

QUALITY CONTROL OF SUBSURFACE DRAINAGE PROJECTS ^[1]

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ABSTRACT

A subsurface drainage system has to function properly over a long period. Therefore it must be accurately and properly installed. There are currently about 470,000 feddans of land with pipe drainage in Egypt, approximately 11% of the total drained area, which are not functioning properly. The poor quality of subsurface drainage construction is due to several reasons, including: damaged pipe materials, poor pipe connections, misalignment and depth fluctuations of collectors and laterals during installation, pipe sedimentation, and lack of envelope. A quality control and quality assurance system for subsurface drainage projects was developed to improve their quality. A questionnaire was conducted within Egyptian Public Authority for Drainage Project (EPADP) to analyze the current construction practices and the main phases of the project. The main phases analyzed here are Field Investigation phase, Construction phase, and Operation and Maintenance phase. The specifications and standards of each phase and the main control points were determined. After that, the weakness points and the required corrective actions were also determined for each phase. The results showed that, the low quality of subsurface drainage system construction is attributed to the lack of adequate aspects of quality control and quality assurance for the phases of the project. To improve the quality control and quality assurance for the project, it is important to concentrate on the main control points of each phase and apply the required corrective actions.

Keywords: Quality assurance, Quality control, Quality system, Subsurface drainage system

1 INTRODUCTION

The Nile Delta and the Nile valley of Egypt, is one of the most fertile and intensively cultivated regions in the world having been under continuous cultivation for at least 5000 years. This is due to the Nile mud brought down by the Nile from the Ethiopian plateau (Amer and Ridder, 1989). The agricultural sector accounts for more than 30% of the gross national product (Abu-Zeid, 1990). At the turn of the 19th century, perennial irrigation was introduced in the Nile River Delta and Valley of Egypt. This led to raise groundwater table, and increase problems of water logging and salinity. As a consequent result of these problems the productivity of the agricultural land decreased. If subsurface drainage is not provided, when needed, the crop yield will be reduced by as much as 20 percent in a very few years. In response to this challenge, the government gave high priority for installing drainage systems because it would be uneconomical to cultivate land with this reduced productivity (Johnston, 1976).

One of the main advantages of constructing subsurface drainage system in the Nile Delta is increasing the productivity of crops actually by 138%, 48%, 75% and 10% for Wheat, Clover, Maize and Rice respectively (Abdel-Dayem et al, 1990). In Egypt, it is estimated that up to 1995, approximately 4.3 million Feddans (1 Feddan = 0.42ha) have been subsurface drained and another 2.1 million Feddans will be implemented between 1996 and 2010 (Advisory Panel on Land Drainage, 1996). As part of the National Drainage Program, over US \$ 35 million are to be spent on the rehabilitation of drainage systems. According to the performance indicators and measurements by the Drainage Research Institute (DRI, 1993) in selected areas, it was shown that the major reasons for system failure are the low quality of construction and lack of adequate inspection and supervision.

Given the significant public investments in subsurface drainage, it is imperative that systems be properly installed and maintained, and function effectively. Furthermore, considerable amounts of time, money and energy are expended in project formulation, financing, and engineering design. These investments need to be protected, and it is essential that full benefits of drainage be accrued, to ensure system sustainability. It is expected that if proper attention is paid to quality control and quality assurance in drainage construction, then the maintenance cost and need for renewal is minimum. Quality control and quality assurance of tile drainage projects is the main tool for proving the highest efficiency and durability of such projects. Thus the highest priority should be given to the implementation of tile drainage networks on the basis of the scientific study, which consider all the affecting factors. Although the general organizational arrangements within the agency responsible for implementation of subsurface drainage projects in Egypt, Egyptian Public Authority For Drainage Project (EPADP), is satisfactory, there is always a need to improve construction planning and management, construction supervision and follow up. In order to address any weakness in implementation, development of guidelines and reporting procedures for the quality control of drainage work must be done.

