.0	31	152.0	4	13.0	15	63.0	2691.0
11. GIZA	76	1167.0	1	200.0	22	100.0	-	-	-	-	28	312.0	1779.0
12. BENI SUEF	90	740.0	72	623.0	192	637.0	-	-	-	-	8	62.0	2062.0
13. FAYOUM	84	539.0	5	91.0	-	-	2	7.0	19	145.0	17	36.3	818.3
14. WEST MINIA	26	971.5	-	-	43	48.0	69	78.0	-	-	-	-	1097.5
15. EAST MINIA	70	1262.0	-	-	50	282.0	4	18.0	-	-	16	24.0	1586.0
16. ASSIUT	2	17.0	-	-	22	49.5	23	37.0	-	-	-	-	103.5
17. SOUHAG	32	1220.0	31	300.0	39	161.0	-	-	-	-	-	-	1681.0
18. KENA	15	213.0	-	-	27	89.0	8	26.0	-	-	5	7.5	335.5
19. ASWAN	28	397.0	-	-	55	268.0	16	86.0	-	-	31	46.5	797.5
TOTAL	1736	24188.5	441	9011.0	1665	6986.5	592	2389.0	23	158.0	385	1276.6	44009.6

ANNEX B

Table 2

Ministry of Irrigation

Irrigation Department

Chapter I, Salaries & Wages Budgets (1)

(Thousands of Egyptian Pounds)

	1978 (2)	1979 (2)	Trans. 1980 (3)	1980/81 (4)	1981/82 (5)
Salaries Wages	11,654.0	12,333.0	6,501.0	13,453.0	20,007.0

Chapter II, Current Expenses & Project (1)

(Thousands of Egyptian Pounds)

	1978 (2)	1979 (2)	Trans. 1980 (3)	1980/81 (4)	1981/82 (5)
Current Expenses and Projects	21,033.0	22,067.0	11,761.6	20,337.0	37,841.5

(1) Data from MOI Planning Department

(2) Full calendar year 1 July through 31 December

(3) Fiscal year was changed mid year, These figures are shown for 6-month period 31 December, 1979 through 30 June, 1980.

(4) 1 July, 1980 through 30 June, 1981 fiscal year

(5) 1 July, 1981 through 30 June, 1982 proposed but not approved budget

Table 3

Ministry of Irrigation

Irrigation Department

Chapter III, Capital Budgets (1)

(Thousands of Egyptian Pounds)

	1978 (2)	1979 (2)	Trans. 1980 (3)	1980/81 (4)	1981/82 (5)
Horizontal Expansion	16,184.5	16,002.7	15,050.0	22,150.0	118,600.0
Upper Nile	3,977.0	3,500.0	2,800.0	10,600.0	14,800.0
Rehabilitation and Modernization	4,905.0	7,313.0	5,307.8	12,300.0	36,000.0
Erosion Protection	87.5	165.5	450.0	900.0	1,900.0
Nile Barrage Studies	926.0	514.5	517.2	497.0	5,700.0
Alternate Water Supply Studies	741.0	650.0	150.0	-	-
Aquatic Weed Control	3,855.0	2,354.3	950.0	1,500.0	4,950.0
TOTAL BUDGET (Chapter III)	30,676.0	30,500.0	25,225.0	47,947.0	181,950.0

(1) Data from MOI Planning Department

(2) Full calendar year 1 January through 31 December

(3) Fiscal year was changed mid-year. These figures are shown for 6-month period from 31 December, 1979 through 30 June, 1980

(4) 1 July, 1980 through 30 June, 1981 fiscal year

(5) 1 July, 1981 through 30 June, 1982 ~~proposed but not approved budget~~

ANNEX B

Table 4

Annual Replacement Cost For Irrigation Structures

Type Structure	Hydraulic Area M^2					Unit Replace Cost	Total Cost		
	RC	M	P	S	T		RC+M+P	S	T
						LE/M^2	LE mill	LE mill	LE mill
Intake Regulators	9405	8880	3479	--	--	3000	65.29	--	--
Head Regulators	6472	5322	1383	--	--	2500	32.94	--	--
Weirs	1039	879	20	--	--	1500	2.91	--	--
Tail Escapes	285	154	3250	--	--	1500	5.54	--	--
Spillways	285	229	252	--	--	1500	1.15	--	--
Bridges	47265	5810	3718	1001	9757	2500	209.48	2.50	24.39
Crossing Works	250	--	482	3	--	3000	3.67	0.02	--
Total							320.98	2.52	24.39
Useful Life Yrs.	50	50	50	30	15				
Annual Replace Cost							12.84	0.17	3.25
Total Annual							16.26		

RC Reinforced Concrete
M Masonry
P Pipe
S Steel
T Timber

Data from Technical Report 20, Water Master Plan, Page32, Table 7

ANNEX C
Supporting Calculations for Typical Bridge Cost Estimate

Standard Bridge as Presently Constructed

For the purpose of cost analysis assume a 7 meter span bridge would be an average length for the project.

