UNIVERSITY OF CALGARY

STATE OF WATER QUALITY MANAGEMENT IN EGYPT

A MASTER'S DEGREE PROJECT SUBMITTED TO
THE FACULTY OF ENVIRONMENT DESIGN
FOR PARTIAL CREDIT

ENVIRONMENTAL SCIENCE PROGRAMME

BY

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CALGARY, ALBERTA

MARCH 1999

0-612-42329-8

ABSTRACT

STATE OF WATER QUALITY MANAGEMENT IN EGYPT

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March 29, 1999

This document was prepared in partial fulfillment of the requirements of the MEDes Degree in the Faculty of Environmental Design, The University of Calgary

The River Nile has been the lifeblood of Egypt for thousands of years. It is, however, facing multiple pressures. Rapid population growth and increasing industrialisation are pushing up water demands, which threaten to exceed Egypt's available supply. Contributing to the deteriorating situation are the rising amounts of pollution entering the River Nile from industrial, agricultural, and domestic sources. Traditionally, the Government of Egypt has primarily focused on management of water quantity. This state of affairs is starting to change; the government has begun to give more attention to water quality management.

The main elements found in most well-established national water quality management programmes are legislation and enforcement, monitoring, capacity building, and data management and information systems. Egypt's water quality management programme was assessed according to the presence or absence of each of these elements. Each component was then analyzed and recommendations were developed.

Egypt has the basic elements for a successful national water quality management programme, except for a well-developed information infrastructure. The three dominant issues hindering Egypt from effectively and efficiently addressing water quality are heavy reliance on foreign assistance, insufficient budgets provided to ministries to carry out their responsibilities, and inadequate cooperation and collaboration among agencies.

Critical levels of water pollution have so far been limited to localized areas. The national government still has the opportunity to safeguard the quality of the Nile waters. This can be achieved by developing domestic sources of funding, rigorously supporting education and training, optimizing the use of existing resources through improved cooperation and collaboration, and introducing feedback loops at each stage of planning and implementation. In order to facilitate such changes, the Egyptian government will need to shift from a sectoral, unilinear approach to water resources management to a hierarchical, multidimensional approach. External support agencies can assist in the transition by providing more effective aid to Egypt through means such as providing funding to follow-up project activities, and strengthening the criteria for project approval.

Keywords: Capacity Building, Egypt, External Support Agencies, Information Systems, Integrated Water Resources Management, Legislation, Monitoring, River Nile, Water Quality Management

ACKNOWLEDGEMENTS

There are a number of people to whom I am deeply indebted.

This project would never have gotten of the ground without the early guidance of Prof. Nkemdirim. Prof. Dixon Thompson challenged me to reach my full potential and kept me focused during the entire process. Dr. Abdelbary of the Nile Research Institute granted me the opportunity to work alongside his staff in Egypt and was very generous in providing me with information. Without his cooperation, this Master's Degree Project would not have been possible. I would also like to thank Dr. El-Sherbini, Head of the Water Quality Division at the Nile Research Institute, and the staff at the Nile Research Laboratory for their patience in answering all my questions. Their hospitality was greatly appreciated. Finally, I would like to thank Hatem and Nadia for providing me with encouragement and support throughout this undertaking.

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List of Acronyms

AHD	Aswan High Dam
BOD	Biological Oxygen Demand
CCME	Canadian Council of Ministers of the Environment
CIA	Central Intelligence Agency
CIDA	Canadian International Development Agency
CLEQM	Central Laboratory for Environmental Quality Monitoring
COD	Chemical Oxygen Demand
EEAA	Egyptian Environmental Affairs Agency
EEIS	Egyptian Environmental Information System
EPAP	Environmental Pollution Abatement Project
ESAs	External Support Agencies
ESCAP	Economic and Social Commission for Asia and the Pacific
GDP	Gross Domestic Product
GEMS	Global Environment Monitoring System
GOE	Government of Egypt
GOFI	General Organisation for Industry
IMF	International Monetary Fund
IWRM	Integrated Water Resources Management
MoH	Ministry of Health
MPWWR	Ministry of Public Works and Water Resources
NGOs	Non-Governmental Organisations
NOPWASD	National Organisation for Potable Water and Sanitary Drainage
NRI	Nile Research Institute
NRL	Nile Research Laboratory
NWRC	National Water Research Center
OECD	Organisation for Economic Cooperation and Development
POPs	Persistent Organic Pollutants
PSR	Pressure-State-Response
PSR/E	Pressure-State-Response/Effects
QA	Quality Assurance
QC	Quality Control
RITSEC	Regional Information Technology and Software Engineering Centre
RNPD	River Nile Protection and Development Project
TECCONILE	Technical Co-operation Committee for the Promotion of the Development and Environmental Protection of the Nile Basin
UNDP	United Nations Development Programme
UNICEF	United Nations Children's Fund
UNU/INWEH	United Nations University International Network on Water, Environment and Health
US AID	United States Agency for International Development
US EPA	United States Environmental Protection Agency
USGS	United States Department of Interior: Geological Survey
VEAs	Valued Environmental Attributes
WASAMS	Water and Sanitation Monitoring System
WHO	World Health Organization
WRC	Water Research Center
WQI	Water Quality Index

Every time I have written the history of man there hovered before my mind's eye the image of a river, but only once have I beheld in a river the image of man and his fate.

- Emile Lodwig -

CHAPTER ONE - INTRODUCTION

With the dawn of the twenty-first century approaching, scarcity and misuse of water have begun to emerge as significant threats to the political and socio-economic well-being of a number of nations throughout the world (Homer-Dixon, 10 May 1994; World Resources Institute, 1996). Between 1940-1990, withdrawals of freshwater from rivers, lakes, reservoirs, aquifers, and other sources increased by more than a factor of four. Increases in irrigation and industrial use of water accounted for most of this steep growth in demand (World Resources Institute, 1996). According to the World Resources Institute, "[t]he world's thirst for water is likely to become one of the most pressing resource issues of the 21st Century" (1998, 1). The ability to meet the demand will depend on three factors: the amount of renewable water available to the respective countries, the quality of the water, and the effectiveness and efficiency in managing the resource.

The contamination of water supplies contributes heavily to problems of water scarcity by reducing the available quantity of usable water. Over the past three decades, strict legislation and major investments in water and sanitation infrastructure have led to significant progress in improving water quality throughout much of the developed world. In many developing countries, contamination of water supplies is on the rise (World Resources Institute, 1998). Traditionally, the focus of water resources management in non-western countries has been on water quantity (Biswas, 1992). Within the past decade, there has been a movement towards widening this focus to include water quality. Thus far, water quality management has only been loosely established in the developing world (Carrier and Parry, 1995; World Resources Institute, 1998).

Water quality management in Egypt has recently been gaining in importance as the country's only supply of renewable freshwater, the River Nile, receives more waste from both point and non-point sources due to a rapidly growing population and accelerated industrialisation. Studies have been undertaken which suggest that pollution is affecting the utilization of Nile water (Abdel-Gawad, 1994; El-Sherbini and El-Moattassem, 1991). In the absence of effective water quality management and a strong policy environment, sustainable development of the nation's socio-economic resources cannot occur (World Resources Institute, 1996).

PURPOSE AND OBJECTIVES

This study assesses the state of water quality management in Egypt for the purpose of providing recommendations to the appropriate agencies on where improvements to the system can be made. Specifically, the following will be achieved:

- identification of the sectors of government directly or indirectly involved in water quality monitoring and management in Egypt and the determination of their roles and responsibilities;
- identification and summation of the main components of Egypt's national water quality management programme;
- situational analyses of the main components of Egypt's national water quality management programme;
- determination of the role of international agencies and multi-lateral banks in water quality monitoring and management, current trends and their implications;
- development of recommendations regarding the main components of Egypt's national water quality management programme; and
- communication of findings to the appropriate authorities and the general public.

SCOPE

In both developed and developing countries, water resources planners and managers are experimenting with a nascent theoretical approach to water resources management – integrated water resources management (IWRM) – in place of the traditional unilinear, sectoral approach (Perry and Vanderklein, 1996). In order to effectively address current water concerns, the Egyptian Ministry of Public Works and Water Resources (MPWWR) has adopted a policy of integrated water resources management. The Ministry's approach comprises "the quantitative and qualitative management of water resources, including the institutional framework that governs the obligations and benefits of the water users" (Attia and van Leeuwen, 1994, T2-S2:4.15). On an operational level, however, water resources management is not fully integrated in Egypt nor anywhere else in the world at the national level (Gardiner et al., 1994; Perry and Vanderklein, 1996; Thompson, personal communication, 1998). Hence it was not feasible given the resources and time available for this study to evaluate both the quantitative and qualitative management of Egypt's water resources. This Master's Degree Project will focus specifically on water quality management although the author acknowledges that the two are strongly interrelated.

Water quality management is a complex subject. Its scope is related to the types of water-uses, which are manifold. Also relevant is the nature of the source such as groundwater, surface water, or precipitation. For the purposes of this document, only the River Nile, which is the main and almost exclusive source of surface water in Egypt, was considered. Although groundwater is extracted for various uses, it was not included within the realm of this study, mainly for the sake of concentrating the focus. Moreover, the issues surrounding groundwater are quite different from those of managing the surface waters of the River Nile Valley and the magnitude of the groundwater issues is of a smaller scale.

The River Nile crosses through ten nations prior to spilling its waters into the Mediterranean Sea. The Nile Basin countries are Burundi, Democratic Republic of Congo, Egypt, Eritrea, Ethiopia, Kenya, Rwanda, Sudan, Tanzania, and Uganda. Transboundary issues are being addressed by the Technical Co-operation Committee for the Promotion of the Development and Environmental Protection of the Nile Basin (TECCONILE, 1994). This assessment concentrates solely on the activities occurring within the River Nile Basin boundaries of Egypt. The overall focus is not on the scientific or technical aspects of maintaining or restoring water quality, but rather on the existing and potential capabilities of the Egyptian government in addressing water quality issues.

In summary, the present study is an examination of the state of quality management of the River Nile waters within the borders of Egypt. It is intended for water quality managers, decision-makers, planners, and academia.

RESEARCH METHODOLOGY

Two research methodologies were used for the purpose of this study: literature review and key informant interviews.

Literature Review

The literature review involved a review of relevant research topics and a review of methodology. A variety of sources were used including consultants' reports, government documents, the author's undergraduate thesis, international development agency reports, conference proceedings, United Nations documents, CARL UnCover and other library databases, previous Master's Degree Projects, and the World Wide Web. Search terms included water quality management, water quality monitoring, and River Nile.

Review of Relevant Research Topics

The review of relevant research topics was broken down into several main categories:

(1) background information on Egypt;

(2) information on Egypt's national water quality management programme;

(3) Egypt's institutional set-up (i.e. institutions and agencies with mandates that encompass water quality);

(4) studies in which water quality management has been assessed; and

(5) information on water quality management programmes in other nations.

Moreover, a set of criteria for analysing the main elements of Egypt's national water quality management programme were derived predominantly from Criteria for and

Approaches to Water Quality Management in Developing Countries (United Nations Department of Technical Co-operation for Development, 1991) and Water Quality Monitoring in the Asian and Pacific Region (ESCAP, 1990). Based on the situational analyses of the components, key informant interviews, and a review of the approaches of other nations to water quality management, recommendations were devised.

Review of Methodology

The review of methodology focused on key informant interviews and instrument development (e.g. devising a set of criteria). The review included social science research method books such as Neuman (1997), Sproull (1995), and Berg (1989).

Key Informant Interviews

The key informant interviews served the following five purposes:

- to provide information on the different mechanisms used to manage the quality of water resources;
- to provide expert input on water quality management problems and issues within Egypt;
- to test conclusions of the researcher such as inferences made from readings;
- to provide feedback on the recommendations; and
- to provide feedback on research instruments and their development (e.g. questionnaire).

The interviews were conducted in person and by email. They consisted of a series of semi-structured, open-ended questions (see Appendix A). The focus of the interview changed according to the person's area(s) of expertise and knowledge gained from previous interviews. The nature of the data was inherently qualitative due to the restructuring from interview to interview. In order to increase the degree of validity, several of the same questions were posed to different informants.

The selection of informants is a key component in ensuring high quality, credible, and reliable information. Based on a lecture given by Wardell (1996) on key informant interviews and previous personal experience, a set of criteria for selecting key informants was developed. The criteria were as follows:

- *role* – an informant's role is usually an indicator of his or her responsibility and authority;
- *knowledge* – the informant had to be thoroughly knowledgeable on the subject;
- *impartiality* – a balance had to be achieved through interviewing partially biased experts and impartial informants. The benefits of including both types are the range of information that can be acquired and the additional insight gained from getting different perspectives on the various issues. Furthermore, it can serve to draw out some latent issues;
- *accessibility to researcher* – the researcher had to have access to the expert, either electronically or face-to-face; and
- *willingness* – the person had to be willing to share his or her knowledge with the researcher.

Experts were identified through the literature review, personal referrals, and through current contacts. Approval was received by the Faculty of Environmental Design Ethics Committee prior to the interviews.

LIMITATIONS

Given the nature of the study, an investigation into water quality management in a developing country, two key problems were expectedly encountered. They are briefly described below. Neither of the problems, however, was serious enough to prevent the objectives of the Master's Degree Project from being met.

Limited Amount of Published Data

Most of the data collected by the various ministries is for internal use only and can be very difficult to access. The limited amount of published data that is available is found in the form of conference papers and international consultants' reports.

The reader will note that many of the references are from 1992 and 1994. The reason for this occurrence is two-fold: donor project and international conference. In 1992, two water quality reports were published upon completion of a project heavily funded by the United States Agency for International Development (US AID). They represent the last comprehensive assessment of water quality management done to date in Egypt. The author attempted to contact one of the principal investigators to determine the fate of the documents, but received no reply. In 1994, Cairo, Egypt played host to the VIII International Water Resources Association World Congress on Water Resources. The conference provided Egypt's water quality professionals an opportunity to showcase their work.

In order to overcome the lack of published data, key informant interviews were carried out. In addition, access was gained to some internal documents through established contacts. There were situations, however, where due to a lack of available resources the information simply did not exist or had not been recently updated.

Inconsistent Figures

The reader may find that some of the figures in this document do not add up. The author tried to cross check all the figures, however, in certain cases the statistics did not match. The discrepancies between the figures are most likely due to the different measurement techniques used and the different assumptions made by the researchers regarding what to include or exclude in the calculations. In situations were there was a significant difference in the figures provided by several credible sources, the most conservative number was used.

CHAPTER TWO – WATER QUALITY MANAGEMENT: GENERAL DISCUSSION

During the mid-1800s, the main threat to water quality was faecal contamination of surface waters. The untreated water caused serious health problems (e.g. cholera, typhoid). By the turn of the century, sewage networks began to emerge in European and North American cities in order to prevent further outbreaks (Mason, 1991; Wohl, 1983; World Resources Institute, 1996). However, the post-World War II dawning of the "chemical age" has led to new and more complex challenges. Watersheds throughout the world have come under heavy onslaught from industrial and agricultural pollutants including synthetic organic chemicals, radioactive wastes, and micropollutants (GEMS, n.d.; Mason, 1991; Meybeck et al., 1990). Water managers, planners, and decision-makers are no longer concerned solely with securing an adequate supply of water. They are facing the additional tasks of ensuring that the public's health is not endangered, that the natural assimilative capacity of the aquatic ecosystem is maintained and/or restored, and that the water is of suitable quality to support socio-economic development (USGS, n.d.). It is within this context that the current water quality management framework has emerged.

The United Nations Water Conference, held in 1977 in Argentina, was the first high level meeting to specifically discuss water resources. The Mar del Plata Action Plan, which emerged out of the conference, called for "concerted and planned action --- to avoid and combat the effects of pollution in order to protect and improve where necessary the quality of water resources" (United Nations Department of Technical Co-operation for Development, 1977, iii). The conference's action plan led to the declaration of the 1980s (1981-1990) as the United Nations International Drinking Water Supply and Sanitation Decade (Okun, 1991). The ambitious target of the Decade was to provide universal access to clean water and sanitation: the equivalent of providing nearly half a million people with clean water and sanitation every day for a decade (Clarke, 1993; World Resources Institute, 1996). With nearly US $100 billion in investments, some progress was made during the 1980s: the number of urban people in the developing world with access to adequate water supplies increased by about 80% and the number of people with access to adequate sanitation facilities increased by approximately 50% (World Resources Institute, 1996). Population growth, however, served to undermine the success of the programme (Clarke, 1993; Okun, 1991; World Resources Institute, 1996). The greatest contribution of the Decade was the increase in priority given to water supply and sanitation at the national and international levels (Okun, 1991). This was made evident during a special session in 1997 when the United Nations General Assembly called for the highest priority to be given to the problems of freshwater (e.g. quality, quantity), particularly in the developing world (United Nations University: International Network on Water, Environment and Health, n.d.). Against this backdrop and alongside changing values and greater scientific understanding, the field of water quality management has progressively evolved.

CHANGING VALUES

The approach that a nation adopts in addressing water quality issues is dependent upon the political, cultural, and economic processes within that society. More specifically, the approach to water quality management arises out of the assignment of use-oriented values to the water resources, and consequently, the planning for implementation of goals based on those values. According to Perry and Vanderklein (1996), water quality management goals reflect a nation's balance between social pressures, environmental values, public perception, and previous experience with critical pollution problems. Each nation weighs differently the utilitarian uses of water versus the social and ecological values its population places on the resources. This weighting system can be described as lying along a continuum raging from utilitarian to naturalistic.

Meffe and Carroll (1994) describe the utilitarian view as being strictly anthropocentric: the environment is valued solely in terms of the goods and services it yields for humans (i.e. instrumental value – what is it good for?). Management within a utilitarian framework is about the control of nature for human benefit (Livingston, 1989). Countries, such as

Egypt, which subscribe to this paradigm are usually guided by development goals, e.g. constructing irrigation systems. At the turn of the nineteenth century, Gifford Pinchot, a pre-eminent professional forester, concisely summed up the founding principle of utilitarian resource management: "The first great fact about conservation is that it stands for development" (Livingston, 1989, 341). In this context, management refers to the manipulation of natural resources (Thompson, personal communication, 1998). Water quality is addressed only insofar as it affects the beneficial uses of the resources. Maintaining the integrity of aquatic ecosystems is not considered. Historically, the majority of the world's societies adopted this approach. It is still widely used in the developing world. Midway on the values' scale are the societies that place a high value in the instrumental use of the water resources; however, they differ from the utilitarians in that they place explicit value on the integrity of ecosystem functions such as nutrient cycling. Naess (1973) refers to this perspective as shallow ecology. It is centered around the need to apply ecological principles to ensure optimum management of natural resources and advocates pollution control as a means of controlling resource degradation (Jacob, 1994). Over the past two decades countries like the United States, Canada, and several western European nations have shifted from the utilitarian end of the scale to the center, adopting a stewardship ethic (Meffe and Carroll, 1994). At the far end of the continuum are the eco-centric naturalists, such as Rolston III (1991), who advocate this extreme paradigm shift. The roots of this movement, which Naess (1973) terms deep ecology and Taylor (1986) refers to as biocentric egalitarianism, can be traced to Leopold (1949) and his Land Ethic. Under a naturalistic system, aquatic ecosystems have intrinsic value and all organisms have a right to exist, irrespective of their commercial value. No nation currently subscribes to the system advocated by the deep ecologists.

Colby (1990) devised a classification system for environmental management as a counterpart to the attitudinal continuum. The environmental management paradigms differ in their consideration of values along an extrinsic-intrinsic continuum and the temporal and spatial levels at which they operate. The most anthropocentric model, Colby termed frontier economics. Under this model, water represents an infinite supply and is available for the sole purpose of benefiting humans (i.e. as a source and sink). At the other end of the spectrum, Colby presents the deep ecology view. It requires an approach of zero-economic growth and a decrease in human population. Perry and Vanderklein (1996) and Harper and Stein (1995) argue that this framework is unrealistic. The mid-point of the classification system, Colby refers to as the environmental protection paradigm. Under this approach, water quality standards are based on command and control policies and end-of-pipe treatments (i.e. "quick fix"). The assimilative capacity of the water bodies is used to define an optimum level of pollution that can ensure the utilitarian uses of the water while maintaining ecosystem functions. This approach to environmental management is fairly moderate; it does not necessarily require a commitment to source reduction. The focus is on treatment of wastewater before it is released into the environment rather than on exploring ways to reduce the waste stream through methods such as demand management and the redesign of industrial processes (i.e. pollution prevention techniques). Not surprisingly, most industrialised countries have adopted this moderate approach to water quality management (Eden and Haigh, 1994).

The ideal environmental management framework is not found in Colby's work. It is one that permits creativity in the selection of mechanisms and tools to address water quality issues (Perry and Vanderklein, 1996; Thompson, 1996). The three main mechanisms are command and control, self-regulation, and economic instruments (Schmidheiny, 1995). The optimum management paradigm would dissuade the use of a blanket approach by encouraging governments to experiment with combining a variety of tools from the three main mechanisms to find the optimum mix for addressing their specific water quality issues (see Table 1).

Table 1. Examples of tools that could be used for water quality management.

Mechanisms	Command and Control	Self-regulation	Economic Instruments
Tools	Taxation	Codes of Practice	Performance bonds
	Regulations	Strategic planning & mgt.	Pollution permits
	Strong enforcement of legislation	Environmental auditing	Full cost pricing
	Strict penalties for violations	Education & training	Subsidy reforms

(Source: Schmidheiny, 1996; Thompson, 1996)

SCIENTIFIC ADVANCEMENTS

While society's value system dictates how water quality issues are addressed, science dictates our level of understanding regarding the biophysical characteristics of our water resources.

Thirty years ago, the practice of water resources management centered on increasing production (e.g. increasing productivity of a fish stock): maintaining water quality was supplemental. As scientific understanding increased, the focus shifted to answering population-specific questions relating to anthropogenic effects. The emphasis on a command and control approach (i.e. government regulations) to achieving population level goals, however, remained.

The command and control approach is ideal in situations where the problem is well defined, clearly delineated, relatively simple, and generally linear with respect to cause and effect (Holling and Meffe, 1996). It is also particularly valuable when there is a critical threat to health or safety (Schmidheiny, 1995). Where this method fails is when the required administrative infrastructure is insufficient to ensure compliance, and most importantly, when it is applied to the complex, nonlinear, and poorly understood world of the natural environment. The results can have severe social and economic repercussions. Moreover, ecosystems face the threat of losing their resiliency, making them more vulnerable to disturbances with unpredictable results. The command and control approach as it has traditionally been applied to natural resources management is based on the assumption that nature must be controlled in order to harvest its goods and services, reduce the threats it poses to humans, and establish predictive outcomes. As Holling and Meffe succinctly state, this method of management is founded on the belief that "humans can select one component of a self-sustaining system and change it to a fundamentally different configuration in which the adjusted system remains in that new configuration indefinitely without other, related changes in the larger system" (1996, 30). Environmental degradation, however, is the result of cumulative interactions between the physical, chemical, and biological elements that compose the ecosystem: any change to one element could affect the others across both spatial and temporal scales.

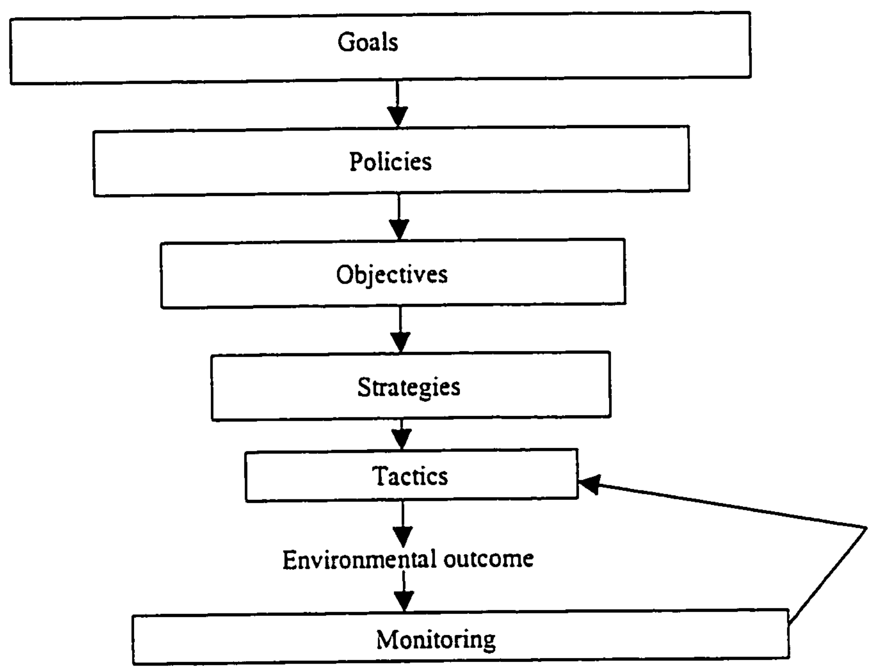
A string of failures ranging from the dying Aral Sea in Kazakhstan and Uzbekistan to the rapidly shrinking Ogallala aquifer in the United States highlight the inherent weakness in the command and control approach to natural resources management (World Resources Institute, 1996). Advances in scientific understanding were needed before a better system of management could be devised. By the end of the 1960s, ecologists working in terrestrial and aquatic ecosystems began to identify ecosystem level properties. It was not until the early 1980s, however, that the scientific ideas regarding ecosystems began to gain credibility and widespread support among scientists (Perry and Vanderklein, 1996). With these new theories came the realization that focusing strictly on one level of the biodiversity hierarchy (genes, species, population, etc.) is not sufficient; managers must seek understanding of the connections between all levels over spatial and temporal scales (Grumbine, 1994). In other words, in order to maintain the ecological integrity of an ecosystem, a prerequisite for multiple use, there must be an awareness of the structure and dynamics of the system.