The quality control and quality assurance system is the organizational structure, responsibilities, procedures, processes and resources for implementing quality management. The quality system has to control what is produced to make sure it meets the requirements of the client and, secondly, it has to provide confidence or assurance is needed by both the contractor and the client

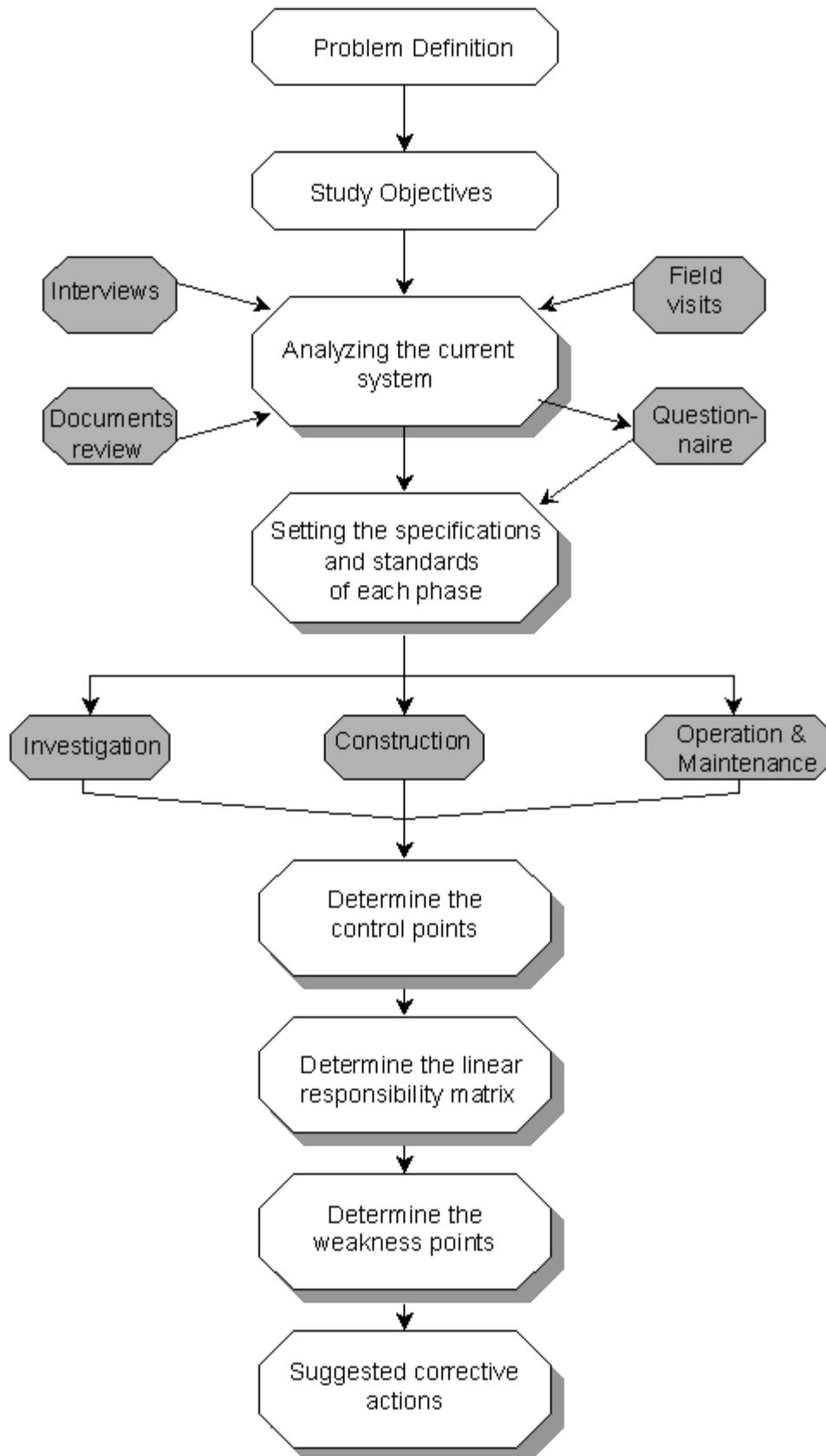
(Ashford, 1989). In this paper Quality Control and Quality Assurance system for subsurface drainage project is developed.