Determine volume of Reinforced Concrete

Beams - (4)
- Main section below deck
  - width 0.35m
  - depth 0.55m
  - length 7.60m
- Thickened end sections of beam
  - width 0.35m
  - sloping end 3:1 Slope - depth 0.2m to 0.0m
  - length 1.10m

End Diaphram (2)
- width 0.2m
- depth 1.25m
- length 8.40m

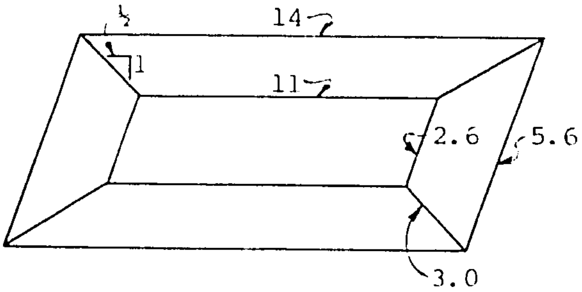
Deck (1)
- width 6.0m
- depth 0.3m
- length 8.0m

Walkway (2)
- average depth 0.3m
- width 1.2m
- length 8.0m

Guardrail (2)
- width 0.2m
- depth 0.8m
- length 8.0m

Volume - beams	-	4 (0.35x0.55x7.6)	=	$5.85m^3$	
beam slop ends	-	4x2 (0.6x0.2)x½)x0.35)	=	0.17	
beam end	-	4x2 (0.35x0.3x0.2)	=	0.17	
end diaphram	-	2 (0.2x1.25x8.4)	=	4.20	
Deck	-	1 (6.0x0.3x8.0)	=	14.40	
Walkway	-	2 (0.3x1.2x8.0	=	5.76	
Guardrail	-	2 (0.2x0.8x8.0)	=	2.56	
		Total	=	$33.11m^3$	$33.1m^3$

Excavation for abutment - assume soil will stand at ½ to 1 slope



Dimensions:

Excavation at bottom
11m long
2.6m wide
Depth of excavation = 3.0m
Excavation at top
14m long
5.6m wide

Volume of excavation (2)

2x3x½ (2.6x11) + (5.6x14) =
6x53.5 = 321m^3

Volume of pitching(2)

average length	15.5m
average width	4.25m
average depth	0.4m

Volume = 15.5x4.25x0.4x2=527∼53.0m^3

Volume of approach road backfill(2)

average width	9.0m
average length	3.0m
average depth	0.7m

Volume = 9x30x0.7x2=37.8 ∼38.0m^3

Volume of material in abutment(2)

assume the brick and concrete will ultimately be approximately the same cost -

base - say 1m larger than abutment and ½m longer than wing (each side)

abutment base -	length	8.4m
	width	2.6
	depth	0.6m
wing bases(2)	length	2.8m
	width	2.6m
	depth	0.6m

abutment vert. mass -

width varies	1.6m to 0.9m
length	8.4m
depth	2.4m

vert. wing mass - (2)

width varies	1.6m to 0.9m and 0.9m to 0.5m
length	2.3m
height	first section 1.9m and second 2.6

Volume of two abutments:

base = 2(8.4x2.6x0.6) = 2x13.1 = 26.2m^3
wing base = 2(2 2.8x2.6x0.6) = 4x4.4 = 17.6
vert. mass = 2((½(1.6+0.9)x8.4x2.4= 2x25.2 = 50.4
wing vert mass = 2x2(½(1.6+0.9)x2.3x1.9))=4x5.5= 22.0
2x2((½(0.9+0.5)x2.3x2.6))=4x4.2= 16.8
Total 133.0m^3

Prices - assumptions from available information for the standard practices in Egypt in MOI projects today.

reinforced concrete	150 LE/m^3
ordinary brick	50 LE/m^3
mass concrete	50 LE/m^3
excavation and backfill	
labor	2 LE/manday
excavation rate	1m^3/manday
backfill/compacted rate	½m^3/manday
backfill material	10 LE/m^3
pitching	
labor	2 LE/manday
laying rate	½m^3/manday
material	10 LE/m^3

Cost from above assumptions for today's constructed bridge (7m)

bridge - Reinf. Conc. 33.1m^{3}x150 LE/m^3 = 4965 LE
abutment - concrete & brick 133m^{3}x50 LE/m^3 = 6650 LE
abutment excavation
321m^{3}x1m^3/day x 2 LE/day = 642 LE
backfill
(321-133)÷½m^3/dayx2 LE/day = 752 LE
pitching - material 53m^{3}x10 LE/m^3 = 530 LE
labor 53÷½m^3/day x 2 LE/day = 212
approach road backfill -
material 38m^{3}x10 LE/m^3 = 380 LE
labor 38m^3÷½m^3/day x 2 LE/day = 152 LE

TOTAL 14,283 LE

Cost of bridge constructed at current prices and construction practices.

Increased Quality Standard Bridge

Assume the above bridge were constructed to standards to meet the requirements of the project. This would require and increase in the cost of the project by the following amounts.

reinforced concrete	250 LE/m^3
quality brick	90 LE/m^3
quality mass concrete	90 LE/m^3

The other costs of the construction would be assumed to remain constant.

Therefore the revised cost would be -

bridge - reinf. conc. = 33.1m^3x250 LE/m^3	=	8275 LE
concrete & brick = 133.0m^3x90 LE/m^3	=	11970 LE
pitching, excavation, and backfill	=	2668 LE
		22,913 LE

Cost of bridge constructed at current prices and increased quality standards as required in standard MOI specifications.

Ratio of the increased cost of the structure

$\frac{22,913}{14,283}$ 1.60± Therefore, the increased quality construction will add 60% to cost.

Determine the average national cost of bridges developed by the Ministry of Irrigaton in Table 1, Cost of Rehabilitation/Replacement of Irrigation Structures by Directorage (1981 prices) - as revised -

Total number of bridges = 1736

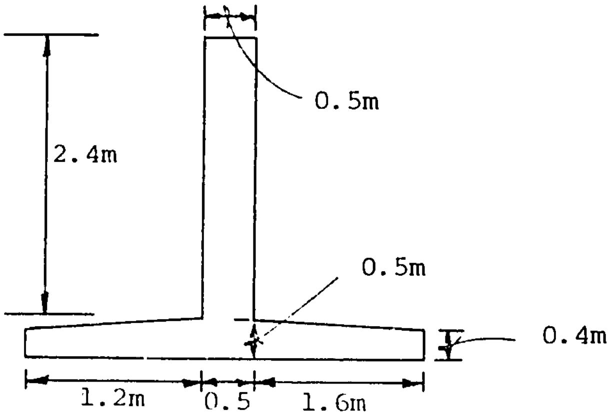
Total cost of bridges = 24,188,500 LE

Average cost of bridges nation wide = $\frac{24,188,500 \text{ LE}}{1736}$ = 13,933 LE

Note: The current bridge construction quality cost compares very closely to the projected nationwide average. MOI calculations appear reasonable.