WATER QUALITY PLANNING AND MANAGEMENT

The changing values of society combined with recent scientific advancements, as discussed above, has focused the attention of decision-makers, planners, and managers to the need for an integrated management paradigm that recognizes and addresses the links between the biophysical resources of an ecosystem and acknowledges the social context in which the resources are managed. Presently, the most widely used water resources management framework has as its foundation a linear management planning process. Within this paradigm, translating goals into action is a unidirectional, linear process (see Figure 1A): water resources management becomes unidimensional with actions designed to address single-purpose needs. The problems with this system include minimal attention given to ecological consequences or impacts on other uses; there is no process for feedback; public input is lacking; and management agencies become myopic, inflexible, and isolated from the managed system (Holling and Meffe, 1996). The rate of sedimentation in the Aswan High Dam (AHD) reservoir provides a good example of why unilinear management approaches do not necessarily succeed given social and environmental realities. The Aswan High Dam was constructed to provided Egypt, the tenth and most downstream nation on the River Nile, a secure supply of water. Over the past several years, rapid population growth in the Nile Basin has led to the destruction of natural areas for settlement and as a source of resources (e.g. clearcutting of the Ethiopian Highlands denuding the slopes of forest cover). Consequently, there has been increased erosion in the Nile watershed leading to greater sediment loads entering the Upper Nile. A portion of the suspended sediment reaches the Aswan reservoir where rates of sedimentation have greatly exceeded forecasts and are reducing the expected life span of the reservoir (Duthie, personal communication). In the future, this could have severe socio-economic repercussions for Egypt. This example highlights both the social pressure placed on the aquatic ecosystem, in this case the River Nile watershed, and the environmental outcome.

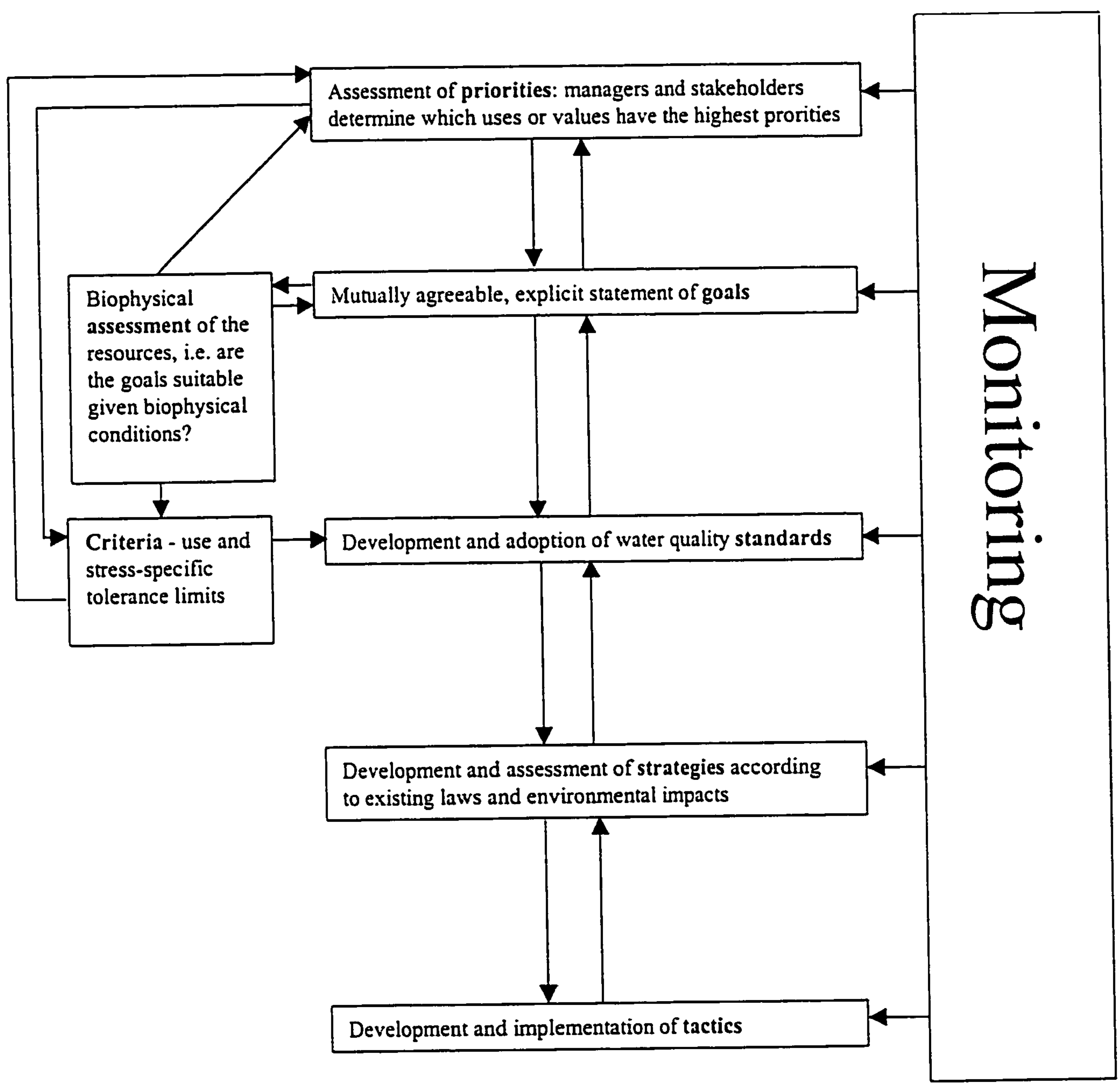
Water quality management is slowly shifting towards more hierarchical, iterative planning models (see Figure 1B). According to Perry and Vanderklein (1996), the following four characteristics separate multidimensional hierarchical planning from unidimensional planning:

Figure 1A. Traditional, unilinear water quality planning model.



(Source: Perry and Vanderklein, 1996)

Figure 1B. Hierarchical, iterative water quality planning model.

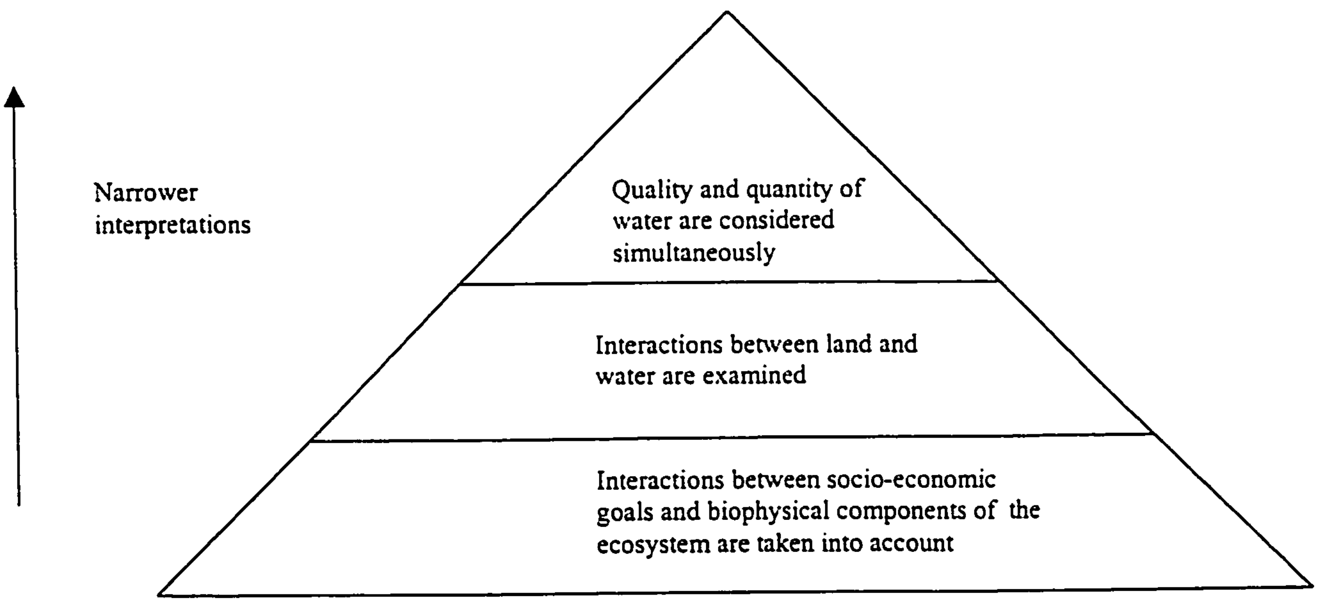


(Source: Adapted from Perry and Vanderklein, 1996)

- understanding of the characteristics of the water resources ranks equally with goal definition;
- feedback loops exist at each stage of planning (i.e. it is an iterative process);
- local population is involved in the decision-making process; and
- monitoring is integrated throughout the stages and effectively links them together (i.e. monitoring involves more than just carrying out biophysical assessments to determine the state of a water body). Information provided by monitoring assists in areas such as determining whether management goals continue to be viable and appropriate and whether environmental impacts could outweigh the benefits of proposed management actions.

To this list should be added assessing social, environmental, and economic risks (i.e. cross sectoral risk assessment) and setting priorities for multi-purpose use (Thompson, 1996). Because multidimensional planning is iterative and multilayered it is more apt than linear planning to detect ecosystem and social impacts arising from management actions. Integrated water resources management has emerged from this paradigm shift. Many countries have adopted IWRM as a general principal. Nevertheless, there exists a range of interpretations as to what constitutes integration similar to the on-going debate over the definition of sustainable development. At one end of the spectrum are the narrower interpretations in which management is seen as being integrated if the quality and quantity of water supplies are considered simultaneously (Perry and Vanderklein, 1996). The Egyptian Ministry of Public Works and Water Resources' policy for IWRM, as defined in Chapter One, aptly reflects this interpretation. Midway along the spectrum are the management approaches in which integration incorporates two main media for the transportation of pollutants – land and water (Gardiner et al., 1994). This broader focus includes riparian zone management and non-point source control. Under the most inclusive definition of integration, management encompasses the interaction between the socio-economic goals set by society and the biophysical components of ecosystems (see Figure 2). (Perry and Vanderklein, 1996). Ecosystem management incorporates this broadest definition of integration.

Figure 2. Spectrum of interpretations of integrated management.



(Sources: Gardiner et al., 1994; Grumbine, 1994; Perry and Vanderklein, 1996)

Grumbine, after conducting an extensive literature review on the subject, formed the following working definition: "Ecosystem management integrates scientific knowledge of ecological relationships within a complex sociopolitical and values framework toward the general goal of protecting native ecosystem integrity over the long term" (1994, 31). It is characterised by adaptive management (i.e. management is considered a learning process whereby results of previous actions are incorporated) and calls for flexible agencies, interagency cooperation, more self-reliant industries, more knowledgeable citizenry, and continuous monitoring and research (Grumbine, 1994; Holling and Meffe, 1996; Ecological Society of America Committee, 1996). Industrialised nations such as the United States, United Kingdom, and Canada are experimenting with implementing an ecosystem management approach to water resources management (see *Tennessee Valley Authority*, Clarke, 1993; *Fraser River Action Plan*, Environment Canada, 1997; *National Rivers Authority*, Gardiner et al., 1994; *Water Conservation Authorities*, Mitchell and Shrubsole, 1992; *International Joint Commission*, Weller, 1990). Although ecosystem management is currently not as popular in the developing world as in the developed world, there are several nations such as Nigeria and Ghana that are attempting to adopt this approach (see *Paradigms in Motion*, Perry and Vanderklein, 1996).

In developed and developing countries alike, there exists a gap between the development of a policy for IWRM and the implementation of such a policy. No country has yet managed to effectively integrate water resources management at the national level; sectoral management continues to occur in nearly every country worldwide (Gardiner et al., 1994; Perry and Vanderklein, 1996; Thompson, personal communication, 1998).

WATER QUALITY MANAGEMENT WITHIN THE CONTEXT OF THE DEVELOPING WORLD

In terms of dealing with water quality issues, there is a clear chasm between the developed world and the developing world. While waterborne diseases have been virtually eliminated in industrialised countries, gastro-enteric diseases continue to plague developing nations at alarming rates (Clarke, 1993; GEMS, n.d.). Poor water quality is responsible for 80% of diseases and 33% of deaths in the developing world (ECOSOC, 1996). At the same time as dealing with microbial pathogens, nations which have introduced industrialisation and overseen the intensification of their agriculture are beginning to encounter eutrophication, nitrates in groundwater, bioaccumulation of pesticides, and bioaccumulation and biomagnification of heavy metals in aquatic biota. For the most part, the developed world has had the relative luxury of dealing with these threats sequentially (Meybeck et al., 1990). Despite facing such a range of different types of pollutants all at once, comprehensive water quality management in developing countries is still in its infancy (Carrier and Parry, 1995). Egypt, having started monitoring water quality in the 1970s to determine the effects of the Aswan High Dam on the River Nile and to support management initiatives, is at the forefront. Currently, information does not exist for most of the non-industrialised world to assess the extent of water pollution and its corresponding social, economic, and environmental impacts. What is known, however, is that nations in hot semi-arid environments (e.g. Egypt) are already on the verge of reaching a condition of water scarcity (1000 cubic metres per capita per year) (Shady et al., 1996). They cannot afford to lose their meager supply of water to pollution. Moreover, international agencies such as the United Nations Department of Technical Co-operation for Development are starting to consider water quality an issue of primary concern. In many contemporary water resources development projects, the principal problem is no longer one of locating a source of water, but locating a source of water of adequate quality (United Nations Department of Technical Co-operation for Development, 1991; World Resources Institute, 1996).

While most developed nations have policies in place to encourage the prevention of water pollution (e.g. through the adoption of non-polluting, low residue technologies), in many developing nations a utilitarian, sectoral approach to water resources management figures prominently: social and environmental dimensions are given cursory consideration. In order for the lower income nations to address the dangers posed by water pollution to the health of their citizens, the health of their ecosystems, and the growth of their economies, they will have to shift from their unilinear, unidimensional planning process to a more multidimensional method. According to the United Nations Department of Technical Co-operation for Development (1991), a lack of long term, strategic planning is one of the underlying reasons why the state of water bodies continues to deteriorate. Strategic planning serves to address three basic questions: Where are we today? Where are we going? and How do we get there? The process, as summarized by Thompson (1996), involves setting goals and objectives; organizing the resources needed to meet the goals and objectives; defining, selecting, and implementing strategies; assessing risks and priorities; and assessing performance and providing feedback. Many nations not only do not follow a process of strategic planning, but also do not possess the requisite building blocks. They are as follows:

- water policy,
- adequate legislation and implementation,
- adequate data and required infrastructure,
- knowledge of appropriate technology, and
- fiscal policy (ESCAP, 1990; Hamza, 1991; Thompson, personal communication, 1998).

Each component is essential to effectively manage water quality.

The perceived cost for developing countries to address water quality issues has been a major reason for the lack of action taken to protect their aquatic ecosystems. To the respective governments it may appear to be prohibitively expensive. However, in the long term, costs of failure to protect water quality may be even higher. Very few cost-benefit analyses of projects aimed at reducing pollutant loads in developing countries have been conducted, although there is general agreement among water resources managers that preventive action is preferable. A cost-benefit analysis of improving the water quality of a river in Thailand revealed that treatment of 75% of the effluent discharged into the river could lead to benefits ten times greater than the estimated cost of the project (United Nations Department of Technical Co-operation for Development, 1991). Over the past decade, various international organizations and foreign aid agencies, having identified financial constraints as one of the key limitations to tackling water pollution, have developed explicit policies for supporting water quality initiatives. For example, WHO and UNICEF, in consultation with agencies and sector managers throughout the developing world, have developed a cost-effective, easy-to-use Water and Sanitation Monitoring System (WASAMS). One of the driving forces behind the development of WASAMS was the recognition by the United Nations that a strong monitoring system can strengthen national capacities in management (WHO/UNICEF Joint Monitoring Programme, n.d.).

Water quality management and the benefits derived should not and need not be the exclusive domain of the developed world. Cooperation and collaboration at all levels from local to global can ensure that the nations which face the greatest threats to their aquatic ecosystems can design and implement a cost-effective national water quality management programme.

CONCLUSION

As we head towards a new millenium, the threat that our waterways are facing is greater than at any other time. Water managers, planners, and decision-makers have to deal with micropollutants, radioactive waste, organochlorines, and other extremely complex pollutants. In developing countries, these pollutants need to be addressed alongside the more traditional contaminants such as microbial pathogens.

Changing values alongside steady scientific advancements have led to the evolution of water quality management in the developed world. In many non-industrialised countries, a utilitarian approach to water resources management predominates with water quality issues receiving minimal attention. In both the developed world and the developing world, water quality management that considers the social, political, economic, and environmental dimensions can help assure that water quality does not become the primary constraint in a nation's socio-economic development, nor threaten the health of its people and its aquatic systems.

CHAPTER THREE – BACKGROUND INFORMATION ON EGYPT

DEMOGRAPHICS AND GEOGRAPHY OF EGYPT

Situated in the arid belt of North Africa and Western Asia, Egypt covers a total area of 1,001,000 km^2 and shares its border with the Mediterranean Sea to the north: Gaza Strip, Israel and the Red Sea to the East; Sudan to the south; and Libya to the west (CIA, 1994). This strategic location places Egypt at the crossroads between Africa, the Middle East and Europe (The Egyptian Presidency, 1997).

Cairo, the capital of Egypt with a population in excess of 15 million, is the largest city in Africa, the Arab World, and the Middle East (Camp, Dresser & McKee Inc., 1995; The Egyptian Presidency, 1997). It is also the industrial and commercial center of Egypt. Other major cities include Alexandria, Egypt's principal port; Luxor; Aswan; Port Said at the Mediterranean entrance to the Suez Canal; and Suez, the southern terminus of the canal. In terms of administrative divisions, Egypt is split into 26 governorates (Information Programme for Governorates Development, 1997).

The River Nile divides the country into four bioregions: the Western Desert which occupies almost two-thirds of the total area, the Eastern Desert, the Sinai Peninsula, and the Nile Valley and Delta. The vast majority of Egypt's population (99%) is concentrated along the coastal zones and in the Nile Valley where the population density reaches 1300 people/km^2 (Espenshade, 1993). The Bedouins sparsely occupy the remaining area, made up mostly of arid desert. Overall, only 5.5% of Egypt's total area (i.e. 55,000 sq km) are inhabited (The Egyptian Presidency, 1997).

Flowing south to north through ten nations and 6,825 km of equatorial and northeast Africa, the River Nile is the longest river in the world. It has as its main sources the White Nile, originating in Lake Victoria and Lake Albert in Central Africa, and the Blue Nile with its headwaters in the highlands of Ethiopia. These two tributaries join at Khartoum, Sudan. At this point, the Nile still has to flow over 3,000 km to reach the Mediterranean Sea through a harsh environment characterized by intense heat and negligible amounts of precipitation, with no significant tributaries to replenish it (Collins, 1990). Slightly north of the city of Cairo, the Nile splits into the Rosetta Branch, flowing northwestward, and the Damietta Branch, flowing northeastward, forming the highly arable Nile Delta (see Figure 3) (Mercer and Nadar, 1991).

Within Egypt, the Nile Valley is composed of an 18 km wide floodplain, which is bordered by flat terraces, and the sizeable Nile Delta, which is 150 km long and widens to 220 km at the coastline. In the Mediterranean coastal zone, rainfall ranges from 125 mm/yr in the west to a national high of 200 mm/yr in the east. As one moves inland, annual precipitation drops dramatically to about 20 mm/yr around Cairo, 200 km from the coast, and to less than 5 mm/yr in Upper Egypt (Abu Zeid, 1992). Egypt's semi-arid climatic conditions preclude the use of rainfed agriculture except along a narrow strip of the northern coastal areas (Attia et al., 1991).

Home to 62.9 million people, Egypt is the most populous nation in the Arab World. The majority of its citizens (94%) are Muslims, with Christians comprising the remainder (CIDA, 1998). Given the current rate of population growth at 2.1% per annum, it is estimated that the nation's population will swell to 70 million by the year 2000 (Center for International Health Information, 1996). Overall, its citizenry is quite young with 40% of Egyptians under 15 years of age. Presently a slim majority of the people live in rural areas. However, a shortage of employment in the countryside has driven rapid urbanization: within the span of a decade the population of Greater Cairo doubled. The percentage of people living in urban areas has reached an unprecedented 45%. Despite this migration, chronic unemployment affects one out of every five workers (CIDA, 1998).

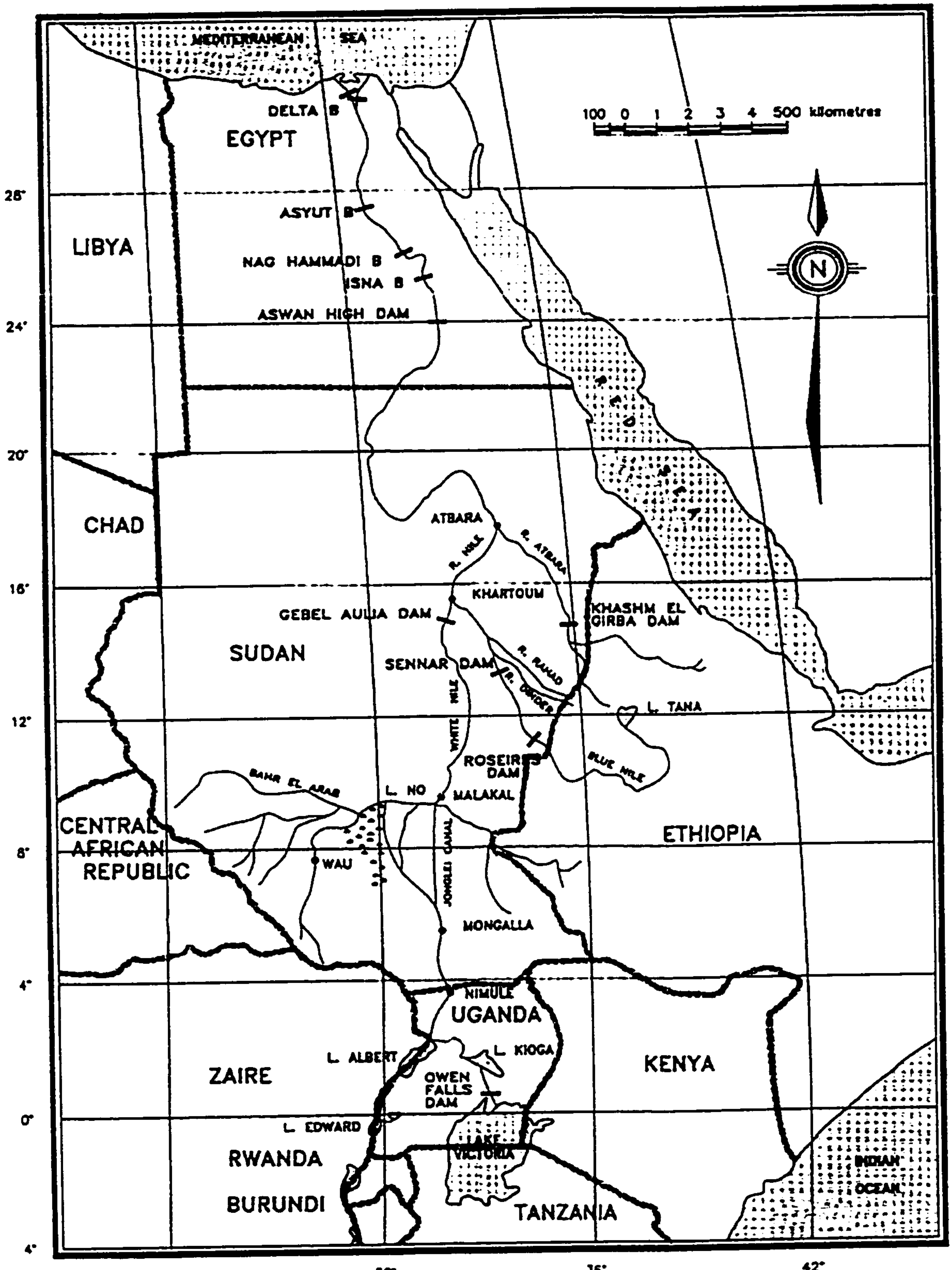


Figure 3. Map of the River Nile Basin

(Source: Abdelbary and Shady, 1992)

ECONOMIC PROFILE

A nation's economy (e.g. agrarian, industrial) greatly affects the amount and quality of water needed for continued economic growth and the manner in which the water resources are managed. Historically, agriculture has been the dominant sector in the Egyptian economy, providing the bulk of employment and output crucial to foreign exchange earnings and has traditionally received substantial government support. During the late 1950s and early 1960s, however, the groundwork was laid for the transition to industrialisation. Through the promulgation of a series of laws, the government took over control of the economy, developing the industrial sector, fixing prices and quotas, and administering a complex welfare system (CIDA, 1998). Growth of the Egyptian economy has come to be based on the expansion of the industrial sector. By 1992, industry accounted for 30% of the Gross Domestic Product (GDP) while agriculture's share of the GDP fell from 34% in 1955 to 18% in 1994 (World Bank, 1994). Today, Egypt has one of the largest public sectors of all the developing economies with the majority of industrial plants being publicly owned (CIA, 1994). There is some contention among Egyptians as to whether Egypt should be considered a developing country or not. The World Bank and the Canadian International Development Agency (CIDA), however, categorize Egypt as part of the developing world. This document adopts their classification.