2 STUDY METHODOLOGY

Effective quality management of a project requires a considerable background of information. The nature of this study requires a study base in a construction engineering and management to evaluate the quality control and quality assurance system of subsurface drainage projects in Egypt. It also needs knowledge of new ideas and approaches about the quality management systems. Then discuss problems, ideas, and proposed approaches with many concerned people. This should be done through interviews and questionnaires. Therefore, the study approach (Figure 1) includes analyzing subsurface drainage project to define its specification and the main control points. Then, define the weakness points and the main reasons of problems and consequently, determine the required improving and corrective actions.

To accomplish the study objectives, a questionnaire was prepared about the steps and arrangements followed in the field investigation, construction and operation and maintenance of the subsurface drainage projects. This questionnaire was accomplished within the Egyptian Public Authority for Drainage Project (EPADP), which is responsible for the design, and implementation of all drainage works, as well as for maintaining field drainage systems in Egypt. The main aim of the questionnaire is to get the views of the involved engineers in the current techniques of project construction and their recommendations to improve its quality. The questionnaire consists of three parts. The first part is concerned with the field investigation phase. It is distributed through the Field Investigation and Research Department (FIRD) of the EPADP. The second part is concerned with the construction phase of the subsurface drainage works. It is divided into two subparts, the first subpart for the engineers of the EPADP who are responsible for the supervision of the construction of the projects. The second subpart for the engineers of the contractors who are responsible for the construction of the subsurface drainage works. The third part is concerning with the Operation and Maintenance of the subsurface drainage works. It is also distributed within EPADP through its directorates of maintenance and filled by engineers who are responsible for the maintenance work of the subsurface drainage systems.

Figure 1



3 RESULTS AND DISCUSSION

Each phase was divided to its main activities. The field investigation phase was divided to three main activities. They were defined as Preparing Maps, Fieldwork, and Processing of the Field Investigation Data. The Construction phase was divided also to three main activities as following: Tendering process, Planning of construction work, and Construction work. The Operation and Maintenance phase was considered as one activity. The main components of each activity were classified as Material, Planning, and Processing. After that, the specification and standards of each element were set. The control points of each activity were determined and evaluated. The control method was defined for each control points. This was done according to the data collected from the questionnaire. The main weakness points related to the control points were defined and the required corrective actions were determined. The specifications and control points of the field investigation phase activities are shown in tables (1, 2 and 3) respectively.

Table 1: Specifications and control points of preparing maps activity

Activity	Description and Specifications	Control Points	Control method	E
Material Field work maps	Map scale 1:25000 or 1:10000 with contour lines and spot levels from Survey Authority.			
Planning - Update of maps	Update of the maps according to the information of EPADP Directorates.	*	Inspect.	0
Processing - Provide maps with grid system - Make the lay-out of canals and drains - Make cross sections of drains and canals	Grid system with grid width of 500 m. A topographical map 1:25000 is made with the layout of canals and drains. Make cross sections of drains and canals and their water levels and direction of water flow.	* * *	Inspect. Inspect. Inspect.	1 1 1

*: Control Point E: Evaluation 1: Under control 0: Need more control

Table 2: Specifications and control points of fieldwork activity

Activity	Description and Specifications	Control Points	Control method	E
Material - K Equipment - EC meter & plastic bags	1 auger, 1 stopwatch, 1 tape. To measure electrical conductivity and store soil samples.			
Planning - Provide maps with grid points - Arrange manpower and equipment for field work	Maps are provided with a 500m grid, one grid covers 60 feddan. The field group consists of one engineer, one observer and two workmen for approx. 5000 feddan.	*	Inspect.	1
Processing - Making leveling for ground surface - Measurements at each grid point - Measuring hydraulic conductivity (K) - Taking disturbed soil samples	The ground elevation must be checked during the fieldwork. Measure the ground water salinity and the ground water table. At each grid point, an auger hole is made to 2 m depth to measure K. Samples are taken at 0.2 and 0.5m below soil surface.	* * * *	Inspect. Inspect. Inspect. Inspect.	0 1 0 1

*: Control Point E: Evaluation 1: Under Control 0: Need more control

Table 3: Specifications and control points of processing of field investigation data