Improved Design R C Abutments

Consider the alternative of a reinforced concrete cantilever wall with footing in-lieu-of the mass concrete and brick abutment. Use the information given by Engineer A. Yehia El Awadi, Design of Simple Span R.C. Bridges - page 70 to obtain details of the new abutment, modified to some extent.



Assume that the excavation, backfill, and pitching will remain about the same for both structures. Also the volume of concrete in the bridge well remain the same. Only change is in abutment. Assume the overall length of the structure would be the same as the previous structure - also the wings will be smaller than main abutment.

Volume Concrete

abutment base = 0.5x0.5x8.4 = 2.1m^3
(0.5+0.4)½x1.6x8.4 = 6.0m^3
(0.5+0.4)½x1.2x8.4 = 4.5m^3

wing base = 0.4x0.4x2x2.8 = 0.9m^3
(0.4+0.4)½x1.6x2x2.8 = 3.6m^3
(0.4+0.4)½x1.2x2x2.8 = 2.7m^3
19.8m^3

abutment vert. wall 0.5x2.4x8.4 = 10.1m^3

wing vert wall 0.4x2.4x2x2.3 = 4.4m^3

guardrail typ on wing 0.3x2.1x2x2.3 = 2.9m^3
17.4m^3

This is the volume of concrete for each abutment.

Total volume concrete - base = 2x19.8 = 39.6
vert. walls 2x17.4 = 34.8
74.4m^3

Use the following unit costs to compare the costs of the R C abutment to the standard design:

Use the following unit costs to compare the costs of the R C abutment to the standard design:

base = 150 LE/m^3
vert walls= 200 LE/m^3

Cost of new abutment = 150 LE/m^3x39.6m^3 = 5940 LE
200 LE/m^3x34.8m^3 = 6960 LE
12,900 LE

If this is compared to the cost of the brick and concrete abutment standard design it can be seen that the costs of 11,970 LE and 12,900 LE are close enough for these calculations to be called essentially equal.

If the volume of reinforced concrete used here is compared to volume of brick and concrete shown as 133.0m^3 on page 4, the ratio is:

$$\frac{7.4m^3}{133.0m^3} = 0.56$$

Summary

For the purpose of this demonstration it can be said that the volume of concrete saved by going to reinforced concrete is approximately 50%. This should demonstrate that alternate analysis of a structure may show that one structure is approximately equal in cost but there could significant savings in materials.

The calculation showed that to go from a concrete structure constructed to low standards to one of acceptable quality would increase the cost of cost of that structure approximately 60%.

The structures in this project are not all reinforced concrete structures. R C is mostly used in the bridges and regulators. These structures account for about 33M LE of the total 44M LE or about 75%. The other structures and materials associated with the project would only have a 20 to 30% increase in cost to obtain a quality product.

Therefore the total increase in the cost of project can't be assumed to be 60% to increase the quality of the overall project to the existing level required by the specifications.

Say 75% of project would require a 60% increase
and 25% would require a 25% increase

then 0.75x60% + 0.25x25% = 45% + 6.25% = 51.25%

Therefore say the overall project to obtain an acceptable quality of construction will have to be increased by approximately 50%.

ANNEX D

Equipment Recommended
For
Directorate Level Workshop

Quantity	Item
4	Pickup (3/4 Ton)
2	Medium duty truck (2 Ton)
1	Heavy-duty truck (5 Ton) w/winch and small midship mounted hydraulic crane
1	Concrete Compression test equipment
4	Materials testing equipment (sets)
	Sieves
	Balance
	Slump Cone
	Soils Testing Equipment
	Paint thickness gauge
4	1/3 m^3 concrete mixer (gas engine driven)
4	Concrete finishing tools (sets)
4	Spirit level
2	Woodworking hand tools (sets)
2	Water pump (gas engine driven)
2	Concrete vibrator (electric powered w/cords)
2	Portable welding machine (gas engine driven)
2	Oxy-acetylene torch (sets)
2	Mechanics hand tools (sets)
4	Earthwork hand tools (sets)
2	Soil compactor (wacker)
2	2Kw portable generator (gas engine driven)
4	Survey Equipment (sets)
	Level
	Transit
	Chain
	Rod
4	Power Drill and Saw (electric)
2	Power Hacksaw (electric)
1	Forge