Despite the move towards industrialization, Egypt's economy has not been characterized by steady growth. During the late 1970s and early 1980s, its economy grew quickly. In 1986, however, the collapse of world oil prices, rapid population growth, and an increasingly heavy burden of debt servicing led Egypt to initiate negotiations with the International Monetary Fund (IMF) for balance-of-payments support. By 1991, agreements had been signed with both the IMF and World Bank which spearheaded the Egyptian government's nascent programme of economic liberalization (CIA, 1994). The key objective of this structural programme is to lay the foundation for a decentralized economy through measures aimed at downsizing the government and giving more responsibility to the private sector and non-governmental organizations (NGOs) (CIDA, 1998).

Although the liberalization programme got off to a slow start, some headway has been made towards a more open and efficient economy. The Government of Egypt (GOE) has cut consumer subsidies, reduced trade barriers, liberalized interest rates, and reduced the budget deficit from 20% of Gross Domestic Product to under 1.3% (US AID, 1998; CIDA, 1998). It must be noted that the significant drop in debt was due in part to the members of the Paris Club agreeing to forgive 50% of their holdings of Egyptian debt (US AID, 1996). Despite the progress made to date, the Egyptian Government has been slow in implementing the legal and regulatory reforms needed to support private sector led, export-oriented economic growth. As a result, there has been a steady increase in the rate of unemployment (chronic unemployment affects 20% of the workforce) and impoverishment, slow economic growth, a rise in religious extremism, and a stagnant per capita Gross National Product (CIA, 1994; CIDA, 1998; US AID, 1996). Physical constraints such as a shortage of arable land and a lack of water are compounding the problems (CIDA, 1998).

The area of Egypt's economy, which has been hardest hit over the last 30 years, has been the agriculture sector. In the past, Egypt was agriculturally self-sufficient. During the 1960s, agricultural production grew at over 3% annually. Throughout the 1970s and early 1980s, the pace of growth declined to around 2%. In 1973, Egypt crossed over a critical threshold becoming a net importer of agricultural products (Kishk and Lundquvist, 1994). By 1994, the annual growth in agricultural production had declined to 1.4% (World Bank, 1994). The driving forces behind the reduced growth in the agricultural sector have been the expansion of the industrial sector, population growth, and year-round irrigation without proper field drainage which has led to a rising water table and increased salinisation (Abu Zeid, 1992; CIA, 1994). However, there have been very optimistic statements issued by Dr. Y. Waly, the Minister of Agriculture and Land Reclamation, which suggest that since 1993 Egypt has made significant progress in agricultural production (e.g. better crop yield, greater area of land reclamation) and that by the end of the year 2000, the country will be self-sufficient in wheat production (Abdelbary, personal communication, 1999).

Despite Egypt's checkered economic performance, the nation has maintained its position as the dominant economic power in the Nile basin with a labor force of 15 million (1992 est.) and a Gross National Product per capita of US $660.00 (1996 est.) (CIA, 1994; US AID, 1996).

WATER SUPPLY

The socio-economic sustainability and growth of a nation is heavily dependent upon a secure and adequate supply of affordably priced "clean" water. In 1990, per capita water availability in Egypt, measured as the annual available renewable water resources per capita, was 1,070 m^3/person/year (Homer-Dixon, 10 May 1994). This amount was sufficient to meet the needs of the country. However, a rapidly escalating population, increasing living standards, and industrialisation are leading Egypt rapidly towards the water poverty line of 1000 m^3/person/yr. This level is considered the benchmark below which a nation is likely to experience chronic water scarcity on a magnitude large enough to impede development and harm human health (Clarke, 1993; World Resources Institute, 1996). It is estimated that by the year 2025, per capita water availability in Egypt will be 620 m^3/year (Homer-Dixon, 10 May 1994).

A more revealing indicator of the stress placed on a nation's water resources currently being utilized by the United Nations, is determining a country's ratio of water consumption to water availability - its use to resource index. Use levels in excess of 20% of the available supply are indicative of moderate to high stress (World Resources Institute, 1998). According to this index, Egypt's available water supplies are under significant stress with 97% being used (Clarke, 1993). Increased efficiency in the water distribution system, improved irrigation methods (e.g. drip irrigation) and the implementation and completion of several planned water resources development projects (e.g. completion of the Jonglei Canal in the Sudd region of Sudan, providing an additional

2.0 bcm/yr of water at Aswan) are several schemes that could potentially increase Egypt's available supply of water and increase the efficient use of its existing supplies (Abdelbary, personal communication, 1999; Abu Zeid, 1992). Presently, ensuring that the quality of existing water supplies is adequate to meet users' needs is imperative; water quality requirements *must* be addressed alongside quantity requirements in order to ensure that the utility of the supply is not impaired.

The main source of water for Egypt is the River Nile. More than 95% of the nation's water supply comes from the river with over 97% of its flow diverted for beneficial use (Abu Zeid and Abdel-Samie, 1994). No other nation in the world is so dependent upon on a single river; the Nile is truly the lifeblood of the nation. Secondary sources (i.e. sources that are fed by water from the Nile) are of a much smaller scale and consist of groundwater, drainage water, and treated wastewater (see Table 2). They will only be briefly discussed in this section. Minor local sources, which are rainfall along the northern coastal areas and rainfall in the Sinai peninsula, won't be discussed further.

Table 2. Annual water supply in Egypt. The year is indicated in brackets.

Source	Current Supply (bcm/yr)	Potential Supply (bcm/yr)
River Nile	55.5	55.5
Flow available for Use (97% of total Nile flow)	54.0	54.0
Groundwater	3.15 (1995)	5.45
Reuse of Agricultural Drainage Water	4.7 (1998)	7.0
Treated Municipal Wastewater	0.26 (1995)	0.73

(Sources: Adbelbary, personal communication, 1999; Attia, 1995; Camp Dresser & McKee Inc., 1995)

Surface Water – River Nile

Within the past century, extensive development throughout the Nile Basin has increased the amount of water that can be used. Currently, there are seven dams and reservoirs built on the Nile and its tributaries. Two of them are for over-year storage including the Aswan High Dam on the main Nile in Egypt (Abu Zeid and Abdel-Samie, 1994). Nearly all the easily available and economically feasible sources of water have been developed or are in the process of being developed.

The River Nile is the exclusive source of surface freshwater in Egypt. Seasonal variations of the main Nile flow are significant. During the flood period, from August to October, more than 80% of the river's total annual discharge occurs. The remaining nine months account for only 20% of the annual discharge (Mancy and Welsh, 1992). Prior to construction of the AHD the total water storage capacity in Egypt was no more than 15 bcm and it was seasonal. No over-year storage facilities existed. The reliance on seasonal storage meant that at least 80% of the annual flood had to be released. Consequently, the supply was insufficient to meet Egypt's growing needs. Furthermore, discharge fluctuated widely from year to year according to the flow of the Nile (annual standard deviation of the river was about 20 bcm), while real needs were constant and high (Waterbury, 1979). The completion of the AHD in 1968 ensured complete control over the Nile from Aswan to the Mediterranean and a reliable supply of water. As Collins wrote in his book The Waters of the Nile:

> From its confluence with the 'Atbara the Nile makes its great S-bend, rolling over three cataracts to flow placidly into the enormous reservoir behind the dam at Aswan. Here the Nile bed is only 87 metres above sea-level, yet has to flow 1,180 km through a myriad of irrigation works and a labyrinth of canals in the delta to deposit a drop of water into the Mediterranean Sea. To all intents and purposes, however, the course of the Nile stops at Aswan (1990, 25).

Despite the control the dam has provided Egypt over the surface water resources within its national boundaries, the geographic position of the country as the most downstream nation in the River Nile Basin makes it very vulnerable to any upstream land or water use changes. To reduce Egypt's vulnerability, the government of Egypt sought a legal agreement with Sudan that would ensure a steady supply. The outcome of the discussions between the two nations was the 1959 Agreement for the Full Utilization of the Nile Waters, otherwise known as the Nile Waters Agreement, which is still in effect. The agreement was based on the average annual natural flow at Aswan during the period 1900-1959 (84 bcm/yr). It allocated 55.5 bcm/yr of the Nile waters to Egypt (Abu-Zeild, 1994).

The AHD reservoir, formed upstream of the dam, is 500 km long with an average width of 12 km. The southern third of the reservoir, located in Sudan, is known as Lake Nuba, while the northern two-thirds, located in Egypt, is known as Lake Nasser (Mancy and Welsh, 1992). The live storage capacity of the AHD reservoir is 90 bcm (Abdelbary, personal communication, 1999). This amount is sufficient to meet both Egypt and Sudan's allocations, absorb the estimated annual evaporation loss of 10 bcm, and still have water remaining for over-year storage. The key independent variable for meeting the water allocations as set out in the agreement is long term average annual natural flow at Aswan; it can not drop below 84 bcm/yr. Reduced annual inflow created by severe climatic variations over several years has already been experienced. During the drought that took place during 1979-1988 the average River Nile flow dropped to 48.6 bcm/yr. The live storage in Lake Nasser decreased to its minimum of 6.84 bcm during July 1988. As a result, the Ministry of Public Works and Water Resources launched a management programme whereby releases from the AHD were reduced to below 55.5 bcm/yr between 1980-1988 (Abdelbary, personal communication, 1999). In 1988/89 the reservoir started refilling. Natural flow reliability will always remain a concern and will require water resource managers, decision-makers, and planners to adapt to the existing situation (Abu Zeid, 1992).

Groundwater

Two separate categories of groundwater exist in Egypt. The first is the Nile Valley and Delta system. The total storage capacity of the Nile Valley aquifer is approximately 200 bcm, while the storage capacity of the Delta aquifer is 300 bcm (Abu Zeid, 1992). The current rate of abstraction of groundwater from the Valley and Delta aquifers is 3.15 bcm/yr. Research indicates that 5.45 bcm/yr could be safely extracted (Attia, 1995).

The groundwater in the Nile aquifers is not an additional water resource since the aquifers are recharged by the deep percolation of applied irrigation water from the Nile. All extracted groundwater will eventually need to be replenished by the Nile water. Therefore, extreme care must be taken not to exceed the amount of groundwater that can be safely extracted. Groundwater withdrawn at an unsustainable rate could reduce the drainage flow of water towards the Nile (i.e. decrease hydrostatic pressure). If continued over the long term, draw down could reverse the flow of groundwater causing sea water to inflow into the aquifer and cause an increase in soil salinity.

The second category of groundwater comprises the western desert and Sinai Peninsula. The groundwater in the western desert is located at great depths and is not a renewable resource. Studies are being undertaken to determine the potential of using this groundwater. Within Sinai, the groundwater is available in numerous aquifers of varying capacities and qualities. In general, however, it is believed that these are of a very limited scale. In the northern and central parts of Sinai, rainstorms falling and collecting in the valleys recharge the aquifers. The coastal area aquifers in the region of El-Arish-Rafaa in northern Sinai have historically been an important source of water. The current rate of extraction from the aquifers in the region is 95 000 m^3/day. Currently, this area is facing a state of quality deterioration in space and time due to overexploitation (Abu Zeid, 1992).

Reuse of Water Resources

One of the main strategies adopted by the Egyptian government for meeting demand given the limited supply of renewable freshwater is the reuse of water several times before it spills into the Mediterranean Sea and terminal lakes. This strategy allows for the maximum exploitation of existing supplies.

Reuse of Agricultural Drainage Water

The reuse of agricultural drainage water is dependent upon several factors: quantity of irrigation water and salinity of the water, location where the water is available, salt balance of the area, cropping pattern, and tolerance of the cultivated crops. In the Nile Valley and Delta, agricultural drainage water originates mainly from the Nile water used in irrigation (Adbel-Dayem, 1994). Neither water of high salinity nor water contaminated by municipal and industrial wastes is used in irrigation. Pollutants in the drainage water are ranked according to their effect on public health, the environment, and crop yields. The Drainage Research Institute utilizes the following set of questions to determine the risk posed by a particularly type of pollutant in drainage water, as detailed by Abdel-Gawad:

(1) How dangerous are the pollutants to the ecosystem, particularly for human health?

(2) Are harmful levels of pollutants widespread or localized in the environment?

(3) Do the pollutants easily decompose to compounds or materials that have little adverse effect?

(4) Do pollutants accumulate in fish or other food?

(5) Are current trends likely to increase or decrease human exposure and the risk of harm?

(1994, T4-S1:3.6)

The risk rankings established by the Drainage Research Institute, based on the answers to the above questions, are by decreasing order of concern: pathogens, pesticides, heavy metals, and salinity (Abdel-Gawad, 1994). Within the Delta, drainage water with low salinity is used directly and drainage water with moderate salinity is mixed with fresh canal water. Under no circumstances can and will all the drainage water be used. The key to drainage water reuse is to achieve optimum levels of use while discharging high enough quantities of water to keep soil salinity from increasing (Abu Zeid, 1992; Adbel-Dayem, 1994).

At present, the amount of drainage water reused in irrigation is approximately 4.7 bcm/yr (Abdelbary, personal communication, 1999). The majority of this water is used in the Nile Delta (Abu Zeid, 1994). The potential exists for augmenting the amount of drainage water reused to 7.0 bcm/yr by the year 2000 (i.e. an increase of 2.3 bcm/yr). Once this level is reached, all drainage resources will have been exploited (Abdelbary, personal communication, 1999).

Reuse of Treated Municipal Wastewater

For centuries, Egypt has indirectly relied on wastewater. The first formal use of wastewater, however, did not occur until 1915. After primary treatment, municipal wastewater was used to cultivate 100 hectares of land located in the desert north-east of Cairo (Abu Zeid, 1992). The primary constraint to reclaiming land for agriculture has always been the lack of available water. Treated wastewater provides an alternative source of water and nutrients for additional irrigation. The total amount of treated municipal sewage water available for reuse in the Cairo area in 1995 was 0.26 bcm. As new primary wastewater treatment plants come on stream and other plants are upgraded, the amounts of treated wastewater available for agricultural activities will increase steadily. One of the largest public works projects in the world, the Greater Cairo Wastewater Project, is currently under way. It is expected that by the year 2010, 0.73 bcm/yr of treated effluent will be available for reuse (Camp Dresser & McKee Inc., 1995).

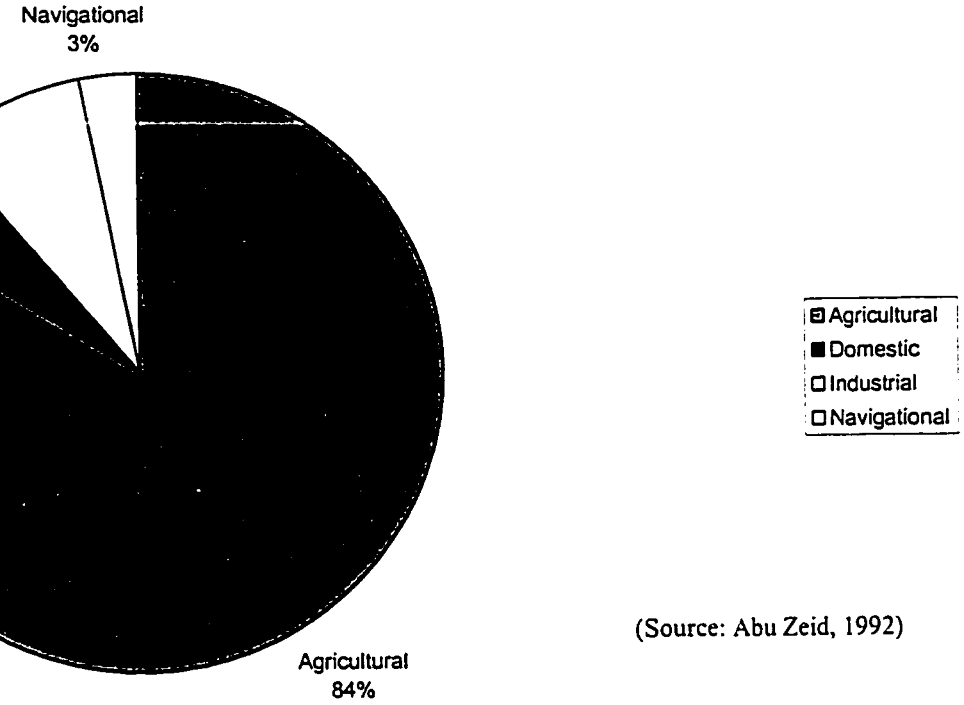
Experience with wastewater reuse in Egypt has been somewhat limited to date. The government is carefully considering providing the necessary infrastructure to increase the current capacity for the reuse of treated wastewater for irrigation. Detailed criteria for wastewater reuse in agriculture are under review, and several pilot projects have been initiated and are under continuous monitoring (Abu Zeid, 1994).

One other use for the treated effluent, which has not been considered by the Egyptian government, is in the recharge of groundwater supplies (World Resources Institute, 1996). If carried out, the government could possibly increase the rate of abstraction of groundwater from the aquifers while maintaining the hydrostatic pressure.

WATER DEMAND

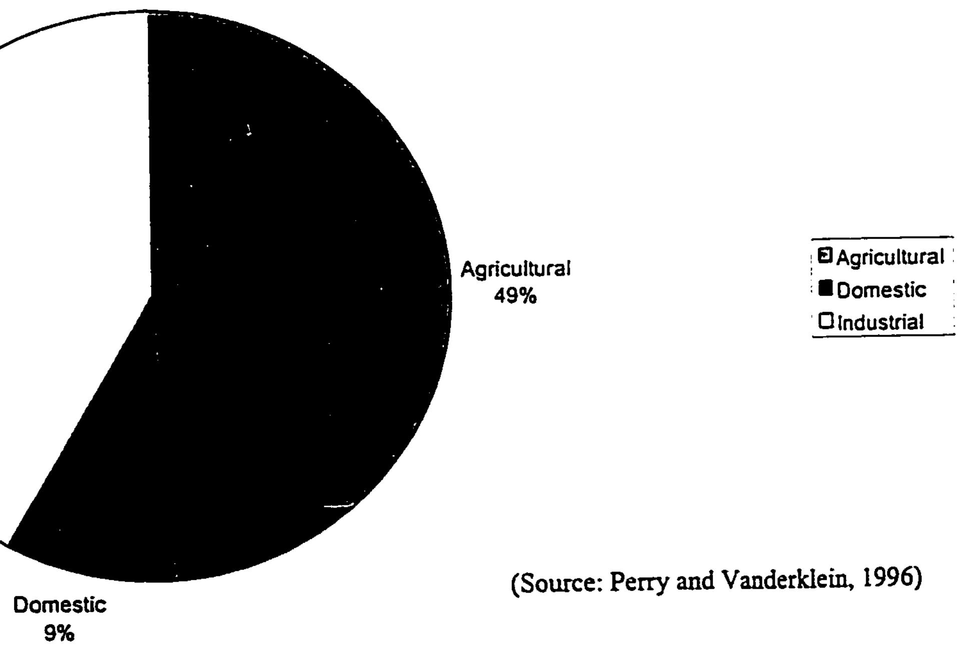
How clean and safe is the water in Egypt? A relatively simple question, yet quite complex to answer. Part of the challenge involved in answering this question is that no absolute standards of quality exist. The assessment of water quality is directly linked to the different users' requirements (Alberta Water Quality Branch, 1977). As user demands change, the pressures placed on the aquatic environment change as well. It is therefore imperative to have a clear picture of the users of the water supply and their requirements in order to make informed decisions regarding water quality management.

Total water use in Egypt in 1990 was estimated at 59.2 bcm/yr, of which agricultural use accounted for 84%. Industrial, municipal and navigational uses accounted for 8%, 5% and 3% respectively (Abu Zeid, 1992). In comparison to water figures from North and Central America for 1995, agricultural use constituted only 49% of water demand while industry accounted for 42% (see Figures 4A and 4B) (Perry and Vanderklein, 1996). It is estimated that total water usage in Egypt will increase to 69.4 bcm/yr by the turn of the century. Moreover, it is forecast that the percentage of water used by the agricultural and municipal sectors will not vary much from 1990 levels, while industrial requirements could increase by 50% and navigational use could decline drastically (Abu Zeid, 1992). The total amount of source water available to meet user demands is approximately 54.0 bcm/yr (see Figure 5 and Table 3). The gap between annual water use (57.55 bcm/yr) and annual water ure 4A. Annual water usage in Egypt.



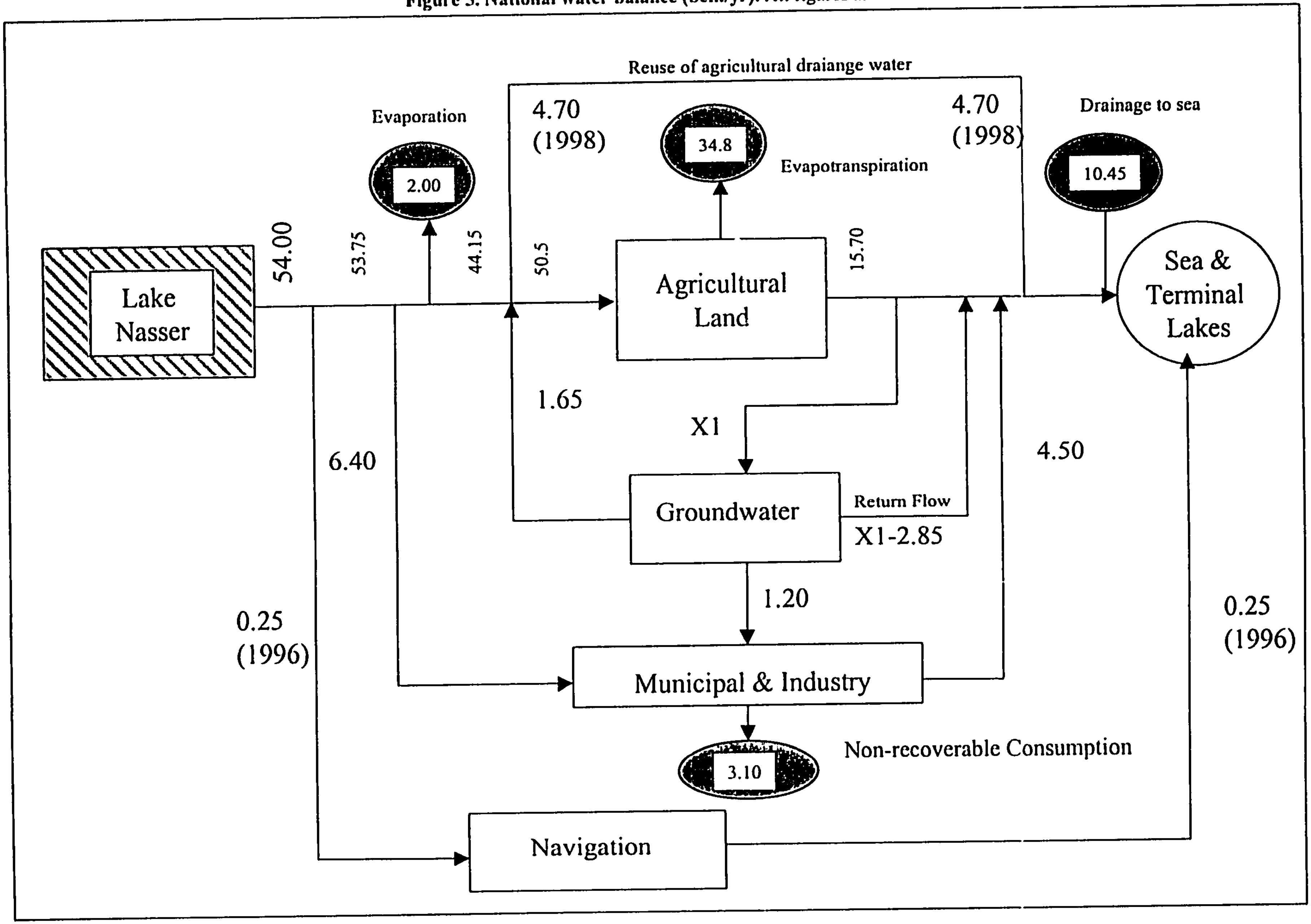
(Source: Abu Zeid, 1992)

nnual water usage in North and Central America.