Activity	Description and Specifications	Control	Control	E
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		Points	method	
Material - Field measurements data and soil samples	Include ground water table, salinity, K and soil samples at each grid point.	*	Inspect.	1
Planning - Sending soil samples to the laboratory	The soil samples are stored out by the engineer and sent to the laboratory.			
Processing - Analyze soil samples - Store the data - Drawing field data	EC, pH, water ESP and soil texture. Collected data is stored in the computer. The assistant design engineer draws the field data on 1:25000 map.	*	Inspect.	0

*: Control Point E: Evaluation 1: Under Control 0: Need more control

The suggested corrective actions for the field investigation phase were determined in relation to the control points and according to the national and international experiences and approved with the experiences that collected through the questionnaire as following:

1. Old field investigation maps: The maps must be updated according to the information of the directorates of EPADP. Obstacles must be recorded during the investigation work.
2. Need for make leveling for the project area: The project area must be leveled before design work to determine optimum layout and avoid any suddenly changes during implementation.
3. The insufficient measurements of hydraulic conductivity: The number of grid points must be increased to one boring for every 40 feddans to increase the reliability of collected data. It is also recommended to make the permeability tests for different depths in case of variability with depth.
4. Delay of the laboratory analysis: The laboratories must be increased and provided with the required-trained personnel.

Tendering and construction phase was divided to its activities, components and elements. Specification and standards of each element were set. Control points of each activity were evaluated. Specifications and control points of the activities are shown in tables (4, 5 and 6).

Table 4: Specifications and control points of tendering process activity

Activity	Description and Specifications	Control Points	Control method	E
Material - Tender document - Submitted tenders	Includes the necessary information and specifications about the project. The submitted tenders of the interested contractors.	*	Inspect.	1
Planning - Pre-qualifying of the contractors - Advertise tender	Contractors must be pre-qualified to measure their eligibility for bidding. EPADP advertise the documents and the interested contractors can obtain additional data from EPADP.	*	Inspect.	1
Processing - Submit and judge of the tenders - Awarding of the contract	Contractors submit their tenders. The tenders are judged on the responsiveness of contractors to the specifications and total price. The contract is awarded to the tender with the lowest bid	*	Inspect.	1

*: Control Point E: Evaluation 1: Under Control 0: Need more control

Table 5: Specification and control points of planning of construction work activity

Activity	Description and Specifications	Control Points	Control method	E
Material - Maps, drawings, and lists of	They are laid in the project documents with the	*	Inspect.	1

quantities	technical specification.			
Planning				
- Organize planning meetings and collect the pre-experience	Obtain guidance from key people and pre-experience that gained from the previous projects.	*	Inspect.	0
- Schedule the project time and draft plan	Implementation time is scheduled and the work plan is developed.	*	Inspect.	0
Processing				
- Prepare plan tools	These tools are used in the field.	*	Inspect.	0
- Follow up the work	Using survey formats to follow up the work and evaluate its progress.	*	Inspect.	0
- Submit progressing reports	The engineer submits reports to the director to evaluate and follow up the progress of the work.	*	Inspect.	1

*: Control Point E: Evaluation 1: Under Control 0: Need more control

Table 6: Specification and control points of construction work activity

Activity	Description and Specifications	Control Points	Control method	E
Material				
- Manpower	Engineers and Technicians.	*	Inspect.	1
- Material	Pipes, envelop material and water.	*	Inspect.	1
- Structures	Connections, manholes, outlets.	*	Inspect.	1
- Machines	Leveling machine, the laying machines.	*	Inspect.	1
Planning				
- Collect pre-experience	Pre-experience of previous projects.	*	Inspect.	0
- Schedule project time and responsibilities	Implementation time is scheduled and assure of availability of manpower.	*	Inspect.	0
- Preparing work-shop	To produce concrete pipes and store materials and machines.	*	Inspect.	0
- Check plastic pipes and envelope material	Check quality and storage condition at workshop and field.	*	Inspect.	0
Processing				
- Deliver material to site	Check materials quality and quantity.	*	Inspect.	0
- Construct outlets	Check the level and slope of outlet.	*	Inspect.	0
- Stake out collectors, laterals, and manholes	Determine level and slope of collectors and laterals and position of manholes.	*	Inspect.	0
- Installing manholes and crossings	Install required manholes, also T-connections, and required crossings.	*	Inspect.	0
- Lay collectors and laterals	Lay collectors and laterals with trencher or trenchless.	*	Inspect.	0
- Work evaluation	Evaluate quality of the work with new technologies.	*	Inspect.	0
- Delivery washing	Do a final check by flushing.	*	Inspect.	1