Equipment Recommended
For
Inspectorate Level Workshop

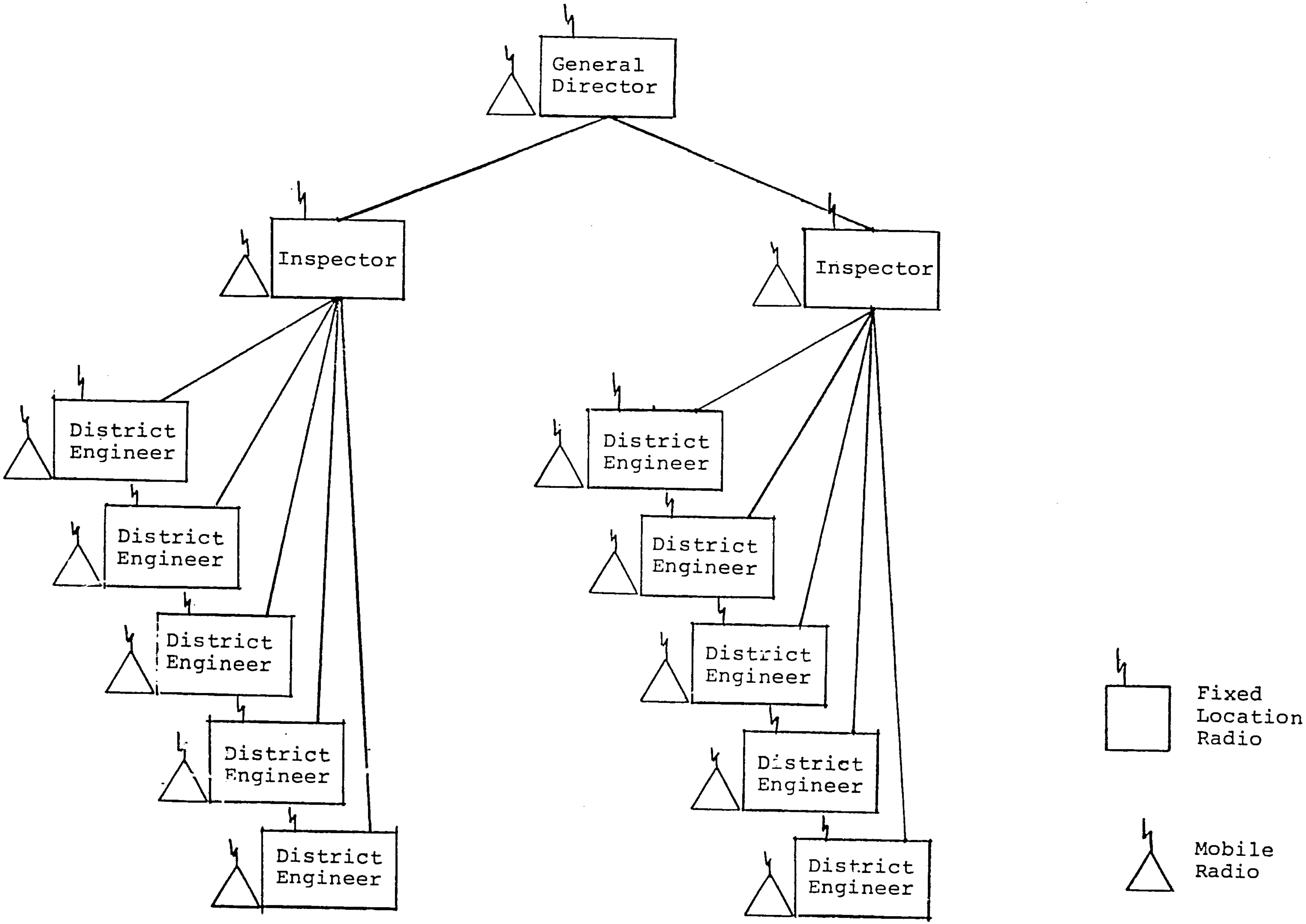
Quantity	Item
2	Pickups (3/4 Ton)
1	Medium-duty truck (2 Ton)
1	Heavy-duty truck (5 Ton) w/winch and small midship mounted hydraulic crane
2	Materials Testing Equipment (sets)
	Sieves
	Balance
	Slump Cone
	Soils Testing Equipment
	Paint thickness gauge
2	1/3 m^3 concrete mixer (gas engine driven)
2	Concrete finishing tools (sets)
2	Spirit level
1	Wood working hand tools (set)
1	Water pump (gas engine driven)
1	Concrete vibrator (electric powered w/cord)
1	Portable welding machine (gas engine driven)
1	Oxy-acetylene torch (set)
1	Mechanics hand tools (set)
2	Earthwork hand tools (sets)
1	Soil compactor (wacker)
1	2Kw portable generator (gas engine driven)
2	Survey Equipment (sets)
	Level
	Transit
	Chain
	Rod
2	Power Drill and Saw (electric)
1	Power Hacksaw (electric)

Equipment Recommended
For
District Level Workshop

Quantity	Item
1	Pickups (3/4 Ton)
1	Medium-duty truck (2 Ton) w/winch and small midship mounted hydraulic crane
1	Materials Testing Equipment (set)
	Sieves
	Balances
	Slump Cone
	Soils Testing Equipment
	Paint thickness gauge
1	1/3 m^3 concrete mixer (gas engine driven)
1	Concrete finishing tools (sets)
1	Spirit level
1	Wood working hand tools (set)
1	Water pump (gas engine driven)
1	Concrete vibrator (electric powered w/cord)
1	Portable welding machine (gas engine driven)
1	Oxy-acetylene torch (set)
1	Mechanics hand tools (set)
1	Earthwork hand tools (sets)
1	Soil compactor (wacker)
1	2Kw portable generator (gas engine driven)
1	Survey Equipment (set)
	Level
	Transit
	Chain
	Rod
1	Power Drill and Saw (electric)

ANNEX E

Directorate Level Radio Communications Network



ANNEX E

Projected Cost for Directorate Level Communications Network

fixed location radio

radio	938 LE
antenna	280
cable	140
antenna support	140
installation	140
system set up	164
	1802 LE
or approx.	1800 LE

mobile radio

radio	889 LE
installation	70
system set up	96
	1055 LE
or approx.	1100 LE

spares = 1000 LE

Test Equipment = 16,000 LE

Radio Equipment for One Directorate

Mobile + fixed location radio - 12 units each installed

12 (1800 LE+1100 LE) = 34,800 LE

spare units - 3 units

3x1000 LE = 3,000 LE

37,800 LE

or approx. 38,000 LE per Directorate

Radio Equipment for 20 Directorates plus support

Directorate units installed	= 38,000 x 20	=	760,000 LE
Spare units	= 1,000 x 5	=	5,000
Repair and Test Equipment	= 16,000 x 1	=	16,000
			781,000 LE