(Source: Perry and Vanderklein, 1996)

Figure 5. National water balance (bcm/yr). All figures are for 1990 unless otherwise indicated.



(Sources: Abdelbary, personal communication, 1999; Abu Zeid, 1992; Attia et al., 1991; Mancy & Welsh, 1992; Mercer and Nadar,1991) discharge from the AHD (54.0 bcm/yr) is due to the reuse of wastewater and drainage water.

Table 3. Annual water demand in Egypt. All figures are for 1990 unless otherwise indicated.

Water Users	Amount (bcm/yr)
Agriculture	49.7
evaporation	2.0
evapotranspiration	34.8
Industrial	4.6
consumption	0.7
Municipal	3.0
consumption	2.4
Navigationai	0.25 (1996)
Total Consumption	39.9
Total Water Use	57.55

(Sources: Abdelbary, personal communication, 1999; Abu Zeid, 1992; Attia et al., 1991; Mancy and Welsh, 1992)

Municipal Water Use

Municipal water use is "the volume of water needed to meet the demand for all purposes served by public potable water networks in both rural and urban areas" (Attia et al., 1991, 132). It is dependent upon population growth, religion, and standard of living. The religion of Islam dictates that people wash five times a day prior to prayers. This requirement places additional pressure on managers to supply adequate quantities of suitable quality water (i.e. the water and wastewater infrastructure must be able to handle the peaks in demand) (Perry and Vanderklein, 1996). Domestic demand in 1990 was approximately 3.0 bcm/yr. Distribution losses, which are as high as 50%, are taken into account when allocating the water resources to meet municipal requirements. Consumption is the portion of water that is lost annually from the River Nile system (i.e. the difference between the raw water and the wastewater). Municipal consumption was estimated at 2.4 billion m^3/yr, approximately 4% of the net water supply (Attia et al., 1991; Mancy and Welsh, 1992).

Agricultural Water Use

The River Nile Valley and Nile Delta have been under continuous cultivation for more than 5000 years, making the region one of the world's oldest agricultural areas. Two unique features of Egypt's agricultural sector are that over 95% of its production is derived from irrigated land and the irrigation waters originate from outside the national borders. Given the negligible rainfall Egypt receives annually, a reliable supply of irrigation water is mandatory for agricultural development (Abu Zeid, 1992).

Much of the water applied to irrigated agricultural crops is consumed through either evaporation or evapotranspiration. The excess waters are released back to the Nile via drainage ditches. Within Egypt, agriculture uses 49.7 bcm annually, representing the bulk of available water supplies. This amount does not include an estimated loss of 2 bcm/yr due to evaporation from the irrigation system and 34.8 bcm/yr due to evapotranspiration (varies according to cropping pattern). Both these outputs represent losses from the irrigation system that cannot be recovered (Attia et al., 1991; Abu-Zeid, 1992).

Hydropower Generation

Throughout the period 1976-1978 to 1983-1984, 31.6 bcm of water was released annually from the Aswan High Dam reservoir solely to meet the demand for power generation. As previously mentioned, during the drought that took place between 1979-1988, the live storage capacity in the Aswan High Dam reservoir dropped to its minimum level. Consequently, the Ministry of Public Works and Water Resources (formerly the Egyptian Ministry of Irrigation) reviewed its water policy in 1988 and made the decision to disallow the additional release of water from the AHD for power generation (Abu Zeid, 1992). The water requirements for hydropower generation are now fully met by the irrigation releases throughout the year and by the navigation releases during the closure period (Attia et al., 1991).

Navigational Water Requirements

The River Nile and parts of the irrigation canal and drainage system are used for navigation. The river traffic consists mostly of bulk cargo barges and luxury ships that travel from Luxor to Aswan and back. From February to September, water released for irrigation is sufficient to meet the requirements for navigation. However, in October through January, irrigation demands are not enough to maintain the draft for navigation. This period coincides with peak tourist season.

Maintenance and construction activities of the hydraulic structures along the River Nile and the irrigation canals are undertaken during the winter since agricultural requirements are minimal. Releases from the AHD during this time need to be sufficient to maintain a channel depth great enough to safely accommodate the draft from the largest ships plying the river. Navigation is one area that has been targetted by the government for a reduction in water use in order to increase the amount of water available for planned land reclamation projects. Management action has already been taken. The Nag Hammadi Lock and Isna Barrage and Lock have been rebuilt to improve the navigational facilities and to provide better control of the Nile water levels (Saleh and Abu Zeid, 1994). In 1990, 1.8 bcm of water had to be released during the winter months to maintain navigational levels (Attia et al., 1991). By 1996, this amount had decreased to only 0.25 bcm (Abdelbary, personal communication, 1999). None of this water is recoverable to the irrigation system; it is left to flow directly to the Mediterranean Sea.

Industrial Water Use

Within the industrial sector, most water is used for cooling although some industries consume sizeable quantities in their manufacturing processes. At present, no precise figures for industrial demands are available. Water requirements for industry are based on an extrapolation of a 1980 field study carried out as part of the Water Master Plan Project. The comprehensive survey covered nearly 500 factories, which accounted for an estimated 90% of the industrial water demand at that time (Attia et al., 1991). Based on the extrapolation for 1990 (the most recent year for which figures are available), the industrial requirement for raw water is approximately 4.6 bcm/yr. This figure is expected to jump to 7.9 bcm/yr by the year 2000 (Mancy and Welsh, 1992).

The figure of primary importance to the government in terms of water usage is the rate of consumption which is estimated to be 0.7 bcm/yr (Attia et al., 1991). This figure represents the amount of water that cannot be reused. It is, therefore, crucial to minimize industrial consumption rates as much as possible. Using the "business as usual" scenario, by the year 2000 it is projected that industry's rate of consumption will hit 1.8 bcm/yr (Attia et al., 1991).

Ecological Requirements

Top priority for the allocation of water in Egypt is given to human uses - municipal, agricultural, navigational, and industrial. This stance is reflected in the government's approach to navigational water use, which is aimed at reducing the amount of water "lost" to the Mediterranean Sea. There is no explicit recognition by the Egyptian government of minimum ecological requirements for such non-human uses as the maintenance of the aquatic ecosystem's assimilative capacity.

According to Perry and Vanderklein, a protected use "results from a political or managerial decision that assigns a higher priority to one (or more) beneficial uses than to competing or conflicting uses" (1996, 69). The government should consider classifying certain non-human uses as protected.

The selection of certain ecological requirements as protected uses would require a greater effort by the GOE to integrate the management of water quality and quantity. For example, during the winter season river flow may be sufficient to maintain safe navigation levels; however, it may not be adequate to maintain the assimilative capacity of the River Nile, which is dependent upon such factors as dissolved oxygen and biochemical oxygen demand (ESCAP, 1990). This situation would eventually lead to a general deterioration in water quality. Management actions by government could include regulating flow requirements according the minimum needed to maintain the assimilative capacity of the aquatic ecosystem or renegotiating releases from the dam (Perry and Vanderklein, 1996).

Demand Management

Egypt has few remaining options for increasing water supply to meet rising demands (Abu Zeid, 1994). Consequently, the Egyptian government, through the MPWWR, has shifted its focus away from tradition hardware development to software development. This approach is aimed at improving the efficiency and performance of the hydraulic system. Demand management plays a large role in this new strategy, with a particular emphasis on agriculture. The overall objective of demand management is the better utilization of water resources (Saleh and Abu Zeid, 1994). Towards that end, the Egyptian government has launched several water management programs at both the micro and macro levels, several of which have already been mentioned (e.g. reuse of municipal wastewater and agricultural drainage water).

Efforts targeted at increasing the efficient use of water in agriculture, by far the largest consumer of water in Egypt, have the most potential in saving water resources for future social and economic development, in comparison to the other sectors. Therefore, the government has launched a comprehensive Irrigation Management System Project. The major project components include structural replacement, preventive maintenance, and the Regional Irrigation Improvement Project (responsible for the formation of water users' associations and the introduction of tile drainage to the Nile Valley, among other things) (Abu Zeid, 1994).

WATER QUALITY IN EGYPT - GENERAL OVERVIEW

Water pollution has already become a serious problem in certain parts of Egypt. A very high proportion of domestic and industrial effluents is presently untreated. This untreated wastewater is directly discharged into the River Nile, which continues to be the recipient of most of the wastewaters in Egypt; into irrigation canals; and into drainage ditches that run into the river. According to Abu Zeid (1992), it was estimated in one World Bank study of sixty-six agricultural drains that they carried an annual discharge of 3.2 billion m^2 which included raw sewage from "5000 rural agglomerations, semi-treated or untreated wastewater from Cairo and other urban centres, and mostly raw sewage from rapidly growing unserviced peri-urban areas" (Abu Zeid, 1992, 82).

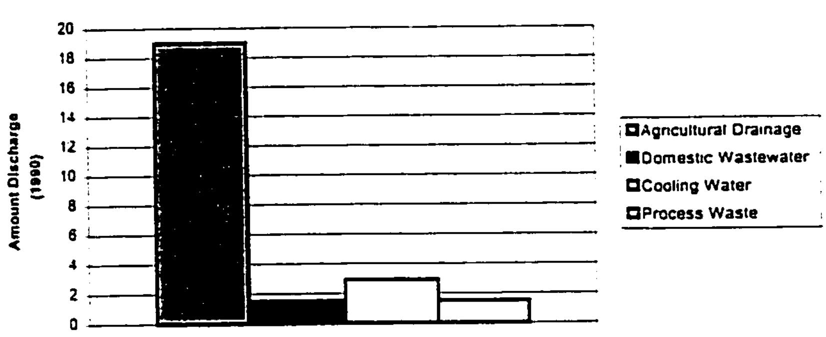
Increasing water pollution from industrial, agricultural, and domestic sources, if allowed to grow unchecked, is likely to reduce the already limited amounts of water available for various uses in the future. Moreover, total socio-economic, environmental, and health costs due to unrestrained polluting of the River Nile could become substantial. Warning signs have already begun to emerge. For example, the Second Pumping Station Rehabilitation Loan Report of the World Bank concluded that excessive pollution of drainage water around Alexandria reduced the life-span of irrigation pumps from twenty years to only four, and required more sophisticated pumps and piping at higher costs (Abu Zeid, 1992). Also, groundwater on which the City of Alexandria relies for its municipal water supplies has been contaminated by nearby industrial effluent (McClelland and Whittington, 1992).

Egypt, like many other developing countries, has traditionally focused on water quantity; water quality has not become a dominant issue thus far (Biswas, 1992). A reasonably good knowledge base exists concerning salinity of water. The availability of practical information on other water quality parameters is limited predominantly to data collected during the summer (i.e. high flow conditions). The cost of water degradation to the national economy has not been researched in any great detail, although some experts believe it could be quite significant (Adbel-Gawad, 1994; Abu-Zeid, 1992; CIDA and EEAA, 1997; Mancy and Welsh, 1992).

Water Quality of the River Nile

Since the completion of the Aswan High Dam, the quality of Nile water just below the dam has reflected the uniform quality of stored reservoir water and managed releases, both seasonally and from year to year. This situation provides an opportunity to determine the impact the various water users within Egypt are having on the waters of the River Nile through the analysis of data that could be gathered from a comprehensive monitoring system. Each year, an estimated 24.9 bcm of agricultural drainage, and municipal and industrial discharges enter the River Nile system between Aswan and the Mediterranean Sea (see Figure 6) (Mancy and Welsh, 1992). Based on the existing information, these discharges can and do have sizeable impacts along certain reaches of the watercourse.

Figure 6. Annual Discharges into River Nile (bcm/yr)



(Adapted from: Mancy and Welsh, 1992)

The Nile Research Institute (NRI), within the Ministry of Public Works and Water Resources, has used an index, the Water Quality Index[1] (WQI), to assess the overall quality of the Nile water. The WQI is calculated from ten major biological, chemical, and physical parameters affecting the quality of water. These parameters are temperature, pH, dissolved oxygen, biochemical oxygen demand, total dissolved solids, suspended matter, phosphates, nitrates, ammonia, and faecal coliform The index was calculated for 1977 and 1986 (years for which data was available and samples were taken in the same season - late summer) enabling a limited temporal and spatial comparison to be made. The findings indicate that the quality of River Nile water is deteriorating with time and that in some locations the deterioration is significant (Abu Zeid, 1990; El-Sherbini and El-Moattassem, 1991).

Spatially, water quality generally declines and primary productivity increases as the river flows northward. The impact on water quality is most pronounced downstream of urban areas and industrial centres. Data collected in June 1998 suggest that the overall water quality of the River Nile is good (Abdelbary and Heikal, 1998). Table 4 provides an overview of four water quality parameters. The initial selection criterion was the availability of data on the respective parameters. Then according to the information they could yield, parameters were selected. Faecal coliform is the main indicator of the possible presence of infectious agents. Heavy metals from industrial discharges pose a growing concern and in the future may become a serious problem as more industries come online. Biochemical Oxygen Demand (BOD) and Dissolved Oxygen (DO) provide information on the River Nile's capacity to cope with current organic loads.

[1] Research is ongoing by the Nile Research Institute to find a more accurate index, which is feasible for Egypt given the country's resources, semi-arid climate, and hydrological regime (El-Sherbini, personal communication). This type of research is not just confined to water resource managers in Egypt. Within the field of water quality management as a whole, studies are continually being undertaken to develop better and more accurate indices.

Table 4. Select parameter measurements of the River Nile.

Parameter	Category	Measurements	Comments
Biochemical Oxygen Demand	Organic Pollution Indicator	Ranges between a low of 1.2 mg/l to a high of 3.2 mg/l (below Egyptian water quality standards)	BOD peaks immediately downstream of point sources with a corresponding reduction in DO (oxygen sag)
Dissolved Oxygen	Organic Pollution Indicator	At or near level of saturation in most locations except downstream of point sources	Given the Nile's generally large width, combined with its shallow depth, the assimilative capacity is sufficient for DO to recover from point source inputs
Heavy Metals	Inorganic Micropollutants	Present and accumulating in sediments near industrial outfalls. Fe and Cu concentrations are within Egyptian water quality standards.	Could potentially pose serious health risk since heavy metals tend to bioaccumulate & are very slow to break down in the aquatic env.
Faecal Coliform	Microbiological	Reaches 5,000 MPN/100 ml & higher downstream from major municipal waste discharges & some drains	According to WHO guidelines, these levels indicate marked contamination - i.e. serious health risk present

(Sources: Abdelbary and Heikal, 1998; Mancy and Kelly, 1992; Mason, 1991)

General Sources of Water Pollution in Egypt

As previously mentioned, the assessment of water quality is dependent upon the users' requirements. Conversely the users affect water quality to varying degrees (see Table 5). In order to adequately address water quality issues (e.g. public health threats) it is necessary to have a good understanding of the main sources of pollution into the River Nile (i.e. the pressures placed upon the watercourse).

Table 5. Links between water users and water quality.

Uses affecting water quality	
(i) Municipal and rural	Sewage discharge, run-off
(ii) Agricultural	Manure disposal; use of fertilizers, pesticides, and herbicides; drainage water discharge
(iii) Industrial	Process waste, cooling water discharges
(iv) Navigation	Fuel spills, sewage discharge
Uses affected by water quality	
(i) Municipal and rural	Drinking, domestic uses, public uses
(ii) Agricultural	Livestock watering, irrigation
(iii) Industrial	Food processing, boiler feeding, other processing
(iv) Aquatic life	Aquatic and wildlife, fishing, wetland habitat
Uses not linked to water quality	
(i) Commercial	Hydropower generation

(Adapted from: Meybeck et al., 1990)

Municipal and Rural Domestic Wastewater

In many developing countries, population growth has outpaced the planning and development of water and sanitation systems. Because wastewater treatment facilities can be extremely expensive, the cash-strapped governments of these countries have placed substantial emphasis on the natural assimilative capacities of their water bodies (Perry and Vanderklein, 1996): Egypt is no exception.

By the late 1970s, population growth and increased urbanisation, coupled with minimal investment in wastewater infrastructure, had severely overwhelmed the sanitary services of Egypt's urban areas. This situation resulted in numerous health hazards, including outbreaks of cholera, and constrained Egypt's capacity for economic development; a problem that still exists today, although some headway has been made (US AID, 1998). Untreated sanitary waste is considered the greatest source of human exposure to parasites and pathogens in Egypt (Abdel-Gawad, 1994).

Downstream impacts of municipal wastewater are numerous. They include increases in organic matter, reduced levels of dissolved oxygen, increases in nutrient loadings, and increases in certain toxic substances such as chloramines (Perry and Vanderklein, 1996). Moreover, a lack of basic sanitation leads to a number of health problems. According to 1991 figures from WHO, Egyptians suffer the highest rates of water-borne diseases in the Middle East, and the City of Alexandria has the highest rate in the nation (Okun, 1991). Impacts on public health due to the absence of an adequate sewer system are reflected in the city's infant mortality rate, which is ten times higher than the average of the industrialised countries. Sanitary infrastructure is lacking due to regulations which permit developers to build and install their own facilities for supplying water, but do not require them to invest in the public sewer system (Okun, 1991). Statistics compiled by UNICEF (1997) reflect the outcome of these regulations. Among the fifteen developing countries with the largest under-5 populations, Egypt has the largest gap between access to safe drinking water and access to sanitation[2] (83% vs 29% - 54 percentage points).

Dramatic increases in discharge rates of municipal and rural domestic waste could potentially overload the natural assimilative capacity of the Nile. In addition to Cairo, there are 60 cities located in the River Nile drainage system with a total population of about 13 million. Out of these cities, 40 of them have sewer systems and primary or secondary treatment plants. Discharges from these cities, excluding Cairo, are estimated at 0.5 bcm/yr. Annual discharges from Cairo are estimated at 1.0 bcm/yr. A majority of the wastewater treatment plants are operating discontinuously and inefficiently (Earth Summit Watch, 1994; Mancy and Welsh, 1992). Aside from the sub-optimal functioning of a number of the existing wastewater treatment plants, a key issue that needs to be addressed is waste discharge from villages. They represent a notable source of pollution into the River Nile system. This is especially true when one considers

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[2] There exists no standardized definition for access to sanitation. The statistics in UNICEF's Progress of Nations 1997 report are derived according to each country's own definition of sanitation. The report did indicate, however, that since the WHO/UNICEF Joint Monitoring Programme was established in 1990, national definitions have become more restrictive.

that there are approximately 4,300 villages in Egypt (population est. 31 million) and most of the inhabitants (95%) rely on on-site disposal methods (e.g. leaching pits) or direct disposal to drains and canals (Abdel-Gawad, 1994; US AID, 1998). This lack of adequate sanitation poses a significant health risk. According to Abdel-Gawad, "lack of rural sanitation is the major health-related water quality problem" (1994, T4-S1:3.10).

Over the past two decades, significant steps have been taken by the Egyptian government with the assistance of the international community to reduce the discharge of raw sewage into the River Nile. As the 1970s drew to a close with most urban areas suffering from unsanitary conditions and polluted groundwater, the Egypt government saw the need for a program to plan, design, and construct a comprehensive sewerage system. Thus, the Greater Cairo Wastewater Treatment Project was launched in 1977. The purpose of the project is fourfold:

1) To rehabilitate and extend existing wastewater facilities;
2) To improve existing conveyance systems;
3) To construct conveyance systems in unsewered areas; and
4) To provide sewerage facilities in unsewered areas.

The first steps towards implementation were taken in 1979. The project, which is still ongoing, has received massive infusions of aid from the United States, the United Kingdom, the European Community, and Italy (Camp Dresser & McKee Inc., 1995).

The results to date have been quite impressive. The River Nile splits Greater Cairo into the East Bank and the West Bank. The East Bank areas are mostly urbanised and have long been sewered. The West Bank areas are rapidly growing and prior to 1994 were largely unserviced (Camp Dresser & McKee Inc., 1995). In 1984, approximately 700,000 cubic metres per day of untreated sewage flowed from the West Bank of Greater Cairo directly into the Rosetta branch. By the end of 1994, two million area residents were connected to sewage collection systems leading to the virtual elimination of raw sewage discharged into the Nile from the West Bank. On the East Bank, the overall sanitation system has benefited from an improved collection system, including the rehabilitation of pumping stations, and additional treatment facilities (Camp Dresser & McKee Inc., 1995; US AID, 1998). A crucial element to the long-term success of the project will be the proper operation and maintenance of the sanitation system. US AID, therefore, is providing a post-construction training program for Egyptian workers on how to operate and maintain the major components of the system and US $1.6 million for equipment and spare parts (Camp Dresser & McKee Inc., 1995).

Inroads in dealing with the wastewater issue have also been made in urban areas outside of Greater Cairo. In Alexandria, two new facilities are providing wastewater treatment to three million people and more than one million residents of Suez, Ismailia, and Port Said are connected to new wastewater treatment plants. US AID (1998) estimates that one out of every three Egyptians (i.e. 22 million) have benefited from the infrastructure developments over the past two decades. Institutional reforms have also been made in order to strengthen the capacity of local wastewater utilities to deliver adequate services. Presidential decrees have been amended for Cairo and Alexandria granting institutional autonomy and decentralized decision-making authority to wastewater utilities and new decrees have been issued for seven governorates, allowing them to operate as economic entities on a cost recovery basis (US AID, 1998).

Most of the progress made to date in addressing wastewater issues has been in the urban centres where wastewater problems are the most critical and where the most people benefit from infrastructure investments due to the high density. The Government of Egypt, however, has not entirely overlooked the impact of raw sewage from the villages. Pilot projects have been launched in three governorates, covering a total of 24 villages (Mancy and Welsh, 1992). This reflects a small, but somewhat positive gesture that rural areas will not be neglected.

Agriculture

(I) Application of fertilizers/pesticides/herbicides

For centuries, the River Nile carried 50 million to 150 million tons of silt, clay, and sand each year to the land stretching along the banks and to the Mediterranean Sea (Abdelbary, personal communication, 1999). On the land, the silty water enriched nutrient-impoverished soil as the river spilled over its banks. The nutrients removed from the soil by agriculture were replaced by the natural floods that occurred each year in late summer and early fall, floods caused by the monsoon rains along the river's headwaters (Chiras, 1991).

In 1908, Sir William Willcocks foresaw the future when he stated, "it will be an evil day for Egypt if she forgets that through perennial irrigation with its cotton fields, the lessons which basin irrigation has taught for 7,000 years cannot be unlearned with impunity. The rich, muddy water of the Nile flood has been the mainstay of Egypt for many generations, and it can no more be dispensed with today than it could in the past" (Waterbury, 1979:39). Not long after the completion of the AHD in 1968 and Lake Nasser began to fill, numerous problems became evident. One of these problems was that the periodic flooding that had provided annual fertilization for the land ceased. Nearly all the sediment is currently being entrapped by the AHD reservoir, where the dead storage capacity available for this purpose is 30 bcm (Waterbury, 1979). In 1974, Sayyid Marei, the then Egyptian Minister of Agriculture and Chairman of the World Food Conference, voiced his fears publicly when he commented, "I say in all candor, as loudly as possible, I am worried, extremely worried, because of the threat to the fertility of our soils" (Waterbury, 1979:129). His fears were justified. The impact of the loss of downstream soil fertility was much greater than had been anticipated by the planners of the Aswan High Dam. The official view was that the silt held minor nutritive value and could easily be replaced by chemical fertilizers. Moreover, due to the low nitrogen content of the silt, Egypt already relied heavily on chemical fertilizers before the Aswan dam was built. What the experts failed to take into account was the great importance of the trace elements in the silt, especially iron, zinc, and magnesium. Their absence is increasingly being felt by farmers who are having to import fertilizer for their land at an extremely high cost given Egypt's relatively weak currency (Chiras, 1991). A feasible solution to this situation is the reuse of wastewater for irrigation and the application of sludge to agricultural fields: both of which are not yet occurring on a significant scale in Egypt.