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The suggested corrective actions for tendering and construction phase are as following:

1. Judging tenders: It is recommended to pre-qualify the public and private contractors periodically to measure their eligibility for bidding and increase competitiveness. It is also recommended to inspect the plant, equipment, and resources of the apparent low bidders, who will become the contractor if all other requirements are satisfied. This must be done after bid opening and before contract awarding to affirm suitability of contractor's resources for project construction.
2. Lack of feedback information: The feedback information from previous projects must be registered and collected to help in work

planning.

3. Lack of time schedule and manpower organization: The time of implementation must be scheduled according to cropping and water management conditions to avoid any problems or delay. Work team must be assigned full-time to project site.
4. Low quality of plastic pipes: Plastic Pipes must be routinely tested, stored regularly, protected from direct sunlight and transported and handled carefully to avoid damages. Drainage machine should be equipped with a power feeder to prevent stretch.
5. Bad construction of outlets: Pitching with stones and mortar must protect the outlets. It must have a free fall into the open drain.
6. Low accuracy of the laser work: drainage machine should never install drains further than 300m from laser command post. Do not drive the machinery close to the command post as the vibration may affect the laser beam. It is also recommended to check periodically with levelling instrument behind laser to check the accuracy.
7. Poor quality of pipes laying: The lateral must be laid at proper elevation by using a backhoe to excavate holes at lateral/main line connections. Use trenchless machine especially with collapsing soils to improve quality of construction.
8. Low accuracy of evaluation work: Examine new techniques for inspection and evaluation at wide scale to determine their suitability under Egyptian conditions.

The components and elements of the Operation and Maintenance phase were defined. Specification and standards of each element were set. Control points of each activity were evaluated. Specifications and control points of the activities are shown in Table 7.

The suggested corrective actions for Operation and Maintenance phase in relation to the control points are as following:

1. Need for organizing the operation and maintenance work: The operation and maintenance work must be scheduled and organized. It will be easier to the engineer to operate and maintain the system with the help of the farmers.
2. Need for improved technology flushing: Evaluate the performance of the high-pressure machines to determine their effect on the soil around the drain. The special connection must be used with laterals to make it easy to use flushing machines for cleaning laterals not connected to manholes.
3. Lack of using new procedures techniques of inspection: The recent procedures techniques of inspection and checking damages in the system must be improved and used with the subsurface drainage systems in Egypt.

Table 7: Specifications and control points of operation and maintenance activity

Activity	Description and Specifications	Control Points	Control method	E
Material - Preserved maps	The maps should show the location of all ditches and covered drains, their size and depth, and their grade and distance apart.	*	Inspect.	1
Planning - The manpower and financial requirements - Planning of maintenance work	It is important to provide maintenance directorates with required manpower and financial resource. Develop an organization and a schedule for the maintenance work.	* *	Inspect. Inspect.	1 0
Processing - Routine inspections - Repairing	Routine inspection is simple operational and maintenance checks to verify whether the system is functioning properly and if there is any need for repair or cleaning. Repair of damages that are found during inspection.	* *	Inspect. Inspect.	1 1

Flushing	Use flushing machines to clean the system.	*	Inspect.	0
Using the new techniques	Use new techniques for checking damages in the system.	*	Inspect.	0

*: Control Point E: Evaluation 1: Under control 0: Need more control

4 CONCLUSIONS

The main conclusions can be identified as following:

1. Low quality of the implemented subsurface drainage systems is attributed mainly to lack of adequate aspects of quality control.
2. The inadequate reliability of collected data in the field investigation is due to: the insufficient number of bore holes for field measurements, using of old date maps, make no leveling for the project area, and delay of the laboratory results. This also led to insufficient quality assurance for the construction phase.
3. Insufficient quality of subsurface drainage projects construction is related to: lack of planning before construction work and need for good distribution of responsibilities, bad conditions of transporting, storage and handling of material and need to improve inspection techniques.
4. To improve quality of the operation and maintenance work it is important to schedule and organize them and improve the use of inspection and flushing techniques.

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