for Nationwide system

Assumptions -

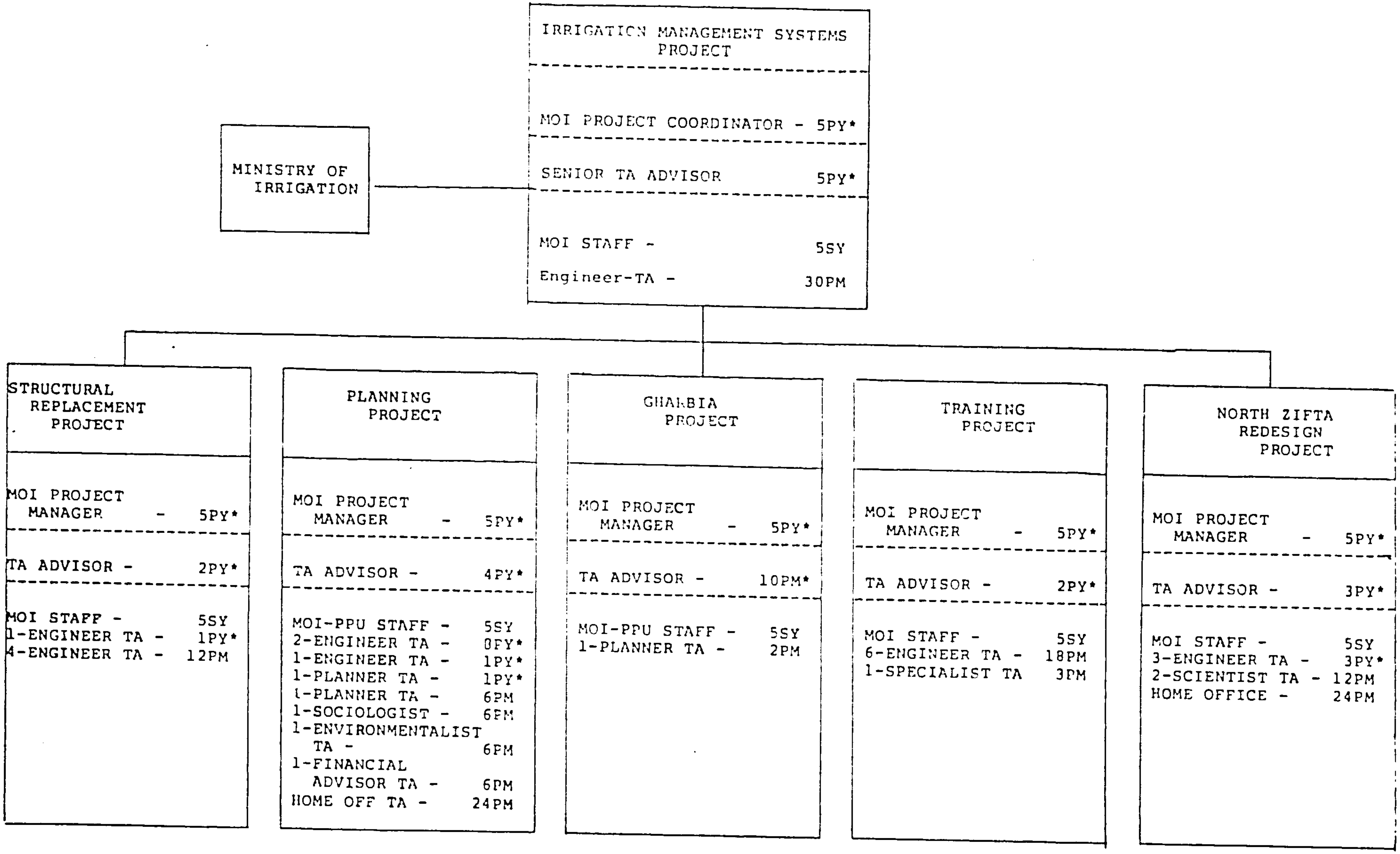
1. Repair and test equipment will be set up in existing building
2. No contingency has been added except for those indicated. A minimum of 25% should be added before data is used for any budget figures.

The above costs would be for the Directorate local communications system installed and operating. This includes an estimated cost for the equipment and materials in-country and installed in the vehicles and offices. It does not include the cost of any vehicles or repair facility building. No allowances for inflation or contingencies have been made.

The estimate assumes on a national average there will be approximately 9 District Engineers, 2 Inspectors and one General Director in each Directorate. In correspondence to the attached diagram the fixed location transceiver is located in the office of the engineer indicated and the mobile transceiver is in the vehicle associated with that person. All radios within a Directorate will be on the same frequency with different directorates on separate frequencies. On the average there are 24 radios on each frequency.

ANNEX F
Table 1

IMPLEMENTATION STAFF REQUIREMENTS
(Developed by USAID Design Team)



MINISTRY OF IRRIGATION

IRRIGATION MANAGEMENT SYSTEMS PROJECT

MOI PROJECT COORDINATOR - 5PY*

SENIOR TA ADVISOR 5PY*

MOI STAFF - 5SY
Engineer-TA - 30PM

STRUCTURAL REPLACEMENT PROJECT

MOI PROJECT MANAGER - 5PY*

TA ADVISOR - 2PY*

MOI STAFF - 5SY
1-ENGINEER TA - 1PY*
4-ENGINEER TA - 12PM

PLANNING PROJECT

MOI PROJECT MANAGER - 5PY*

TA ADVISOR - 4PY*

MOI-PPU STAFF - 5SY
2-ENGINEER TA - 8PY*
1-ENGINEER TA - 1PY*
1-PLANNER TA - 1PY*
1-PLANNER TA - 6PM
1-SOCIOLOGIST - 6PM
1-ENVIRONMENTALIST TA - 6PM
1-FINANCIAL ADVISOR TA - 6PM
HOME OFF TA - 24PM