The loss in nitrogen (sediment N) due to the entrapment of the sediment in the AHD reservoir is estimated at 12 000 tons/yr and for phosphorus (soluble P) 6000 tons/yr (Mancy and Welsh, 1992). These amounts are substantial. According to 1994 figures released by Badiane et al., Egypt is among the highest consumers of fertilizers in the world. Fertilizer use, which is concentrated along the Nile Valley, is in excess of 350 kg/hectare. This amount is more than ten times the global average of fertilizer use per hectare. Furthermore, there has been a gradual increase in fertilizer consumption over the past two decades. In 1993, nitrogen fertilizer consumption was approximately double compared to 1980, while phosphate consumption increased 70% for the same period (Abdel Ghani et al., 1994). Significant portions of these fertilizers, along with some pesticides, leach into the water system.

There are several reasons for the increased consumption of fertilizers. The construction of the AHD represented the completion of Egypt's transition, begun at the turn of the nineteenth century, from a system of basin irrigation and subsistence agriculture to a system of perennial for the production of agricultural surplus. Releases from the AHD now provide farmers with a reliable supply of water during the summer, a time when the Nile was historically at its lowest, to cultivate crops such as cotton (Waterbury, 1979). Under this perennial system of irrigation, crop rotations consist of two to three crops (i.e. several planting seasons per year) with the fields never being left fallow to restore the nutrients in the soil. A corollary to the continuous decrease in soil fertility is the increase in recommended fertilizer rates for various crops. Other contributing factors are the release of high yielding varieties of wheat, rice, and maize that require intensive fertilizer use, and the high loss of applied fertilizers (Abdel Ghani et al., 1994). It should be noted though, that according to the Ministry of Agriculture and Land Reclamation, the use of chemical fertilizers has been significantly reduced in the last few years (Abdelbary, personal communication, 1999).

A key problem with the fertilizers is the nitrates, which are readily leached into the water system if not taken up by the plants. Nitrates' are a major contributor to pollution of surface and groundwater (Abdel-Gawad, 1994; Mason, 1991). High concentrations of nitrate and ammonia have been detected in agricultural drains running into the River Nile, particularly downstream of the Delta barrage. The main sources were fertilization, sewage system outfalls, and industrial effluent (Adbel-Gawad, 1994). High nitrate concentrations in surface water can have detrimental environmental and health effects. It can lead to the proliferation of algae, often called eutrophication, dissolved oxygen depletion, and a decrease in water clarity.

Although studies on the adverse impact of high nitrate concentrations are limited in Egypt, research in other countries reveals that high concentrations in drinking water could pose serious threats to overall health. There are possible links between stomach cancer, and nitrate concentrations (Abdel Ghani et al., 1994, Mason, 1991). Particularly vulnerable are infants under six months of age, who may develop *metheamoglobinemia* by drinking milk or water high in nitrates. This condition causes the oxygen-carrying capacity of the blood to be reduced and, in extreme cases, can be fatal (Mason, 1991).

Possible solutions, which are currently being investigated to decrease nitrate and ammonia concentrations, include increasing the efficiency and effectiveness of applied nitrogen fertilizers through applying fertilizers at the right time and using better methods. This would lead to a higher recovery by plants and less nitrogen leached into waterways while at the same time increasing the economic rate of return for the farmers. Furthermore, research is currently being conducted on the potential of using biofertilizers such as Azollo and blue-green algae for replacing chemical fertilizers (Abdel Ghani et al, 1994). In the future, proper sewage treatment may also become an important contributor to the reduction in the use of chemical fertilizers. The dried sludge that is produced can be effectively used as a soil conditioner for agricultural land, thereby reducing the need to use fertilizers. During 1988, 46,000 m^3 of dried sludge was produced and sold to farmers and various organizations. It is estimated that at the completion of the Greater Cairo Wastewater Project in the year 2010, 3410 tons/day of dried sludge will be generated (Abu Zeid, 1992). The effluent from the primary and secondary wastewater treatment plants, if reused for irrigation, could also reduce the need for fertilizers.

Egypt is quite dependent upon pesticides to increase food production and protect its crops. The use of pesticides, which are mostly imported, has increased over the past several decades as well, but not at the same rate as fertilizers. It is estimated that 620,000 tons of 200 different types of pesticides have been used by the agricultural sector since 1960 (Abdel-Gawad, 1994). Depending on the specific years, between 48-88% of the imported pesticides were used for cotton, a primary commodity and an important source of foreign exchange earnings (Abu Zeid, 1992).

Very little attention has been given by the GOE to the leaching of pesticides from agricultural land into the drains, canals, and river, and the possible health and environmental threats they pose (e.g. biomagnification of organochlorine pesticides) (Mancy and Welsh, 1992). Part of the reason for this may be due to the immense complexity involved in determining the amount and concentration of pesticides lost to the waterways. Among the factors that must be considered when calculating the amount of pesticides that is leached are soil characteristics, hydrogeological conditions, properties of individual pesticides, and cropping patterns. It is therefore impossible to generalize on the amount of pesticides entering the Nile and their concentrations. Detailed research on the different pesticides would be needed. A prerequisite is the placement of the issue of pesticides higher up on the list of priorities for action by the Egyptian government.

One area where public pressure has successfully led to change is in the application of herbicides. In early 1991, the use of herbicides to control aquatic weeds gained widespread public and media attention. Aquatic weeds are a major concern for efficient water management. The extent of the problem is quite widespread. In 1990, it was estimated that 13,000 km of canals and drains were being clogged by submerged aquatic weeds, and another 1900 km were covered by water hyacinths. Acrolein was used in the canals to control submerged weeds, and ametryn to control water hyacinths in drains (Abu Zeid, 1992). Due to increased political and public concern, the use of herbicides to control aquatic weeds in Egypt was stopped in 1991 (Abu Zeid, 1994). Water managers are currently experimenting with a combination of manual, mechanical and biological means as substitutes for the application of herbicides (Abdel-Gawad, 1994; Mancy and Welsh, 1992). The alternatives being explored could provide auxiliary benefits. For example, if the government were to use carp as a biological means to control aquatic weeds, the fish could be caught and used as either food and/or fertilizer (Thompson, personal communication, 1998).

(II) Waterlogging and Salinization

Waterlogging and salinization of soils are major concerns with respect to the threat they pose to increasing crop productivity. The working definition of waterlogging used by the MPWWR is the following: "A waterlogging condition exists if the water table depth is less than 80 cm below ground level for a period of more than 2 months in the winter season" (Attia and van Leeuwen, 1994, T2-S2:4.7). Waterlogging causes water to fill the air spaces in the soil and suffocate the roots of the crops. Salinization occurs when the irrigation waters evaporate near the soil surface leaving behind salts and minerals. The deposit of these substances inhibits plant growth and can reduce the penetrability of the soil (Chiras, 1991). The quality of the irrigation water plays a less important role in the accumulation of soluble salts in the soil than the sheer volume of water used and evaporated. Hence the link between waterlogging and salinization. Globally, salinity affects productivity on 7% of the irrigated land. In the hot semi-arid and arid regions of the world, this figure is on average quite a bit higher due to the elevated rates of evaporation. An estimated 30% of Egypt's cropland suffers from salinization (Perry and Vanderklein, 1996). Consequently, the drainage water from these cultivated lands are quite high in total soluble salts. Due to the high dilution capability of the Nile, however, the increase in total dissolved solids from the drainage waters has not excluded any types of water use (Mancy and Welsh, 1992).

The root causes behind widescale waterlogging and salinization in Egypt are described below.

Perennial irrigation. Basin irrigation, which was practised for millenia prior to the late 1800s, relied primarily upon the annual flood of the Nile, whose excess waters would drain through the aquifer into the river and as return flows, carrying with it salts leached from the soil. Under perennial irrigation, fallows were eliminated, the irrigation network was greatly expanded without adequate drainage, and water applications were increased. These factors resulted in a rising of the water table, leading to waterlogging. Due to the high evaporation rates experienced throughout the irrigation network and on the agricultural land, salts concentrated in the soil's upper layers causing salinization (Waterbury, 1979).

Inadequate drainage. Prior to construction of the AHD, water planners assumed that drainage would not be a problem, since the dam would lower the average level of the river and canals, which would improve the natural flow of drainage water through the aquifer back to the riverbed. As a result, between 1958-1969 all projects dealing with the introduction of main and field drains to all Egypt's cultivated lands were shelved (Waterbury, 1979).

According to Attia and van Leeuwen (1994), the most feasible way to cope with waterlogging and salinization is to attack both the symptoms of the problem and the cause. They suggest an effect approach, i.e. removing excess water in the Nile Valley by drainage measures, and a source approach, i.e. preventing excessive recharge through lining main canals and branches. This inclusive approach is reflected in the MPWWR's Regional Irrigation Improvement Project, a national program for irrigation improvement approved in 1984. The first phase of the program started in an area of 40,000 acres. It included the lining of main canals to reduce percolation losses which can range between 20-30% of the water (Hvidt, 1994). The plan for 1992-1997 covered an additional area of 350,000 acres with an estimated cost of US $120 million. In addition, as part of the national program, the MPWWR embarked on the construction of an extensive drainage system, a significant part of which is already operational (3.9×10^6 million acres), and to introduce tile drainage into the Nile Valley. The goal is to have the network completed by the year 2000 (Abu Zeid, 1994).

Industrial Effluent

Egypt's current path of industrialisation began in the early 1960s (Abdelbary and El-Shanshoury, 1991). Prior to that time, food processing, textile manufacturing and cement and fertilizer producers were the main industries. Over the past three to four decades there has been a shift away from the traditional agrarian industries to heavy industries such as steel, machinery, and chemicals. Most of these new industries are concentrated in Alexandria, north and south Cairo, and the Nile Delta; and discharge wastes into the river without treatment.

The majority of industries in Egypt are state-owned. The GOE owns and operates 367 industrial facilities. Several ministries have industrial facilities for which they are responsible. The Ministry of Industry, however, is the major industry stakeholder (Mancy and Welsh, 1992). This information is important when evaluating the success or lack thereof of current pollution control programs and legislation and recommending amendments.

Industries produce two types of liquid waste that must be differentiated when discussing the impacts of industries on water quality. The first type is cooling water that is relatively clean. The second type, and of greater importance in Egypt, is the process waste that can contain sizeable amounts of organic matter and toxic pollutants. The type of industry usually determines the nature of the wastewater generated. Certain industries produce wastewater that consists of relatively clean cooling water while others such as chemical plants, tend to produce effluent laden with toxic pollutants. These toxic pollutants fall under two categories: heavy metals and persistent organic pollutants (POPs) (Abdel-Gawad, 1994). The three main characteristics that they share are their long-term persistence in the environment, their tendency to bioaccumulate, and their toxicity (Mason, 1991; World Resources Institute, 1998).

According to 1990 figures, industry discharged an estimated 4.4 bcm/yr of wastewater into the river and agricultural drains. Process waste comprised 1.5 bcm/yr of this sum (Mancy and Welsh, 1992). No information is available on the amount of toxic pollutants in the process waste. Based on forecasts made by the Ministry of Industry's General Organization for Industrialization (GOFI), the discharge of process waste will climb to 3 bcm/yr by the year 2000, a twofold increase (Mancy and Welsh, 1992).

Discharge of untreated and partially treated industrial effluent is considered a major threat to the quality of Nile water and a principal health hazard (Abdel-Gawad, 1994). An estimated 350 industries discharge waste directly into the Nile or indirectly through municipal systems (Mancy and Welsh, 1992). The volume of effluents being produced is steadily increasing along with the variety of toxic contaminants discharged into the river system. Currently, the impacts of industrial discharges have been localized. However, increasing loads of organic pollutants entering the Nile system could in the future irrevocably stress the natural assimilative capacity of the river. In addition, increasing amounts of toxic pollutants could cause irreversible harm to human and animal health (e.g. liver damage in mammals, reduced rates of reproduction in fish) and disrupt the food chain. Secondary treatment will be of little use in dealing with these toxic substances, particularly the heavy metals and the pollutants that contain biological inhibitors. An effective pollution control/pollution prevention programme, combined with enforceable legislation and a comprehensive monitoring system, are required to address the current situation.

The industries that produce the greatest volumes or highest concentrations of toxic pollutants should be the prime targets of any management actions aimed at the industrial sector. A step in this direction was made by Abdelbary and El-Shanshoury (1991). They developed a classification system that categorized industries into three grades according to the characteristics of their effluents and the impact of these effluents on the River Nile (see Table 6). The purpose of their classification system is to help prioritise industries according to the need for proper treatment of process waste. In devising the system of categorization, Abdelbary and El-Shanshoury (1991) took into consideration the type and amount of toxic pollutants generated by the industries. A classification system just based on the amount of process waste generated by the different industries would have been much less valuable. The classification system proposed by Abdelbary and El-Shanshoury (1991) could be used in designing and implementing a strategic plan of action to combat the pollution of the River Nile by industry. There exists, however, a defect in their classification system. It reflects the policy environment in which it was created. Namely, the controlling of waste after it is generated (i.e. end-of-pipe approach). It does not consider the potential of the various industries to adopt pollution prevention measures. This represents a serious oversight since the only feasible way to tackle most persistent toxic substances is by stopping the toxins at their source as they cannot be treated by secondary wastewater treatment. Abdelbary and El-Shanshoury's classification of industries would be of more value if the waste was characterised according to whether biological (i.e. secondary) treatment is possible or not. A change in the GOE's policy will have to be made before this classification system can be revised and adopted. A positive step in this direction was made by Abdelbary and Heikal (1998) in their conference paper, "Pollution Sources in the Nile and their Environmental Impact", in which they recommend pollution prevention (i.e. source reduction) in place of pollution control.

Table 6. Classification of industries.

Category	Type of Industries	Characteristics of Waste
Grade One (highest priority for treatment)	Chemical, metallurgical, and mineral industries	High concentration of chemicals, metals, ions, and oil and grease
Grade Two	Food and food processing industries	High concentrations of solids, organic loads, traces of dye and alkaline impurities
Grade Three	Food and food processing industries	High concentrations of oil and grease, organic compounds and suspended solids

(Source: Abdelbary and El-Shanshoury, 1991)

CHAPTER FOUR – WATER QUALITY MANAGEMENT IN EGYPT

This chapter provides an overview of the government's attempts to address water quality issues, focusing on the main elements found in most well-established national water quality management programmes: legislation, water quality monitoring, capacity building, and data management and information systems (ESCAP, 1990). Each component is analyzed and recommendations are made based on the analysis and research of Egypt's and other nations water quality management endeavours. The role of external agencies is also discussed since the international community has traditionally been a major player in Egypt's water quality management initiatives.

WATER QUALITY MONITORING

The goal of water quality management is to maintain or enhance the quality of a country's surface water and groundwater (Soliman and Ward, 1994). Monitoring to obtain water quality information for decision-making purposes is therefore a requisite for an effective national water quality management programme. Without data there is no way of determining where pollution problems exist (e.g. reaches where the quality of water is impairing uses), where to focus time and resources, whether any progress has been made in achieving water quality objectives, and whether pollution control efforts are successful or not (US EPA, 1997A). In the absence of monitoring, pollution levels can build up gradually over time until they have a pronounced effect on human health and/or the aquatic ecosystem (e.g. dramatic decrease in biological diversity). This situation is particularly true for heavy metals and chlorinated organics (Meybeck et al., 1990). In the long term, an ad hoc reactionary approach (i.e. crisis management) can lead to the permanent impairment of the natural assimilative capacity of the aquatic environment. Monitoring alone, however, cannot protect water quality. The data, once processed and analysed, needs to make it into the hands of water users, planners, managers, and decision-makers and the requisite response taken (e.g. reallocation of resources).

Moreover, the monitoring system must be designed according to the management strategy. Otherwise, the information provided by the monitoring system will fail to meet the needs of decision-makers and managers and would be of little value in the determination of effective management initiatives (Soliman and Ward, 1994).

The purpose of this section is to answer two fundamental questions: (1) Where is Egypt right now in terms of water quality monitoring? (2) Where should Egypt strive to be with regards to water quality monitoring? It must be noted that Egypt has three monitoring programmes: (1) River Nile and its branches (Rosetta and Damietta); (2) Agricultural Drainage, mainly salinity; and (3) Groundwater. The main programme, and the focus of this section, is the monitoring of the River Nile and its branches.

Water Quality Monitoring: General Discussion

Water quality is generally assessed in terms of various measurable parameters, the main categories being chemical, physical, and biological. The choice of which parameters to monitor depends upon the objectives, which should be clearly defined, of the management programme. Ideally, parameters from all three categories should be selected in order to provide a more holistic picture of the state of water quality. No blanket approach to monitoring exists. It can be undertaken at regular sites on a continuous basis (i.e. fixed station monitoring), at selected sites on an as needed basis or to answer specific questions (i.e. intensive surveys), on a temporary or seasonal basis, or on an emergency basis such as after a spill (EPA, 1997A).

Water quality monitoring has traditionally been very narrowly defined. The following two definitions of monitoring provide classic examples.

The United Nations Economic and Social Commission for Asia and the Pacific (ESCAP) describes monitoring as "a systematic process of collecting, preserving and analysing water samples to identify quantitative and qualitative characteristics of water" (ESCAP, 1990, 15). The Commission has identified the phases of activities involved in water quality monitoring as follows:

1) Planning, designing and establishing monitoring network system;
2) Field sampling;
3) Preservation and sample processing;
4) Field and laboratory testing;
5) Data handling
    a) Processing and interpretation
    b) Data storage and retrieval
    c) Dissemination and use (ESCAP, 1990, 18).

Soliman and Ward in their research paper Matching Evolving Water Quality Management Strategies to Monitoring Systems Design provided this description: "Water quality monitoring, in general, can be defined as consisting of six linear activities: (1) sampling the water; (2) analyzing the sample in the field or laboratory; (3) storing and retrieving the data; (4) analyzing the data via plots, statistics and/or models; (5) preparing reports that present the findings; and (6) having the generated information readily understood and incorporated into water quality management decision making" (Soliman and Ward, 1994, T4-S2:5.5).

Both of the above definitions focus on one type of indicator - the state of the water body (e.g. chemical, physical, biological). Information from such monitoring systems would not help decision-makers in measuring the effectiveness of their programs in improving or maintaining water quality, nor provide information on what is causing the change in state, if it is occurring. As such, the full benefits of having a monitoring programme in place are not realized. The other problem with the above two definitions is that they reflect a static process with no opportunity for feedback. Water quality management is inherently dynamic due to society's changing values and preferences, and continuous advances in our scientific understanding. Therefore, it requires a flexible and dynamic monitoring system, one that will continue to yield valuable information. This key point was raised by Soliman and Ward (1994), yet it is not reflected in their definition.

Over the past decade and a half, significant developments have taken place which are strengthening the way monitoring is thought about, and ultimately, implemented in the water sector. The IRC, an independent non-governmental organisation with links to the Netherlands Government, UNDP, UNICEF, WHO, World Bank, and Water Supply and Sanitation Collaborative Council, has identified these developments. They are as follows:

(i) Increased stakeholder participation. Communities, the private sector, and NGOs are being included in monitoring activities.

(ii) A wider range of strategies has been developed. Certain strategies for water quality monitoring now include both quantitative and qualitative methods. The difference between the two must be clearly distinguished since the inclusion of qualitative methods embodies this new approach to monitoring. In their document A UNICEF Guide for Monitoring and Evaluation, the organisation makes the differences between the two types of methods clear:

> *Quantitative indicators* are measurable, objective and can be expressed as percentages, rates or ratios.... *Qualitative methods* of observing and interviewing as well as empathy with participants and their situation are useful for gaining a holistic understanding, especially of complex socio-economic changes. Qualitative research uses specialized techniques for obtaining in-depth responses about what people think and how they feel. It enables programme managers to gain insights into attitudes, beliefs, motives and behaviours of the target population.... Quantitative data may be used for measuring "what happened" and qualitative for analysing "how and why" it happened. Qualitative, for exploring a problem and possible solutions; quantitative for showing the extent of a problem or population characteristic (UNICEF, n.d., 17-18).

(iii) Use of participatory evaluation. Local stakeholders (i.e. communities) are directly involved in the design and management of monitoring activities (IRC, 1996).

Another trend, overlooked by the IRC, is the expansion of monitoring systems to include monitoring of non-point sources of pollution as well as point sources. The two differ greatly. Point sources of pollution are from discrete locations and are easy to measure. Non-point pollution is diffuse in nature such as the leaching of pesticides and fertilizers from agricultural fields, and is therefore, more difficult and costly to quantify (Chiras, 1991). Monitoring of non-point sources of pollution requires an in-depth understanding of ecosystems and the impacts of human activities (e.g. the effect of cropping patterns on surface water quality) (Soliman and Ward, 1994; USGS, n.d.).

As a whole, these new developments are causing monitoring to be incorporated into routine activities (i.e. internalized) and are serving to establish avenues for feedback. The WHO and UNICEF, as part of the Joint Monitoring Programme that established WASAMS (mentioned in Chapter 2), stated the benefits of having a strong monitoring system:

> Stronger monitoring systems allow managers and policy makers to use a common language for goals and those indicators which measure progress. They can more quickly and precisely identify constraints and reallocate resources to solve problems. They can also compare progress of similar activities at subnational, and even global level in order to better advocate for resources and influence policy (WHO/UNICEF Joint Monitoring Programme, n.d., 1).

In order to fully achieve these benefits, a broader definition of monitoring than has traditionally been used is needed. The author, therefore, proposes the following definition based on the most recent advances:

Monitoring is

- a management tool to support decision-making;
- a methodical collection of quantitative and qualitative data;
- the analysis of data to determine the natural and anthropogenic pressures placed on the environment, the state of ecosystems and human health, and the effectiveness of management initiatives;

- a dynamic and iterative process providing feedback to decision-makers, operators, and water users; and
- a participatory process.