GHARBIA PROJECT

MOI PROJECT MANAGER - 5PY*

TA ADVISOR - 10PM*

MOI-PPU STAFF - 5SY
1-PLANNER TA - 2PM

TRAINING PROJECT

MOI PROJECT MANAGER - 5PY*

TA ADVISOR - 2PY*

MOI STAFF - 5SY
6-ENGINEER TA - 18PM
1-SPECIALIST TA 3PM

NORTH ZIFTA REDESIGN PROJECT

MOI PROJECT MANAGER - 5PY*

TA ADVISOR - 3PY*

MOI STAFF - 5SY
3-ENGINEER TA - 3PY*
2-SCIENTIST TA - 12PM
HOME OFFICE - 24PM

SY - STAFF YEAR
PY - PERSON YEAR
PM - PERSON MONTH
* - LONG TERM ASSIGNMENT

ANNEX F
Table 2

PROJECT STAFF QUALIFICATIONS
(Developed by USAID Design Team)

POSITION & PROJECT	EXPERTISE**
IRRIGATION MANAGEMENT SYSTEMS PROJECT	
*Senior Technical Assistance Advisor	Project Administrator Project Management Irrigation System Design Construction Management Irrigation System O & M Administrative Management Training Planning
Engineer TA	Project Management Construction Management Engineering Economics Irrigation System Design Irrigation System O & M
STRUCTURE REPLACEMENT PROJECT	
*TA Advisor	Project Management Irrigation System Design Contract Preparation Construction Management Corrosion Engineering
*Engineer TA	Irrigation System Design Irrigation System Construction
Engineer TA	Structural Design
Engineer TA	Irrigation System Construction
Engineer TA	Irrigation System O & M
Engineer TA	Corrosion Engineering

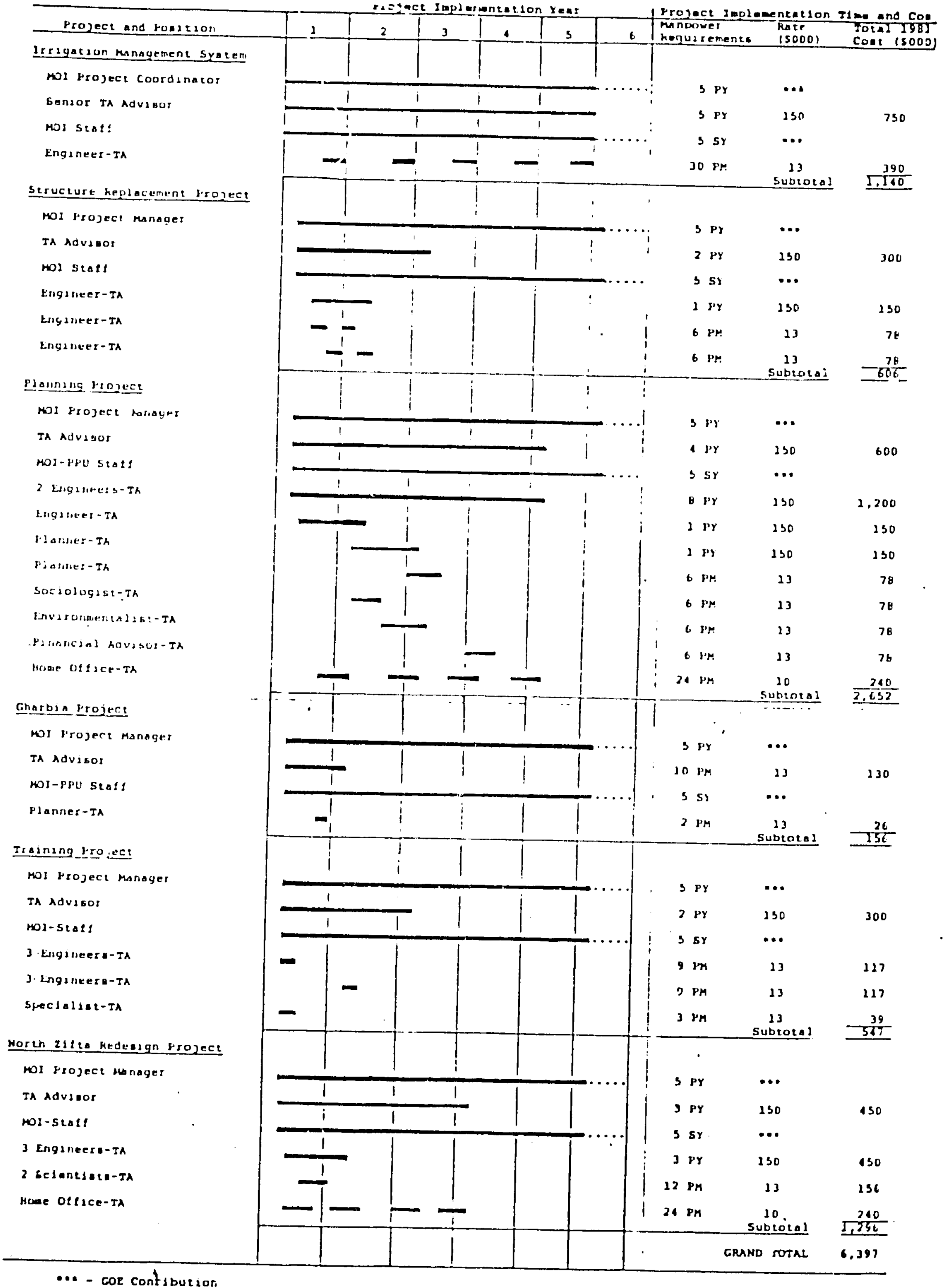
PLANNING PROJECT	
*TA Advisor	Project Management Studies Irrigation Systems Design Construction Management Drainage System Design Planning Environmental Science Sociology Finance,Grant Procurement,& Economics
*Engineer TA	Irrigation Systems Design
*Engineer TA	Construction Management
*Engineer TA	Drainage System Design
*Planner TA	System Layout and Planning
Planner TA	System Implementation
Environmentalist TA	Environmental Factors Irrigation & Drainage Practices
Sociologist TA	Farmer/Gov't. Relationships
Financial Advisor TA	Finance,Grant Procurement,& Economics
GHARBIA PROJECT	
*TA Advisor	Project Management Irrigation System O & M Construction Managment Irrigation Systems Designs Planning & Economics
Planner TA	Implementing Donor Financed Projects

TRAINING PROJECT	
*TA Advisor	Project Management Construction Management Irrigation Systems Design Irrigation Systems O & M Water Management Administrative Management
Engineer TA	Construction Management
Engineer TA	Administrative Management
Engineer TA	Irrigation System Design
Engineer TA	Irrigation System O & M
Engineer TA	Irrigation System O & M
Engineer TA	Water Management
Specialist TA	Communication Media
NORTH ZIFTA REDESIGN PROJECT	
*TA Advisor	Project Management Irrigation System Design Water Management Construction Management
*Engineer TA	Irrigation System Design
*Engineer TA	Drainage System Design
*Engineer TA	Water Management
Scientist TA	Soil Science Agronomy
Scientist TA	Soil-Water-Plant Relationships

* Long Term Assignment
** Qualifications listed in decending order of priority
TA Technical Assistance

ANNEX F
Table 3

IRRIGATION MANAGEMENT SYSTEMS PROJECT IMPLEMENTATION
(Developed by USAID Design Team)



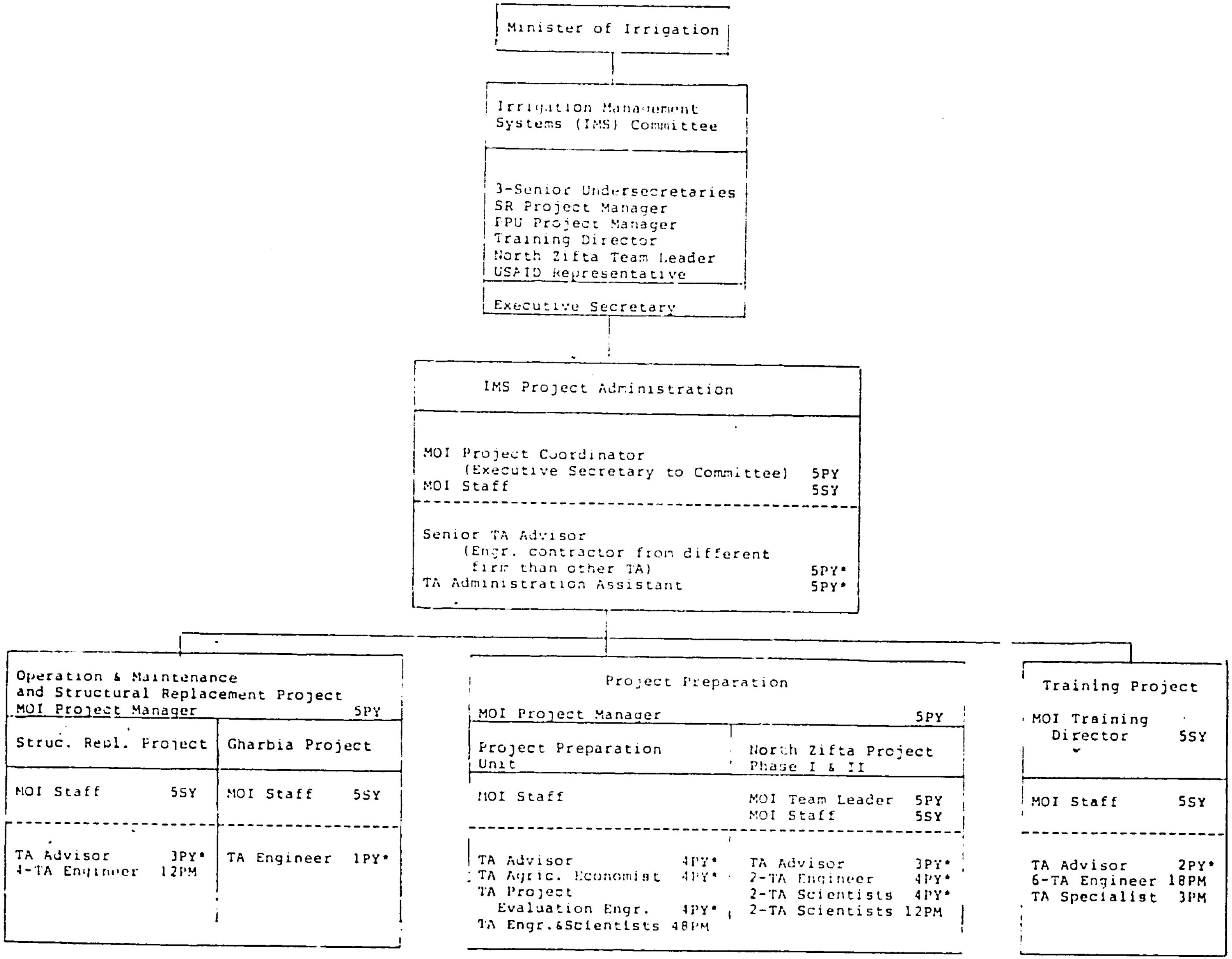
Project and Position	Project Implementation Year 1	2	3	4	5	6	Project Implementation Time and Cos Manpower Requirements	Rate ($000)	Total 1981 Cost ($000)
Irrigation Management System									
MOI Project Coordinator							5 PY	***	
Senior TA Advisor							5 PY	150	750
MOI Staff							5 SY	***	
Engineer-TA							30 PM	13	390
								Subtotal	1,140
Structure Replacement Project									
MOI Project Manager							5 PY	***	
TA Advisor							2 PY	150	300
MOI Staff							5 SY	***	
Engineer-TA							1 PY	150	150
Engineer-TA							6 PM	13	78
Engineer-TA							6 PM	13	78
								Subtotal	606
Planning Project									
MOI Project Manager							5 PY	***	
TA Advisor							4 PY	150	600
MOI-PPU Staff							5 SY	***	
2 Engineers-TA							8 PY	150	1,200
Engineer-TA							1 PY	150	150
Planner-TA							1 PY	150	150
Planner-TA							6 PM	13	78
Sociologist-TA							6 PM	13	78
Environmentalist-TA							6 PM	13	78
Financial Advisor-TA							6 PM	13	76
Home Office-TA							24 PM	10	240
								Subtotal	2,652
Gharbia Project									
MOI Project Manager							5 PY	***	
TA Advisor							10 PM	13	130
MOI-PPU Staff							5 SY	***	
Planner-TA							2 PM	13	26
								Subtotal	156
Training Project									
MOI Project Manager							5 PY	***	
TA Advisor							2 PY	150	300
MOI-Staff							5 SY	***	
3 Engineers-TA							9 PM	13	117
3 Engineers-TA							9 PM	13	117
Specialist-TA							3 PM	13	39
								Subtotal	547
North Zifta Redesign Project									
MOI Project Manager							5 PY	***	
TA Advisor							3 PY	150	450
MOI-Staff							5 SY	***	
3 Engineers-TA							3 PY	150	450
2 Scientists-TA							12 PM	13	156
Home Office-TA							24 PM	10	240
								Subtotal	1,296
								GRAND TOTAL	6,397