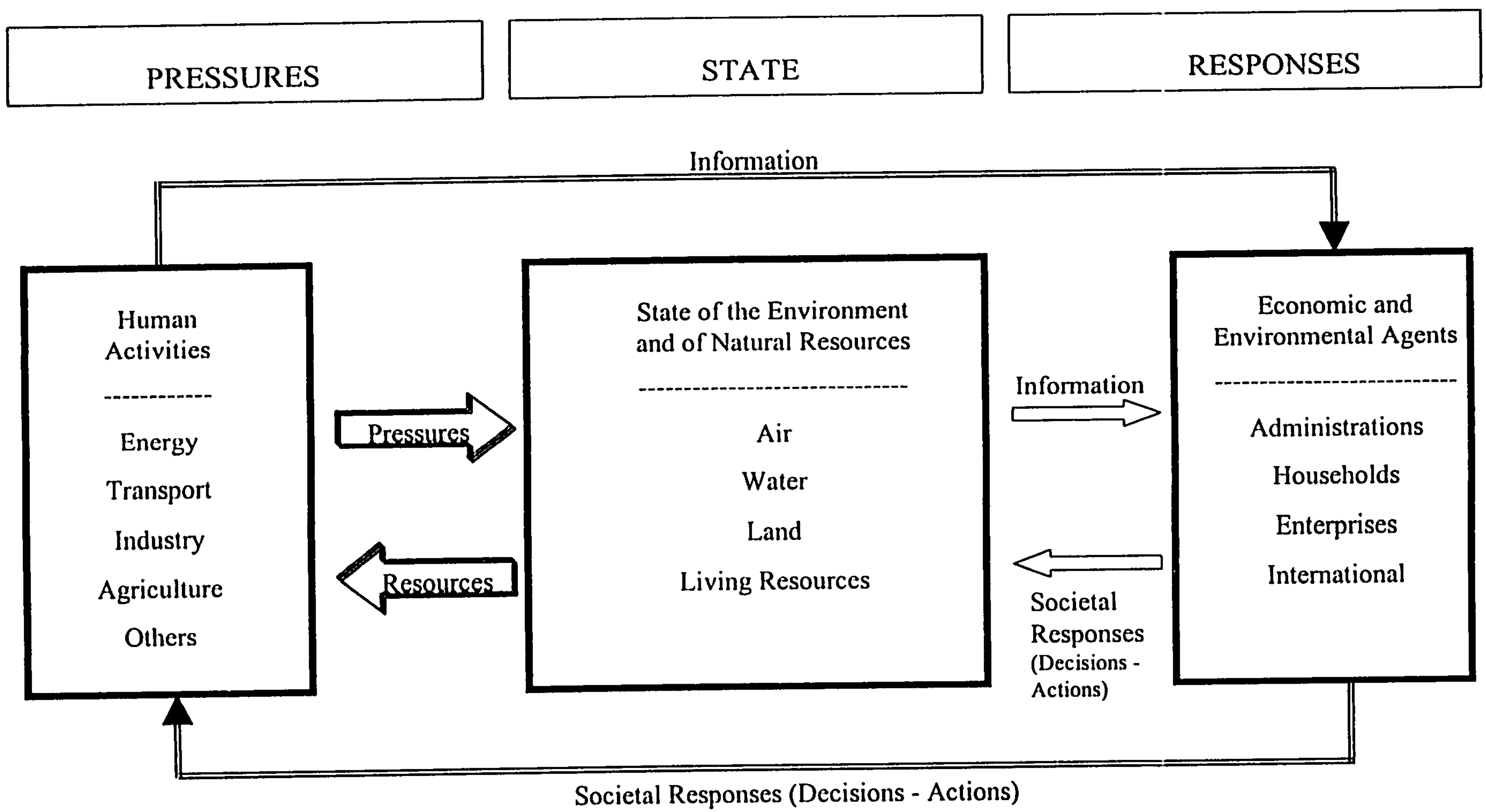
A conceptual framework for organizing environmental information that could support such a monitoring approach already exists in the format of the Organization for Economic Cooperation and Developmentss (OECD) Pressure-State-Response (PSR) model. It is the most widely adopted causal framework for environmental management and is used by the OECD member countries in developing State of the Environment Reports and by the World Bank in devising a set of sustainable development indicators. The OECD's PSR model provides a means of managing information to yield the most value. The framework represents the Pressures generated by human activities that may affect the State of the environment to which societies Respond to alleviate the Pressures or modify the State (e.g. clean-up) if the changes are considered undesirable (see Figure 7) (US EPA, 1997B).

As previously discussed, most monitoring systems provide information only on indicators of the state of a particular natural resource. However, this makes it very difficult for decision-makers to determine what activities should be undertaken since there is no information as to what is causing the changes in the resource. On the other hand, a monitoring programme designed according to the PSR model, and therefore having a much broader focus, would serve to answer the following questions:

- Is there a problem (State)? Where?
- What is the source of the problem (Pressure)?
- Are efforts to solve the problem working (Response)?

Ideally, a monitoring system should have a set of indicators from each of the Pressure-State-Response categories (Thompson, personal communication, 1996).

Figure 7. OECD Pressure-State-Response Model



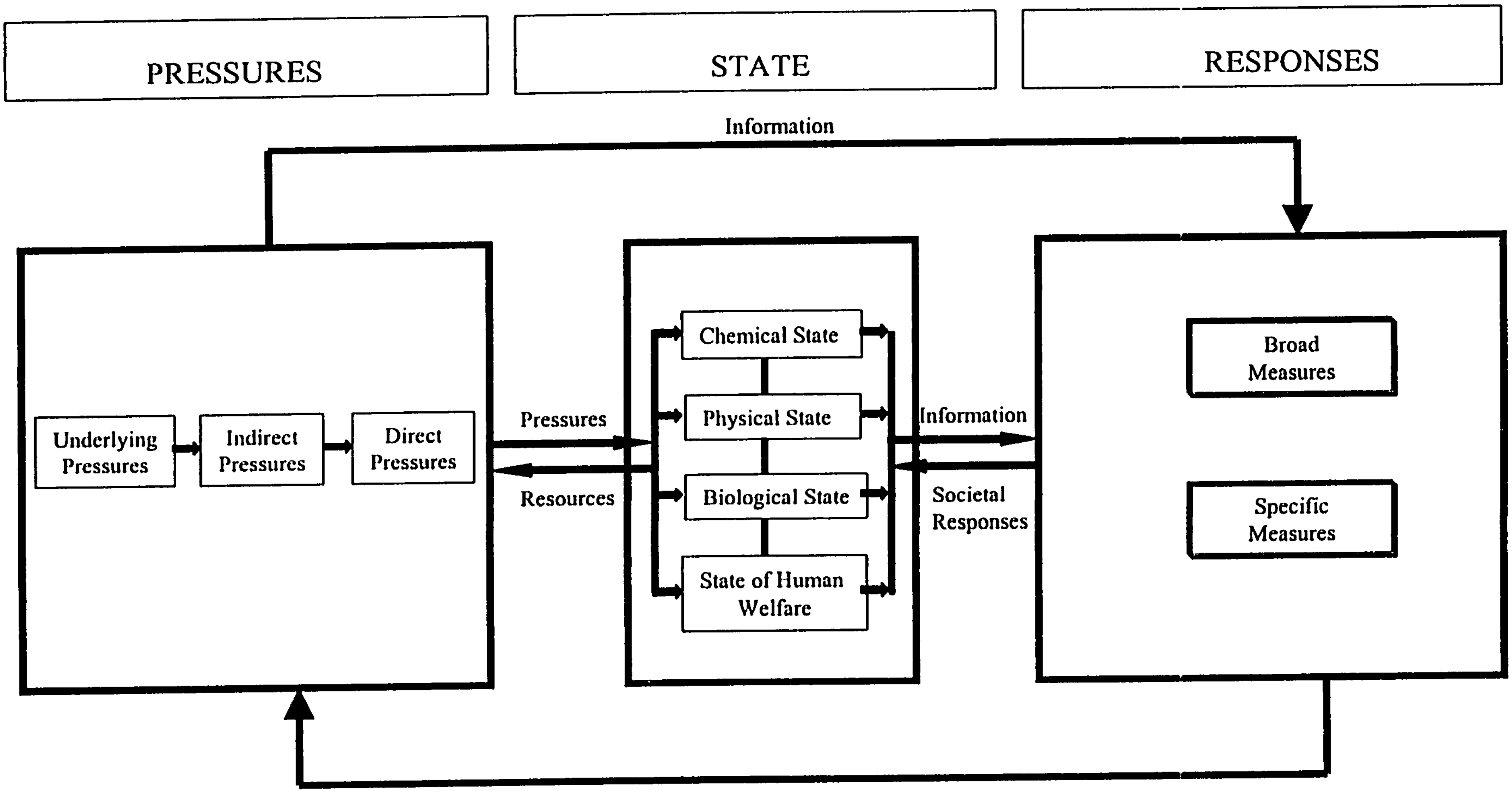
The US EPA has refined the OECD's PSR model and named it the Pressure-State-Response/Effects model (PSR/E). Among the changes they've made to the original framework is to add sub-categories to the three main PSR categories. The agency has separated the pressures category into the following three sub-categories:

- underlying pressures - driving forces motivating human activities
- indirect pressures - socio-economic activities, plus natural processes and factors
- direct pressures - actual biophysical inputs and outputs that exert direct stress on ecosystems

The original OECD model did not include ecocentric pressures. Natural pressures have been incorporated into this revised version of the PSR model since they can create direct biophysical pressure on the the environment, and in many cases, interact either antagonistically, additively or synergistically with human pressures. The State of the Environment is broken down to reflect the spatial nesting of ecosystems, consistent with an ecosystem approach, and an additional sub-category for environmental related human health and welfare has been added. The Societal Response category is structured according to the type of entity making the response (see Figure 8 and Table 7).

Recognizing that a monitoring system cannot track everything, priorities must be set through an open process with stakeholders. The US EPA recommends starting the process of prioritizing by determining a society's valued environmental attributes (VEAs). VEAs are those aspects of ecosystems that society perceives to be the most important and at possible risk from human actitivities and/or natural threats. The VEAs should not only represent the public's preferences, but also the attributes essential for maintaining the integrity of ecosystems based on our current scientific understanding. They should be regularly revisited. Once a core set of VEAs have been selected, the other two categories (Pressure and Response) can be prioritised. Based on the priorities, indicators can then be selected and incorporated into the design and implementation of a monitoring system. An indicator is a parameter, or a value derived from a set of parameters (e.g. a water quality index) that provides useful information for decision-making (US EPA, 1997B). The criteria for the selection of indicators should reflect the characteristics of the data needed to support the objectives of the water quality

Figure 8. Pressure-State-Response/Effects Model



(Adapted from: US EPA, 1997B)

Table 7. "Menus" of elements within each of the components of the PSR/E model. Examples of each element are provided to further clarify the process.

Underlying Pressures

- *Population Structure and Processes*: population size, birth and death rates
- *Social/Cultural Attributes and Practices*: individual and household behaviors, societal values
- *Political Structures and Processes*: federal, state, local laws and regulations; sectoral economic policies
- *Science and Technological Change*: basic and applied research, R & D expenditures

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Indirect Pressures

- *Human activities, generally by economic sector*: production and consumption of commodities, consumption of raw materials
- *Natural processes and factors*: droughts, earthquakes

Direct Pressures

- *Releases of Objects, Substances, Organisms, or Energy*: applications of fertilizers, point source and non-point source discharges of toxic pollutants
- *Harvesting and Extraction of Renewable and Nonrenewable Resources*: groundwater withdrawal, agriculture
- *Land Use Changes*: urbanization, construction of water resource projects

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State of the Environment

- *Global Ecosystem*
  - VEAs: stability of global climate, topsoil quantity and quality
  - Environmental Conditions and Changes of Human and Natural Origin: global temperature, globally transported pollutants in air or water
- *Regional Ecosystems*
  - VEAs: Water quality, contaminant/pollutant dilution by media
  - Conditions and Changes of Human and Natural Origin: salinization, import/export of soil, nutrients, etc. to/from ecosystems
- *Local Ecosystems*
  - VEAs: safe drinking water (quality and quantity), maintenance of hydrological functions
  - Conditions and Changes of Human and Natural Origin: quantity and distribution of water suitable for various human uses, pollutant levels

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State of Human Welfare

- *Human Health and Health-related economic welfare*: longevity, appropriate physiological function of body systems
- *Value of marketed environmental goods*: water supply for: domestic consumption, agriculture, energy production, industrial uses, waste disposal
- *Other use values*: tourism, scientific and research value
- *Non-use values*: historical value, uniqueness value

Societal Responses

- *Government Actions and Policies*
  - Federal: implementation and enforcement of environmental regulations, State of the Environment reporting
  - State: information collection and analysis, integration of environmental policies into existing policies
  - Local: land use planning, environmental education
- *Private Sector Activities*: waste treatment and disposal, environmental cleanup and ecological restoration
- *Individuals and Households*: voluntary pollution prevention, membership in environmental NGOs
- *Cooperative Efforts*: environmentally related research and teaching in schools and universities; partnership between NGOs businesses and/or government to reduce waste, improve management practices

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(Adapted from: US EPA, 1997B)

management programme. Important criteria for indicator selection include cost-effectiveness, legal requirements, technical feasibility, policy relevance and utility, and degree of threat to the environment or human health (Thompson, personal communication, 1996). The data collected on the indicators as part of the monitoring system could then be inputted into an environmental information system based on the conceptual PSR/E framework. Decision-makers could then access the information and make decisions grounded on a better understanding of the processes at work.

Water Quality Monitoring in Egypt

Old Approach

In 1976 the Nile Research Institute (NRI), in collaboration with the Ministry of Health (MoH), launched a River Nile monitoring programme. The programme, which ended in 1986, targeted the river from Aswan to the Delta Barrages (952 km). The main objectives of this monitoring program were to evaluate the quality of the Nile water and determine the effects of pollutants on the suitability of the water for the various uses (i.e. did it meet the water quality criteria set out for the various uses?). Smaller programmes were carried out between the NRI and the Faculty of Agriculture at the University of Alexandria for water quality monitoring on the Rosetta and Damietta branches between 1987 and 1989 (El-Sherbini and El-Moattassem, 1991; Mancy and Welsh, 1992).

As part of the River Nile monitoring programme, three hundred and ninety-eight sampling stations were identified which included point sources of industrial and municipal wastewater, and major drains to the Nile. In addition, stations were located along the river at approximately ten kilometre intervals in order to acquire data that could be used for spatial analysis. The parameters sampled included pH, temperature, dissolved oxygen, conductivity, major cations and anions, total alkalinity, nutrients, total dissolved solids, suspended solids, biological oxygen demand and chemical oxygen demand, faecal coliforms, and nitrogen and phosphates. The program was conducted over two separate periods. During the first period that ran from 1976-1979, samples were taken once a year; starting and ending dates for the sampling runs varied from year to year. Based on the analysis of the data, modifications to the monitoring program were recommended. For the second monitoring period starting in 1984, samples were to be taken twice a year for five years. It was anticipated that under this new sampling strategy a clear picture of the Nile water would emerge which, among other benefits, could assist in forecasting water quality changes. During this second stage of the monitoring programme, which was conducted by the NRI and the Occupational and Environmental Health Center of the MoH, sampling was carried out twice during 1984 but only once a year in 1985 and 1986. Overall, eight sampling runs were made at various times from 1976 to 1986, never at all stations, with some stations being sampled only once. Consequently, an accurate temporal analysis of the data is not possible. The program, however, was successful in terms of encouraging interministerial cooperation between the MPWWR and the MoH. The main recommendation arising from the River Nile monitoring program was the need to establish a permanent water quality monitoring programme for the Nile from the AHD to the Mediterranean Sea (El-Sherbini and El-Moattassem, 1991).

New Approach

In 1988, the River Nile Protection and Development Project (RNDP), a joint project between the MPWWR and CIDA, targeted the water quality management and pollution control division of the NRI as one of the main operational areas. Among the goals of the RNDP was the design of a permanent water quality monitoring program supported by the then newly built Nile Research Laboratory (NRL). Consequently, the NRI revamped its original monitoring programme in 1989.

The objectives of the current monitoring program are as follows:

1) To monitor compliance of wastewater discharge with legislated standards and detect any violations;
2) To determine the seasonal variations of the water quality in the River Nile;
3) To determine the general condition of the Nile water; and
4) To detect any potential public health hazards (Abdelbary and Heikal, 1998).

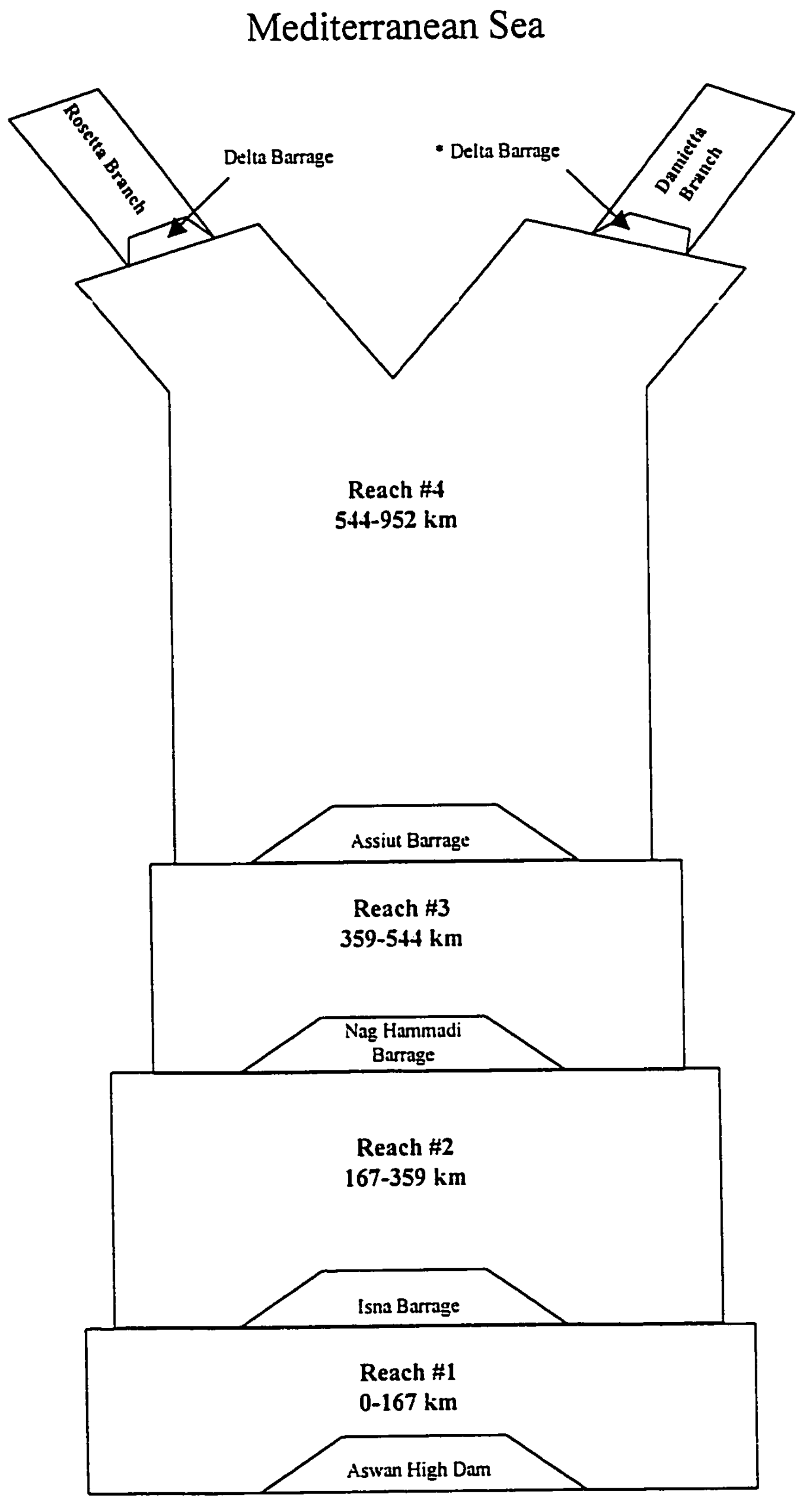
Determining the location and number of sampling sites was critical in designing a monitoring programme that could meet these stated objectives. Design criteria for sampling station locations included the following:

- Macrolocation – river reaches which will be sampled;
- Microlocation – station location relative to outfalls or other unique features within the river reach;
- Representative location – points in the river's cross section from which samples can provide a lateral profile of the river (El-Sherbini, 1994).

Under the new monitoring system, the River Nile is divided into four main reaches, based on the location of the barrages, plus the two branches (see Figure 9). The number of sampling sites was paired down to thirty-four from the +398 previously used. Both the location and number of sites were selected according to the need to optimize the amount of sampling undertaken and to gather comprehensive information at certain key sites for control purposes. Out of the thirty-four sampling sites identified, high priority was given to twelve major sites. These sites were selected due to their proximity to one or more of the following: a barrage; a major industrial area; an intensive agriculture area; and/or a large city. The remaining twenty-two sites were selected at fixed, well known points along the Nile in order to fill the gaps between the key sites and to adequately present the different stages along the river (see Figure 10). In addition to the thirty-four sampling sites, all point sources of pollution (e.g. agricultural drains, industrial discharges) are included in the monitoring programme. Five cross-sectional points are to be sampled at each station (El-Sherbini and El-Moattassem, 1991).

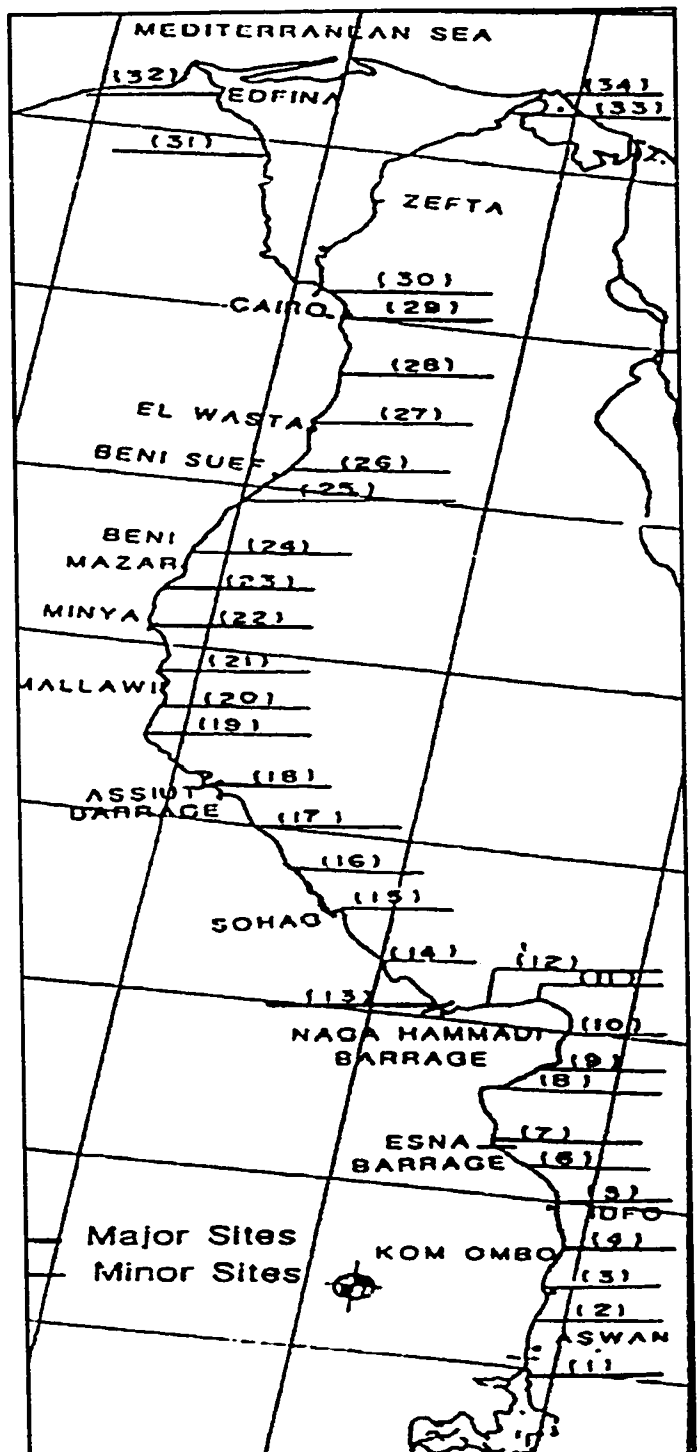
Water quality parameters are selected according to the objectives of the monitoring program, hydraulic and hydrological conditions, budget allocated, and the resources (human, institutional) required (ESCAP, 1990). Under the River Nile monitoring programme, a group of basic parameters is to be determined from all samples with additional parameters being analysed depending on the type of effluents and the importance of the site (see Table 8). Flow velocity is also to be measured at each site. The Nile Research Laboratory at the NRI is equipped to measure all the requisite

Figure 9. Simplified schematic representation of the Nile reaches. * Barrage is another term for dam.



(Adapted from El-Sherbini and El-Moattassem, 1991; Shady and Adbelbary, 1992)

Figure 10. Sampling sites for the River Nile monitoring programme



(Source: El-Sherbini and El-Moattassem, 1991)

Table 8. Parameters to be measured for the River Nile monitoring programme

All Samples (Basic Parameters)	**Major River Sites (12)**	**All Agricultural Drains**	**All Industrial Outfalls**	**All Sites****
pH-value*	All parameters	Calcium	Sulfide	Algal Density
Temperature*		Magnesium	Acidity	Chlorophyll A
Conductivity*		Sodium	Calcium	
Dissolved oxygen*		Potassium	Magnesium	
Total alkalinity*		Oil and grease	Sodium	
Turbidity*		Phenols	Potassium	
Kjeldahl nitrogen		Pesticides	Oil and grease	
Ammonia (dissolved)		Surfactant	Phenols	
Nitrite (dissolved)		Total copper	Surfactant	
Ortho-phosphorous		Total lead	Total lead	
Total phosphorous		Total zinc	Total zinc	
Biochemical oxygen demand			Total chromium	
Chemical oxygen demand			Total arsenic	
Total suspended solids			Total mercury	
Total dissolved solids			Total cadmium	
Chlorides			Iron	
Sulphates			Manganese	
Carbonates			Cyanide	
Bicarbonates			Total Nickel	
E-coli				
Faecal coliform				

(Source: El-Sherbini and El-Moattassem, 1991)

* Field parameters
** Should also include dissolved oxygen, temperature and conductivity profile at mid-channel.

parameters, except for specialized pesticides. Sampling for pesticides is done by the Ministry of Agriculture and Land Reclamation at its modern pesticides laboratory. The NRL has been designated the primary laboratory for examining the Nile samples (CIDA and EEAA, 1997).