*** - GOE Contribution
PY - Person Year
PM - Person Month
.....·Indefinite continuation of project

ANNEX F
Table 4

MODIFIED IMPLEMENTATION STAFF REQUIREMENTS

(Modified version of Table 1, after MOI/USAID meeting 5/11/81)



Minister of Irrigation

Irrigation Management Systems (IMS) Committee

3-Senior Undersecretaries
SR Project Manager
FPU Project Manager
Training Director
North Zifta Team Leader
USAID Representative

Executive Secretary

IMS Project Administration

MOI Project Coordinator (Executive Secretary to Committee) 5PY
MOI Staff 5SY

Senior TA Advisor (Engr. contractor from different firm than other TA) 5PY*
TA Administration Assistant 5PY*

Operation & Maintenance and Structural Replacement Project
MOI Project Manager 5PY

Struc. Repl. Project
MOI Staff 5SY
TA Advisor 3PY*
4-TA Engineer 12PM

Gharbia Project
MOI Staff 5SY
TA Engineer 1PY*

Project Preparation
MOI Project Manager 5PY

Project Preparation Unit
MOI Staff
TA Advisor 4PY*
TA Agric. Economist 4PY*
TA Project Evaluation Engr. 4PY*
TA Engr.&Scientists 48PM

North Zifta Project Phase I & II
MOI Team Leader 5PY
MOI Staff 5SY
TA Advisor 3PY*
2-TA Engineer 4PY*
2-TA Scientists 4PY*
2-TA Scientists 12PM

Training Project
MOI Training Director 5SY
MOI Staff 5SY
TA Advisor 2PY*
6-TA Engineer 18PM
TA Specialist 3PM

SY Staff Year
PY Person Year
PM Person month
* Long term assignment (1 year or more)

ANNEX G
Cost Estimate for Aerial Mapping

Area Estimate - Use conservative estimate -

Upper Nile - 1000 km long x 18 km wide	4.4 million acres
Faiyum - 30 km long x 20 km wide	0.3 " "
Delta - assume approximate triangle 220 km base x 150 km altitude	8.2 " "
	12.9
say increase by 15%	1.9
	14.8
say gross area	15.0 million acres

The estimate below is intended for a rough budget level project cost. Many factors, particularly the survey requirements, would have to be resolved before a firm estimate could be established.

Rectified Photomaps @ Scale 1:10,000

Survey Controls 0.035 LE/acre x 15x10^6acre = 0.525x10^6 LE

Aerial Photography 0.035 LE/acre x 15 x 10^6 acre (high altitude jet) = 0.525x10^6 LE

Photoplan sheet preparation 0.0105 LE/acre x 15x10^6 acre = 1,575x10^6 LE

Total cost 2,625,000 LE

Rectified Photomaps @ 1:10,000 w/1 meter contour interval
(note the above cost has to be added to this cost)

Survey Controls - 0.385 LE/acre x 15x10^6 acre = 5.775x10^6 LE (low level)

Aerial Photography 0.105 LE/acre x 15x10^6 acre= 5.775x10^6 LE

Contour Mapping - 0.385 LE/acre x 15x10^6 acre= 5.775x10^6 LE

Subtotal 13,125,000

Therefore: Photomaps @ 1:10,000 approximately	3,000,000 LE
Photomaps @ 1:10,000 w/1 meter contours	116,000,000 LE

The largest scale maps that could be produced with the high level jet photography would be about 1:10,000

The scale of the low level photography would be about 1:14,400 and this photography could be used for enlargements to about 1:2400

Assumptions for the above work

1 - All work would be coordinated with the GOE National Standards
2 - All equipment, including airplanes, would be in-country.
3 - A trained staff would be available
4 - Bench marks and control point exist on approximately a 1.5 km grid.
5 - No contingencies have been added other than those indicated. A minimum of 25% should be added.
6 - Assume feddans approximately equal acres.

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