The sampling frequency at the sites was another critical component in the design of the permanent monitoring network. Sampling frequencies were planned in stages: short term (1 year), medium term (2 years), and long term (3 years). The end goal was to have a programme where minor point sources of pollution are sampled twice a year, all thirty-four river sites and major point sources of pollution are sampled quarterly, monthly sampling occurs at four predetermined river sites, and intensive surveys for specific areas are carried out for modelling purposes (Abdelbary and Heikal, 1998).

Criteria for Situational Analysis - Water Quality Monitoring

The criteria listed below were used for analysing Egypt's water quality monitoring programme and were derived from El-Sherbini, 1994; Environment Canada, 1993; ESCAP, 1990; Hamza, 1991; UNICEF, n.d.; and from a US AID funded report by principal investigators Mancy and Welsh (1992) that highlighted weaknesses in Egypt's monitoring programme in 1992. The latter document was used as a source for criteria for three other sections being discussed in this Master's Degree Project as well: capacity building, legislative framework, and data management and information systems. The rationale behind using aspects of Mancy and Welsh's work for analysing Egypt's current water quality management situation is to determine whether any progress has been made since 1992. As the reader will note, in certain cases Mancy and Welsh's document represents the most recent information available (and accessible) to date, indicating that further research into those areas has not been carried out.

- Goals and objectives of the monitoring programme clearly stated
- Objectives regularly reassessed
- Objectives being met
- Adequate and steady source of funding

- River sampled frequently enough
- Sufficient manpower available
- Adequate equipment available
- Good dissemination of monitoring results
- QA/QC programme in place
- Sufficient number of sampling stations
- Good location of sampling stations
- Duration of water quality monitoring programme
- Monitoring system includes sampling of biological, physical, and chemical paramters
- Monitoring system includes Pressure, State, and Response indicators

Situational Analysis

Number of sampling stations. In the case of rivers, among the criteria for selecting the number of sampling stations is the size of the catchment. The number of stations required for a river basin greater than 50,000 km^2 is twenty-four[3] (ESCAP, 1990). The quantity of stations in Egypt alone surpasses this number.

Selection of parameters. The parameters being sampled as part of the River Nile monitoring programme are nearly identical to the general guidelines suggested by the United States government for the assessment of water quality. This similarity indicates that the type and numbers of parameters being sampled as part of the River Nile monitoring programme are sufficient to provide valuable information on the state of water quality (see Tables 9A and 9B). However, no indicators have been selected to determine the source of changes in water quality or the effectiveness of management responses and only quantitative methods are being used.

Designing and implementing a permanent monitoring programme. In order to acquire meaningful information from a monitoring programme, data should be collected for a minimum of three-five years (ESCAP, 1990). The most recent River Nile monitoring

[3] The entire River Nile Basin extends over 3,030,000 km^2 (TECCONILE, 1994).

programme, as it was originally designed, provided a good foundation for the collection of data that could be used for temporal and spatial analysis and for the detection of trends in the quality of Nile water. However, due to resource constraints, particularly financial, a scaled back version of the programme is currently being implemented. Since the early 1990s, only one sampling run from the Aswan High Dam to the Mediterranean Sea has been done per year. Ideally, all sampling stations on the river should be sampled four times per year. Moreover, a lack of experience among those implementing the program, combined with the lack of resources, has prevented the monitoring programme from meeting its objectives - objectives that were set by water quality experts within the MPWWR (El-Sherbini, personal communication; Abdelbary, personal communication, 1998).

Table 9A. A general guideline for the assessment of water quality

Fish & Wildlife	Municipal & Industry	Irrigation	Stockwater
Discharge	Discharge	Discharge	Discharge
Dissolved oxygen	Faecal coliform	Conductance	Total dissolved solids
Temperature	Faecal strept.	pH	Turbidity
pH	Hardness	Sodium	Dissolved oxygen
Turbidity	Color	Magnesium	Temperature
	Turbidity	Calcium	
	Temperature	Total dissolved solids	
	pH		
	Dissolved oxygen		
	Manganese		
	Iron		
	Alkalinity		
	Total dissolved solids		
	Phenols		
	Suspended solids		
	Total solids		

(Source: US Dept. of Agriculture, 1976)

Table 9B. Water quality parameters to be monitored for additional water problems

Nutrients	Waste Assimilative Capacity	Toxic Material	Salinity	Industrial
Nitrate Nitrite Total nitrogen Total phosphorous Ortho phosphate	Temperature Dissolved oxygen Biochemical Oxygen demand Nitrite Nitrate Total Kjedahl Nitrogen Time of travel	Specific heavy metals Specific pesticides	Total dissolved solids Chlorides	Check for specific industry & problems unique to it

(Source: US Dept. of Agriculture, 1976)

Laboratory equipment. When it originally opened, the Nile Research Laboratory was fairly well equipped to handle the testing of the River Nile samples. The facility housed all the essential laboratory apparatus including:

- Water sampling, storage and preparation equipment,
- A complete set of equipment for carrying out microbial analysis,
- A complete set of equipment for measuring COD and BOD,
- Infrared colorimeters, turbidity meters, pH meters, salinity meters and dissolved oxygen meters,
- Kjeldahl apparatus for nitrogen analysis,
- Flame photometer for routine analysis of soluble elements, and a
- Computer operated atomic absorption spectrophotometer for heavy metals (Abdelbary and Shady, 1992).

After close to a decade of use, the equipment is starting to break down and is in critical need of repair and maintenance. In most cases, the laboratory has only one set of equipment so when a piece of equipment breaks down, testing of the associated parameter is no longer possible. The capability exists within Egypt to fix most of the equipment (Heikal, personal communication). Government procedures, however, are generally not geared to urgent requests for the repair of equipment or the acquisition and replacement of spare parts (Hamza, 1991). According to Dr. Heikal, director of the NRL, the laboratory is adequately equipped to fulfill its role in measuring the samples generated from the River Nile monitoring programme, although some of the equipment, especially the field instruments, is in need of upgrading. The total budget for maintenance and replacement of laboratory equipment in 1999 is approximately Cdn $140,000 (Abdelbary, personal communication, 1999).

Review of monitoring system. Systematic reviewing of the monitoring programme is not taking place. It is reexamined whenever a problem arises (i.e. a reactive, ad hoc approach) (El-Sherbini, personal communication).

Quality Control and Quality Assurance. Quality Control (QC) and Quality Assurance (QA) activities should govern the three major stages of the River Nile monitoring programme: sampling; laboratory analytical measurements; and data collection and management. The following provides an overview of how QC and QA are currently managed:

(I) Sampling – Quality control measures are in place. The sampling techniques have been developed according to international standards for accuracy and representiveness (Mancy and Welsh, 1992).

(II) Laboratory analytical measurements - Quality control measures are in place. Samples are tested according to methods set by the American Chemical Society. Routine checks, such as periodic calibrations, are performed in order to control the accuracy and precision of the measurements.

(III) Data collection and management – No quality control measures are currently in place.

Quality assurance, the system of activities which ensures that the quality control system is performing properly, was absent in all three of the aforementioned programme components.

Recommendations

Prioritise timing of sampling. The releases from the AHD are managed according to the needs of the perennial agriculture. Consequently, there are now four "hydraulic" seasons on the River Nile: low flow (winter flow); increasing flow (spring time); high flow (summer months); decreasing flow (autumn months). From October to January, the volume of water being released from the Aswan High Dam is drastically reduced since irrigation demands are minimal. In addition, the barrage at the entrance to the Damietta branch is shut for 2-3 weeks to allow for maintenance of the irrigation canals; accordingly, water flow in the Rosetta branch peaks (Abdelbary, personal communication, 1999; Gouda, personal communication). Over the past several years, water sampling has been undertaken during the summer months when the river flow has been at its highest. Given the limited amount of resources available which permits only one sampling run per year, it could be of greater benefit to carry out sampling when the river is at its lowest. It is during the winter months that the assimilative capacity of the Nile, which is dependent upon water flow, would most likely be at its lowest, making the Nile ecosystem more vulnerable to pollutants. The MPWWR may wish to undertake specific studies to confirm that the Nile's assimilative capacity is at its lowest during the winter months since it is dependent upon a variety of factors: temperature, DO, BOD, nitrite, nitrate, total kjeldahl nitrogen, and time of travel (ESCAP, 1990).

Laboratory Equipment. Design and implement a preventive maintenance programme to keep the equipment functioning properly and to intercept malfunctions before they become serious. The programme should include regular servicing of functioning equipment and training of the lab technicians on the handling of the more sensitive and advanced equipment (mishandling of equipment can cause extensive damage). A maintenance programme would reduce the need for replacement parts and costly repairs to the equipment: long term benefits include a decrease in overall operating costs of the NRL.

Greater Biological Surveillance. Limited biological testing is currently being undertaken: algae, chlorophyll, and faecal coliform are the only variables being measured (Heikal, personal communication). Although biological surveillance is inherently complex, there are considerable advantages. Firstly, animal and plant communities respond to intermittent pollution (e.g. discharge of industrial effluent) which may be missed by the sampling of physico-chemical parameters. The aquatic life can sometimes provide a continuous monitor of water quality not otherwise possible except by the installation of automatic analysers at sampling stations (ESCAP, 1990). Secondly, biological communities may respond to new or unsuspected pollutants in the aquatic ecosystem. The industrialization of Egypt over the past four decades has brought with it more complex and diverse types of pollutants. It is neither economical nor practicable to test for the presence and concentration of all the known pollutants. However, a change in the structure or diversity of a biotic community can indicate the need for detailed screening of the pollutants and chemicals not previously considered as posing serious environmental and health risks. Thirdly, biological surveillance can be used to confirm or refute conclusions based on physico-chemical analysis. Fourthly, pronounced changes in the biological communities can be invaluable in identifying effects from bioaccumulative chemicals and cumulative impacts of pollutants (US EPA, 1997A). Bioaccumulation occurs with many toxic pollutants: concentrations in the water may be too low to be detected, whereas very high levels of the chemical may be present in the organism being tested. This information could be very important to know if the species being tested is normally consumed by humans (e.g. commercial fish). In such a situation, biological surveillance would help to reveal a previously unknown health threat. Lastly, and most importantly, monitoring changes in aquatic communities can serve as an early-warning system for the potential effects of the pollutants in the water on human users (Mason, 1991).

In the long term, the use of bioassays and biotic or diversity indices should be incorporated into the River Nile monitoring programme. In order to reach that stage, thorough research is needed on the structure and composition of aquatic communities (e.g. benthic community) within the River Nile ecosystem, with particular emphasis on communities located in areas with minimal pollution and their reaction to changes in river flows.

Broaden scope of monitoring system. As more resources become available, the monitoring system should be revamped. Currently, it only yields information on the State of the River Nile. Furthermore, the process does not include opportunities for stakeholder participation nor a clear strategy for setting priorities. The following steps should be taken to broaden the focus of the monitoring system, thereby increasing its usefulness:

1. Determine the Valued Environmental Attributes of the River Nile.
2. Identify the Pressures on the River Nile and the Responses addressed at maintaining or enhancing surface water quality.
3. Prioritise the Pressures and Responses.
4. Develop criteria for the selection of indicators for each category.
5. Collect and analyze data on the indicators.
6. Input information into an environmental information system accessible to decision-makers, managers, water users, and other interested stakeholders.

Each step should be iterative and open to feedback to stakeholders.

Review of monitoring system. A proactive, systematic approach to the evaluation of the monitoring programme, founded on the principal of continual improvement and in conjunction with the water users and other concerned stakeholders, should be adopted. Water quality managers need to view the monitoring process as a continuous experiment where learning from previous actions and applying the newly acquired knowledge allows them to remain flexible and adapt to uncertainty: both essential elements in effective water quality management. The United States Geological Survey recommends that water quality monitoring systems be reviewed objectively and critically after five years of operation by water quality experts. This recommendation reflects a highly aggressive approach to water quality management and the availability of sufficient resources to carry it out. Resource constraints within the MPWWR may make it unfeasible to carry out a review with such frequency. In such a situation, the important thing is to ensure that the programme is evaluated on a regular and systematic basis. The review should include the following:

- identification of the strengths and weaknesses of the programme;
- determination of whether water users' needs and demands have changed;
- financial audit;
- process for receiving input from the various stakeholders;
- determination of whether programme objectives are being met;
- reexamination of water quality objectives in light of changing social, political and/or economic conditions;
- identification of areas within the programme where efficiency could be increased;
- confirmation that the proper data is being collected to meet the existing objectives;
- assessment of conformity with government policies; and
- assessment of the allocation of resources (Environment Canada, 1993; Perry and Vanderklein, 1996; UNICEF, n.d.; USGS, n.d.).

A formal report of the review will need to be compiled and submitted to the head of the water quality division at the NRI, the director of the NRI, and the Minister of Public Works and Water Resources. Decisions regarding the monitoring system should then be made and carried out. Moreover, the compiled report, including a prospectus of projects (e.g. a study on benthic communities in the River Nile and their response to pollutants), could be used to secure investors or additional sources of funding.

Design and implement intralaboratory and interlaboratory quality control activities for data collection and management. A uniform approach for data storage and retrieval should be developed and promoted as part of a comprehensive quality control programme. In addition, all data should be accompanied by estimates of their precision and accuracy. Raw data of mediocre quality can sometimes be used for analysis providing the limitations are known (Environment Canada, 1993).

Perform quality assurance activities on an occasional basis. The MPWWR could benefit from conducting a few quality assurance activities such as on-site quality control system surveys, performance audits, and interlaboratory comparisons. Ideally the activities should be performed by people external to the day-to-day operations of the monitoring programme.

CAPACITY BUILDING

A central determinant in the long-term success of any national water quality management programme is the ability of institutions and individuals to perform designated tasks efficiently and effectively and to identify and address problems on a sustainable basis. In the absence of this capability, it is exceedingly difficult to achieve positive, lasting results. A long history of project failures in the developing world has underscored this need to strengthen national capacities (Bolger and Qualman, 1996; Grindle and Hilderbrand, 1994; UNDP, 1998).

Many definitions for capacity building exist. The definition put forth by the UNDP will be used herein:

> Capacity building is the sum of efforts needed to nurture, enhance and utilize the skills and capabilities of people and institutions at all levels --- so that they can better progress towards sustainable development. At the basic conceptual level, building capacity is about empowering people and organisations to solve their problems, rather than attempting to fix those problems directly (UNDP, 1998).

Capacity building is fundamentally an endogenous process with the role of foreign aid agencies and international organisations being one of facilitation. Hence, the onus rests on government to create the enabling environment for institutional and human resources' development. This section delves into Egypt's public sector capacity, utilizing institutions and human resources as the principal units of analysis, and provides recommendations on how to strengthen the existing capacity.

Institutional Framework

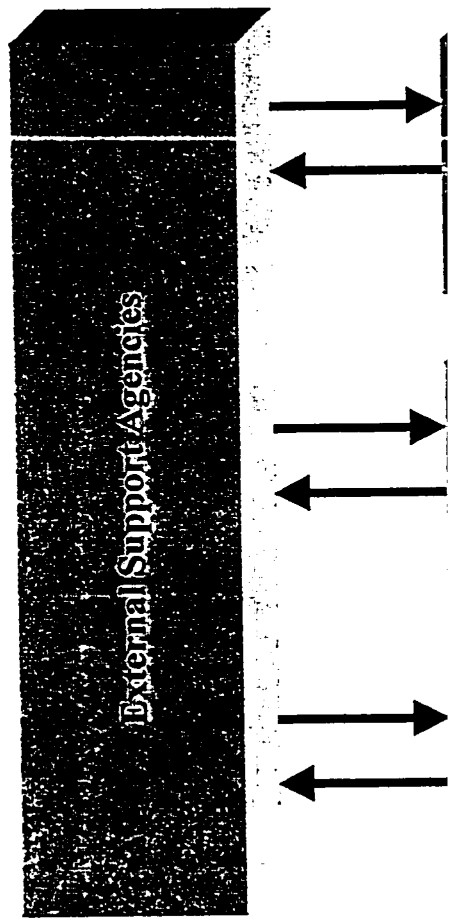
Water quality management is inherently multi-disciplinary and requires the coordinated action of several public sector institutions. The interactions within this 'task network' can facilitate or constrain performance. In analysing a task network, the various institutions involved need to be looked at individually with an eye to both the institution's own capacity and the coordination of its activities with those of the other institutions with which it must interact (Grindle and Hilderbrand, 1994). The following provides an institutional map (figuratively speaking) of Egypt's water quality management network (see Organigram 1). It covers the ministries with primary responsibility for water quality management, those that are less central but still play a role, and those that provide various kinds of support. The ministries were identified through key informant interviews and consultant reports.

Ministry of Public Works and Water Resources

Formerly known as the Ministry of Irrigation, the Ministry of Public Works and Water Resources (MPWWR) is the primary institution involved in water quality management. As the only government ministry concerned solely with water resources in Egypt, its responsibilities include allocating irrigation water; maintaining the complex hydraulic system of barrages, canals and pumping stations; and developing and operating the irrigation and drainage systems. The MPWWR is also concerned with maintaining the water quality of the River Nile suitable to all users, although the focus has typically been on irrigation (CIDA and EEAA, 1997; Mancy and Welsh, 1992). It is necessary to point out that while the MPWWR allocates water for irrigation, the primary water user in Egypt, it does not allocate a share of the Nile water to the remaining users. Any excess water is withdrawn by the other users (i.e. municipal, industrial, domestic) as needed (Mancy and Welsh, 1992).

An important sub-sector within the MPWWR is the National Water Research Centre. During the 1970s, the Government of Egypt, recognizing the importance of research in the development of successful water management programmes, started to heavily support research institutions. One of the outcomes was the establishment of the Water Research Center in 1970 to oversee all the research and development functions within the

Organigram



MPWWR. It was re-organized in 1994 by virtue of a second presidential decree and renamed the National Water Research Centre (NWRC) (CIDA and EEAA, 1997). The Centre's main objectives are to study and propose long-term water management policies, carry out research into the problems associated with irrigation and drainage, attempt to find ways of utilizing the water resources in the most efficient and cost-effective manner, and to study the main effects of the Aswan High Dam (Abu-Zeid and Samie, 1994; CIDA and EEAA, 1997). It operates at the highest policy-making level. The Chairman of the NWRC reports directly to the Minister while the activities of the Center are overseen by a Board of Directors appointed by the Minister.

The NWRC consists of twelve research institutes (Abdelbary, personal communication, 1999). The Center is equipped with two laboratories at El Qanater: the Nile Research Laboratory, as previously mentioned, which analyzes the River Nile monitoring programme samples and the Drainage Research Institute Laboratory, which tests the samples from the drainage monitoring programme. CIDA, through the River Nile Protection and Development Project, is currently funding the building of a central lab, the Central Laboratory for Environmental Quality Monitoring (CLEQM). The lab, which is also located at El Qanater, will be available for use to all the research institutes and will be able to measure all the parameters being monitored, including the testing of water samples for pesticides and herbicides, a capability that the NRI currently does not have (CIDA and EEAA, 1997). The construction of the lab is very near completion. The Nile Research Institute, formerly the High Aswan Dam Side Effects Research Institute, is one of the twelve institutes comprising the NWRC. The NRI's mandate includes the following:

- evaluation and assessment of the impact of new development and interventions on the River Nile Channel, quality of its water, and development of its shores;
- monitoring of water quality in the river channel and influent drains for chemical, physical and biological charactersistics;
- assistance in enforcement of pollution control laws related to Nile waters; and

- dissemination of information and data emanating from studies, research results, and from publications, conferences, symposia and other media (Abdelbary and Shady, 1992).

The NRI is the key implementing agency of the River Nile monitoring programme (CIDA and EEAA, 1997).

Ministry of Health

The Ministry of Health (MoH) has been allocated major responsibilities directly relating to water quality management. Chief among them is the setting of quality standards for the following:

- industrial and sewage treatment plant discharges;
- waste discharged from river vessels; and,
- potable water sources (i.e. River Nile and irrigation canals) (Kelly and Welsh, 1992).

Besides developing standards, the Ministry is responsible for pollution control in all 26 of Egypt's governorates, which requires identifying, sampling, and analyzing all industrial and municipal effluents and submitting reports to the proper authorities as legally mandated (e.g. General Organisation for Industry, Ministry of Public Works and Water Resources). Nine regional laboratories are available for this purpose, along with a central water quality monitoring laboratory located at the Ministry's Environmental and Occupational Health Center (Mancy and Welsh, 1992). This represents a significant amount of work since there are approximately 600 industrial facilities and several hundred water or sewage treatment plants that need to be sampled and analysed every three months in accordance with Ministerial Decree 09/1988 (Kelly and Welsh, 1992). According to the MoH, effluent quality is being measured monthly in approximately 300 observation points. The monitoring activities are predominantly financed by the Egyptian Environmental Affairs Agency (CIDA and EEAA, 1997).

General Organisation for Industry

The General Organisation for Industry (GOFI) of the Ministry of Industry is in charge of managing the majority of the government owned industrial facilities. Within GOFI, an

Environmental Management Department has been established to assist industries in meeting legislative requirements. The department is staffed entirely by engineers. Its mandate is to provide technical assistance to industries in the area of pollution control and to aid them in obtaining the funding needed to install treatment facilities (Kelly and Welsh, 1992).

In 1983, GOFI launched an action plan for controlling liquid waste discharged by 25 public sector industries. The plan was expanded in 1985 to encompass 188 industries. Priority was to be given to the worst polluters (Mancy and Welsh, 1992). Little progress has been made to date in the implementation of the action plan; government owned industries remain the worst polluters (The Economist Intelligence Unit, 1998).

National Organisation for Potable Water and Sanitary Drainage

Within the Ministry of Housing, Reconstruction, and New Communities, the National Organisation for Potable Water and Sanitary Drainage (NOPWASD) is a key organization. It plays a major, but not primary role in water quality management. The NOPWASD oversees the provision of water supply and sanitation services. By receiving water quality analysis carried out by different laboratories, the organisation is also indirectly involved in the monitoring of effluent from municipal sewage treatment plants (Mancy and Welsh, 1992).

As part of its responsibilities, the NOPWASD provides basic training to local operators of sanitary facilities. Advanced training, and operation and maintenance, however, are the responsibility of the governorates. Irregularly, the NOPWASD inspects individual treatment plants to determine whether they are functioning properly. In cases where problems are identified, the NOPWASD is required to cooperate with the governorate in question to resolve the issues (Kelly and Welsh, 1992). Based on the sub-optimal functioning of a number of wastewater treatment plants (see section on Water Quality in Egypt), it appears that neither the NOPWASD nor the governorates are entirely successfully in carrying out this task.

Egyptian Environmental Affairs Agency

The Egyptian Environmental Affairs Agency (EEAA) was established by Presidential Decree 631/82 to act as an umbrella agency in coordinating the environmental activities, including water quality management, of the different ministries (EEAA, 1991). The constitutional structure, established in 1982, however, gave the agency minimal authority. Consequently, it has traditionally played a weak coordinating role among the ministries. This situation may change in the near future. A new law decreed in 1994 (Law 04/94), and which came into effect in 1998, has given the agency more authority (to be discussed in Legislation section) and designated a clear set of agency responsibilities (e.g. enforcing environmental legislation, implementing an environmental impact assessment programme).

Ministry of Agriculture and Land Reclamation

The goal of the Ministry of Agriculture and Land Reclamation is the sustainable development of Egypt's agricultural output to meet the needs of the country's increasing population. Since commercial agriculture is wholly dependent on irrigation, water quality plays a critical role in agriculture production. Monitoring is carried out by the Soil and Water Research Institute of the Ministry's Agriculture Research Centre. The Agriculture Research Centre is equipped with a modern pesticides lab (CIDA and EEAA, 1997).

<u>Criteria for Situational Analysis - Capacity Building</u>

Egypt's capacity building was assessed according to criteria from Austin et al., 1991; Bolger and Qualman, 1996; Grindle and Hilderbrand, 1998; and UNDP, 1998. The criteria are as follows:

- Data disseminated in an efficient and timely manner;
- Central database available for water quality data (i.e. integrated information system);

- Standard data formats;
- Data accessible to all stakeholders, including media and the public;
- Regular exchange of information;
- Quality control standards in place;
- Data easy to retrieve;
- Use of indigenous resources;
- Adequate funds available; and
- Personnel trained in data management and information systems.

Situational Analysis

Leadership. In July 1997, a new Cabinet of Ministers was named. Of particular note in regards to water quality management was the appointment of Dr. Mahmoud Abu Zeid as Minister of Public Works and Water Resources. Dr. Abu Zeid was chairman of the Water Research Centre for a number of years and has a thorough understanding of the capabilities of the institutes. He is trying to bridge the gap between the researchers and the Ministry (El-Sherbini, personal communication).

Another key appointment was the naming of Mrs. Nadia Makram Obeid as the State Minister for the Environment and the new of the Egyptian Environmental Affairs Agency. Mrs. Obeid, according to one senior technical advisor, has brought new life to the agency. She is completely committed to seeing the EEAA fill its intended role as a strong coordinating agency for environmental activities. To this end, she has set-up various interministerial committees. She is also performing, along with staff members of the agency, spot checks of industrial facilities on a regular basis to determine violations and to provide pollution control assistance (Yehia, personal communication; Hamza, personal communication). Law 04/94 has provided the Agency with enough authority, under the strong leadership of Mrs. Obeid, to carry out its function as overseer and coordinator.

Communication and Collaboration. Communication and collaboration among the various ministries is fair: much of it is done informally (El-Sherbini, personal communication).

Each agency carries out its tasks independently of the others and does little to disseminate acquired information. For example, the MPWWR can only do one sampling run on the River Nile per year due to resource constraints (El-Sherbini, personal communication). The MoH, in accordance with its responsibilities, also carries out water quality monitoring, and until recently, was similarly faced with resource constraints. The EEAA has stepped in to provide funding for the MoH's monitoring programme, but there is a lack of trained personnel (CIDA and EEAA, 1997; Mancy and Welsh, 1992). The two ministries do not currently collaborate on water quality monitoring nor exchange information to any significant degree.

National Management Framework. There is some jurisdictional fragmentation inherent in any government's institutional structure. Various roles and responsibilities related to water quality management are parceled off to different administering sectors with a duplication of efforts occurring quite regularly. An interdisciplinary, multi-jurisdictional approach is needed to adequately address water quality issues. Without a national water quality management framework (e.g. Pressure-State-Response/Effects model) to coordinate actions and to determine priorities, it is very difficult to effectively allocate resources and to accurately assess whether any significant progress is being made in maintaining or enhancing water quality. In recent years, however, the Egyptian government has taken steps in remedying the lack of a coordinated effort.

Commencing in 1992, the Government of Egypt has embarked upon setting up and implementing a National Action Plan for the Environment. The EEAA has been named the lead agency in this endeavour. One of the areas targeted for action under this plan is the River Nile (Earth Summit Watch, 1994). Nonetheless, a national water quality strategy to clean-up and protect the freshwater resources of the River Nile, which was a goal set out in the Environmental Action Plan, has yet to be devised. The EEAA doe not have the human resources to develop and oversee implementation of such a strategy; the agency has too few staff with experience in water quality management or pollution control.

Human resources. In general there is an acute shortage of skilled manpower in terms of both quantity and quality (Mancy and Welsh, 1992). This situation is predominantly due to the training and education being provided and to the limited financial resources available (e.g. not having enough funds to hire a sufficient number of staff and not being able to provide competitive salaries to retain qualified staff). Training courses are usually designed according to the requirements of donor funded projects and are instructed by international consultants (Yehia, personal communication).

The EEAA does not have a large permanent staff (i.e. 250 employees) and has traditionally relied quite heavily on consultants (CIDA and EEAA, 1997). The contract workers take part in the training programmes provided, but usually do not work for the EEAA on a long-term basis. Hence, the Agency mostly benefits from the training programmes on only a short-term basis. At the present time, the agency is faced with a difficult staffing problem. In the past, hiring contract workers was fairly easy. However, the Ministry of Labor has set forth a new regulation: money for contract workers can no longer come from the existing budget of the agency. Furthermore, international agencies are unwilling to finance local contract workers. Acquiring permanent staff to fill this gap in human resources is very complicated and involves getting approval from the Ministry of Finance (Yehia, personal communication).

The Nile Research Institute of the MPWWR, unlike the EEAA, has a fairly adequate complement of permanent staff, although the Institute is in critical need of water quality analysts. The NRI is having difficulty in providing advanced training for its people, a role donor agencies could potentially fill in partnership with local universities. Recognizing that they cannot provide sufficient monetary incentives to retain staff, senior management at the NRI strives to provide non-monetary incentives to compensate. They try to be flexible, providing personnel with leave of absences when needed and encouraging their staff to take advantage of donor funded programmes to study and train abroad (Abdelbary, personal communication). Unfortunately, the drawback to this approach is that it reduces the capacity of the institute when key personnel are away for prolonged periods. The positive aspect is that the Institute has an easier time of retaining personnel, although losses can be fairly high in certain critical areas (e.g. water quality modelling).

Recommendations

Make a long term commitment to capacity building. Mary Hilderbrand and Merille Grindle (1994), two Harvard University researchers, have noted that in countries that have received substantial amounts of foreign assistance, long term progress in meeting socio-economic goals has fallen far short of expectations. Among the root causes were efforts to strengthen capacity which focused too much on "getting the job done" rather than on building sustained ability. Capacity building is an on-going process that requires a long term investment. Building up capacity in the short term, with assistance from donor agencies, without a proviso to sustain and enhance this capacity internally will constrain institutional performance and produce few tangible results in the long run (Grindle and Hilderbrand, 1994).

Capacity building must be given high priority by the Government of Egypt. As pointed out in CIDA's annual publication Development Express, "external assistance can temporarily overcome capacity weaknesses – but sustainable, self-sufficient capacity for development cannot be bought, it must be built" (Bolger and Qualmann, 1996, 4). The building of Egypt's capacity in water quality management, after considerable infusions of foreign aid, is slowing down with only the foundation completed. Nonetheless, the building blocks are already in place. Strong political support from the GOE to continue to strengthen Egypt's existing capacity over the long term is essential. This commitment should translate into sustained investment in human resources with emphasis on training and education, and the development of long lasting, indigenous, and alternative sources of funding (e.g. license fees, pollution taxes, performance bonds).

Develop human resources. Human resources development is an integral component of capacity building. The major role of human resources development is providing training and education programmes to improve job performance. Adequate training and education are critical to ensuring personnel carry out their functions according to the standards needed to meet institutional goals. Training, as used in this document, refers to technology-related learning and the teaching of new techniques. Education is the learning of basic concepts and general principles, which do not change over time (Thompson, personal communication, 1998).

Most of the training provided, as previously mentioned, has been linked to individual projects. While this type of training has its merits and should continue to be welcomed by senior management, it is not comprehensive enough. A Training Needs Assessment conducted by qualified personnel needs to be undertaken to identify gaps where skills training or upgrading are needed to improve institutional performance. Upon completion of the assessment, a Skills Development Training Programme for staff at all levels (junior to senior) should be designed, implemented, and evaluated. The respective Institute's requirements and the existing financial and political climate must be considered. Courses should target the main groups involved in water quality management including managers, field and lab technicians, and data analysts. In addition, the training offered should not be confined to just technical areas, as has traditionally been the case (Abdelbary, personal communication, 1998). The following is a list of non-technical subjects for which there is a dearth of expertise among personnel and which training courses should cover:

(I) Applied problem-solving. The education system is heavily focused on textbook learning with students developing limited analytical abilities. Case studies utilized are often taken from other countries. While it is beneficial to study how other nations address certain situations, in the case of water quality management, importing packaged solutions without tailoring it to the local cultural, political, economic environment often results in unsustainable results. Personnel should be capable, at the very least, of identifying problems within their jurisdiction (not just the symptoms), and optimally be able to propose actions feasible within the local context to mitigate problem impacts or develop alternative solutions to them.

(II) Presentation skills. Research papers are prepared and presented at international conferences and to decision-makers. Success in capturing and holding people's attention in order to convey important information depends on the individual's ability to communicate. Individuals who can verbalize their research findings and recommendations so that they are heard and understood are more likely to witness their research being acted upon. The components of an effective presentation, including organizing and presenting ideas logically and convincingly, need to be learned and practised (Toastmasters International, Inc., 1992). Oftentimes, personnel are required to give presentations yet have not had the opportunity to participate in any public-speaking courses.

(III) Interdisciplinary teamwork. In recent years, there has been a shift away from multidisciplinary teamwork to interdisciplinary teamwork in tackling environmental issues. A multidisciplinary approach involves delegating various components of a program to different specialists (e.g. civil engineers, soil scientists, economists). Each group of specialist performs their designated tasks and contributes to the final project output. Interaction among the groups is minimal. An interdisciplinary approach involves the various disciplines working in conjunction with each other to achieve project goals; there is continuous interaction among project members. Interdisciplinary teamwork, an inclusive process, requires a new set of skills; personnel must learn to effectively communicate their ideas to staff members in disciplines outside of their own and to be open to their feedback. To facilitate interdisciplinary teamwork, staff should also receive basic instruction covering the other disciplines whose specialists they would normally be working alongside.

(IV) Leadership, time management, human resources management. Personnel with scientific or technical backgrounds (e.g. engineering) occupy the majority of senior management positions relating to water quality management. While at the top of their respective fields, most of them have had little or no instruction in human resources management, time management, or leadership skills (Yehia, personal communication). A workshop would provide an excellent forum for managers to share ideas and strategies with each other and to learn how to become more effective leaders.

The training courses need to go beyond unidirectional instruction. Trainees should be required to share their workplace experiences, as they relate to the course topic, with their fellow trainees. They should also be challenged to come up with their own ideas and suggestions regarding the topic under discussion. This precludes a spoon fed approach to teaching whereby the instructor provides all the answers.

In cases were external consultants are teaching the courses, there should be a requirement that they partner up with a local university and that they provide faculty members with training on how to teach the courses. This process of partnership with academia and certifying locals to instruct the courses would assist Egypt in building an education programme that could be sustained using internal resources and could serve to increase the level of expertise among the country's water quality professionals.

Created in 1996 with core funding from the Government of Canada, the newest member of the UN University family of organizations is the United Nations University: International Network on Water, Environment and Health (UNU/INWEH) headquartered at McMaster University, Hamilton, Canada. The organisation is committed to strengthening freshwater management training in developing countries and to provide on-the-ground project support with particular emphasis on integrated watershed management. Included in its mandate is the strengthening of human resources locally. UNU/INWEH hopes to fulfill this mandate by training people in developing countries who are expected, in turn, to teach their fellow countrymen. In addition, team members for on-the-ground projects will be actively recruited from developing countries, creating a south-to-south transfer of information. Training areas that will be covered include environmental monitoring, regulatory development and enforcement, information collection and dissemination, and water research. The Network's web site <www.inweh.unu.edu/unuinweh/>, which became fully operational in 1998 will eventually include distance education programmes in integrated water quality management and aquatic ecosystem protection. Africa, Latin America, and the Middle East have been targeted to receive initial funding for project development (UNU/INWEH, 1998). Egypt should view UNU/INWEH as a potentially good source of support for a skills development training programme. In addition, bilateral aid for financing training is extensively available from the Nordic countries, the Netherlands, United Kingdom, Japan, and Germany (Okun, 1991). This source of funding, if secured, should be considered only for the start-up of a skills development training programme. To ensure the sustainability of the programme once it is up and running, funds must originate from within the country (i.e. the training programme should not be dependent upon heavy foreign assistance).

Increase retention of staff. In order acquire returns on the investment in a skills development training programme, the participants must be motivated to stay. To reduce staff turnover and loss of trained manpower, higher priority must be given to the following: provision of promotions based on good performance; use of non-monetary incentives; recognition of individual excellence; and inclusion of non-managerial staff in the decision-making process (Grindle and Hilderbrand, 1994).

Increase transfer of learning. Training and education are of little value unless opportunities exist to apply them. As concluded by Austin and his colleagues, "even the positive effect of the best planned, most technically efficient learning can be nullified by a non-supportive organizational setting" (Austin et al., 1991, 351). Supervisors need to actively encourage trainees and recent university graduates to apply their acquired knowledge.

Foster closer relationships with post-secondary establishments. Linkages between the institutions involved in water quality management and the establishments that provide post-secondary education need to be enhanced. Occasional meetings should be established between managers from the government institutions and representatives from the post-secondary establishments to discuss how the curriculum can be improved to provide more qualified graduates. At the moment, most of the water-related courses being provided are strictly technical. Moreover, water resources management is not taught at the undergraduate level, and only briefly covered at the graduate level. Areas that should be considered for inclusion in the curriculum are advanced analytical techniques, problem-solving skills, natural resources management, and employment relevant skills (e.g. computer literacy).

Develop a national strategy for water quality management. Egypt's existing institutional structure is fairly good. However, there needs to be a national strategy for water quality management to coordinate the activities of the various institutions and to increase communication and collaboration. The US EPA's Pressure-State-Response/Effects model provides a good conceptual framework from which to devise strategies for the River Nile as part of Egypt's Environmental Action Plan. Since the EEAA does not have the human resources capacity to devise and implement a national water quality management strategy, this function should be delegated to the MPWWR, the ministry with the highest level of expertise in the water resources field. The following are steps that could be taken to develop and implement the strategy:

- setting national water quality objectives;
- selecting indicators to be used in measuring progress towards national water quality objectives;
- developing medium- to long-term action plans (e.g. revamping the River Nile monitoring system);
- overseeing plan implementation;
- monitoring and evaluating progress towards objectives; and
- revising objectives or action plans as required.

As part of an adaptive management approach, iterative feedback is essential throughout the aforementioned process. There has to be opportunities for discussion and participation of stakeholders and the other ministries in the decision-making process at each stage. This would increase the commitment among those involved directly or indirectly in water quality management by empowering them and thus given them a greater sense of responsibility and recognition that they have an important role to play. There would also be heightened accountability among the implementing agencies.

Representatives from academia, implementing agencies, private industry, NGOs, and user groups should all be given a say into a national water quality management strategy.

Roundtables, designed and implemented in Canada, provide an example of one potential format for receiving stakeholder input. Round tables are Canada's unique response to the Brundtland report. The format was developed in a society where hierarchical structures for authority are characteristic of its institutions, similar to Egypt's administrative framework. The mandate of a round table is to reconcile divergent interests and to strengthen existing channels between various sectors. It tries to break down barriers by reaching across institutional lines. The techniques used by round tables are as follows:

- drawing its membership from across society (e.g. corporate executives, government ministers, academics, engineers, economists) so that it can bring diversity and wide-ranging expertise to any issue;
- acting as a catalyst and coordinator among people and institutions to encourage commitment to sustainable development and empowerment of the stakeholders;
- decentralizing decision-making to take the decision-making process closer to the problems and to possible solutions; and
- conducting its operations by consensus so as to enlist supporters and promote an atmosphere of co-operation rather than fostering traditionally adversarial positions (National Round Table on the Environment and Economy, 1992).

LEGISLATIVE FRAMEWORK

A national water quality management programme should be backed by effective legislation and enforcement. The legislation should provide the institutions responsible for water quality management with the means to formulate regulations and standards for the quality of water for various uses and set legal limits for the discharge of pollutants. The institutions should also have the power to enforce the law and to prescribe penalties for non-compliance. The strength of the command and control approach (i.e. regulating behavior) lies in its ability to effectively address areas where there exists a serious threat to citizens' health or a high risk of irreversible environmental damage (Schmidheiny, 1995).

The Egyptian government has chosen to address water quality management within a legislative framework. The potential drawbacks to such an approach are the cost, inherent inflexibility of regulations, and administrative infrastructure needed to assure compliance (Schmidheiny, 1995): all issues that the GOE is encountering. Until recently, one primary law, Law 48/1982, provided the legal basis for water quality management of the River Nile. Egypt's legislative landscape, however, is in a state of transition with a comprehensive, new piece of environmental legislation, Law 04/1994, coming into force in 1998 after a prolonged grace period. Both laws will be discussed in this section and the question as to whether the conditions in Egypt are sufficient for a command and control approach to work will be addressed (Thompson, 1998).

Alternatives to a Command and Control Approach - General Discussion

The command and control approach represents only one means to attaining the goal of reducing pollution and conserving natural resources. Moreover, it represents an indirect method of tackling pollution (e.g. developing and implementing standards ---> monitoring compliance ---> prosecuting violators, etc.) and takes several years before results are produced (Thompson, 1998). Over the past twenty years, a variety of tools have emerged which can improve environmental protection and do so at a cost lower than by government regulations. These tools fall under two categories: self-regulation and economic instruments (World Resources Institute, 1998). Self-regulation are voluntary initiatives spearheaded by corporations or sectors of industry in which they regulate themselves though Codes of Practice, pollution reduction targets, public disclosure of environmental performance, etc. (Schmidheiny, 1995). Economic instruments are initiatives that provide industry and consumers with financial incentives to adopt less polluting behavior or technologies (World Resources Institute, 1998). Both self-regulation mechanisms and economic instruments encourage the adoption of pollution prevention measures, rather then pollution control as espoused by the command and control approach.

As defined by the Canadian Council of Ministers of the Environment (CCME), pollution control prevention consists of the following:

> The use of processes, practices, materials, products or energy that avoid or minimize the creation of pollutants and wastes, at the source.
>
> Pollution prevention promotes continuous improvement through operational and behavioural changes. Pollution prevention is a shared responsibility among governments and individuals, industrial, commercial, institutional, and community sectors (CCME, 1996, 2).

Pollution control involves the treatment of waste to reduce the risk posed by pollutants prior to their release into the environment (CCME, 1996). The best method to prevent exposure to toxic pollutants (heavy metals, persistent organic pollutants) is not through treatment, but by reducing their use in the first place (i.e. source reduction). Implementing instruments to make industry both cleaner and more efficient (i.e. do more with less) can yield in the long term economic, environment, and public health benefits. This goal is defined as achieving eco-efficiency. It requires industry to reduce raw material inputs and to decrease the amount of pollutants created for each unit of production (World Resources Institute, 1998).

In the arena of pollution prevention, developing countries have an advantage over their industrialised counterparts. Given recent advances in telecommunications, information systems, new materials, and biotechnology, the developing nations have the opportunity to put in place cleaner production process, skipping over the older, more polluting technologies, as they move towards industrialisation. Proper regulatory, economic, and environmental incentives can dissuade companies from importing "dirty technologies" from the First World. According to the World Resources Institute (1998), conditions for investment in environmentally sound technology are particularly favorable in the rapidly industrializing countries such as Egypt. Decision-makers, when deciding whether to provide financial and technical assistance to industries, will need to recognize that although the initial costs of cleaner technology may be higher than those of older technology, the return on investment will be greater in the long term in terms of economic savings and environmental protection.

Does the emergence of self-regulatory mechanisms and economic instruments aimed at sustainable development make the command and control approach obsolete? Definitely not. A command and control approach can facilitate the use of the other two methods. As will be seen further on in this section, Egypt is currently experimenting with such a system. Each of the three approaches - command and control, self-regulation, economic instruments - has its own strengths and weaknesses. It is the reliance on only one type of approach that needs to be changed. Policy-makers need to select among the various instruments available to achieve the optimal mix for meeting environmental protection goals.

Law 48/1982 – Protection of the River Nile and Water Ways from Pollution

Enacted in 1982, Law 48 on the Protection of the River Nile and Water Ways from Pollution is broadly based on the US Clean Water Act (Kelly and Welsh, 1992). The law prohibits the discharge of solid, liquid, or gaseous waste to the Nile, irrigation canals, agricultural drains, and groundwater without a government-issued license. Applicants (i.e. factories, treatment plants, river vessels) are entitled to a license if the effluent they discharge meets the requisite water quality standards. The generally stringent standards[4] were established in the implementing decree for Law 48/1982 (Decree 8/1983) for the following categories:

- River Nile;
- treated industrial discharges to the River Nile and irrigation canals;
- treated industrial and sanitary waste discharges to drains, lakes, and ponds;
- treated discharges from river vessels to the River Nile and canals; and
- drain waters to be mixed with the River Nile or canals (Kelly & Welsh, 1992).

[4] The desirable quality of water can be expressed in three ways: criteria, guidelines, and standards. Of the three, only standards are absolute and enforceable (i.e. either they are met or violated). Many nations have chosen not to develop any standards for water quality. For example, Canada, a fairly affluent nation, has only criteria for natural waters and guidelines, not standards, for drinking water (excluding the province of Quebec) (Tam and Thanh, 1990).

The standards were mostly derived from international drinking water standards. The exception is the Egyptian standard for coliform, which is exceptionally high at 5,000 MPN (Kelly and Welsh, 1992). Failure to obtain a license or discharging in amounts or concentrations that exceed permissible limits is punishable by a fine, a jail sentence, or both. The fine for a first offence can range between LE 500 to LE 2,000 with a maximum jail sentence of one year (Kelly and Welsh, 1992).

The Ministry of Public Works and Water Resources is the lead agency responsible for the implementation of Law 48/1982 (CIDA and EEAA, 1997; Gouda, personal communication). The Ministry is charged with:

(1) reviewing applications for discharge licenses from municipal and industrial facilities,
(2) inspecting facilities to ensure that adequate treatment systems are present,
(3) ensuring that the MoH samples effluent from the applicant's facility and analyzes the samples for their conformance with the water quality standards, and
(4) issuing a license if all conditions are met.

The Ministry of Health is obligated to report any cases of non-compliance with the terms set out in the license to the MPWWR. A violation notice is then issued by the MPWWR to the offender. The facility is given three months to improve the quality of its effluent. If subsequent sampling by the MoH undertaken after this period reveals a continued violation of Law 48/1982, the MPWWR is required to charge the facility with failure to comply. Nevertheless, the MPWWR is not the sole agency that has been assigned policing powers for upholding Law 48/1982. The Ministry of Interior's Waterways Police is legally required to conduct inspection patrols along the Nile and charge violators for discharging waste from their vessels into the surface waters (Kelly and Welsh, 1992). Offenders are prosecuted in a court of law and face having their licenses revoked and receiving a fine and/or jail sentence (Abdelbary and Heikal, 1998).

Law 04/1994 – Law for the Environment

As part of Egypt's commitment to implementing Agenda 21, an environmental protection bill was passed by parliament in 1994 (Earth Summit Watch, 1994). Law 4/1994, Law for the Environment, amalgamates previous acts and contributes sections on hazardous waste and environmental management: areas never previously incorporated within Egypt's legal framework. In cases where provisions in other pre-existing pieces of legislation contradicted Law 04/1994, those provisions are now annulled (EEAA, 1994). A prolonged grace period was extended to the various establishments[5] to give them adequate time to conform to the latest provisions. The Law officially came into effect on February 28, 1998 (Hamza, personal communication).

The Law for the Environment covers pollutants in three environmental media: air, soil, and water. To avoid overlap with Law 48/1982 that deals with discharges into the River Nile, water pollution is addressed within the context of the marine environment (i.e. salt water). There was previously a law that dealt solely with the Prevention of Pollution of Sea Water by Oil (Law 72/1968). This law was formally repealed when Law 04/1994 took effect (EEAA, 1994). The first article in the introductory provisions of Law 04/1994 stipulates that establishments must conform to the provisions of the Law without affecting compliance to the provisions of Law 48/1982. In other words, the Law for the Environment does not supercede nor replace the Law for the Protection of the River Nile and Water Ways from Pollution. Instead it fills the gap in Egypt's legislative framework for water quality management by comprehensively addressing pollution entering the marine environment. Nevertheless, there are aspects of Law 04/1994 that could potentially have significant impacts on water quality management of the River Nile and will be discussed herein. First, however, the administrative aspects of Law 04/1994 will be covered.

One of the main goals of Law 04/1994 was to strengthen the EEAA's authority. The legislation transfers the various responsibilities for environmental protection that had previously been dispersed among different agencies and led to weak enforcement, to the EEAA. Nonetheless, the Agency is still reliant upon the other ministries to carry out their assigned functions. Article two of the Law for the Environment provides the Egyptian Environmental Affairs Agency with an independent budget (determined each fiscal year

[5] "Establishments" covers industrial & hydroelectrical facilities, tourist establishments, mines, & infrastructure projects (EEAA, 1994).

by the Ministry of Finance) and a head office in Cairo. The Law also gives the Minister for Environmental Affairs, Dr. Nadia Makram Obeid, authority to use Ministerial Decree to establish EEAA branches in the governorates. Eight regional branches have been established (CIDA and EEAA, 1997). Among the Agency's responsibilities under Law 04/1994 are the formulation of a general environmental policy, collection and publication of national environment-related information on a periodic basis, preparation of draft legislation and decrees relevant to the protection of the environment, and preparation of an annual report on the State of the Environment to be submitted to the President and Cabinet.

Law 04/1994 dictates that the Agency's Board of Directors, chaired by the Minister for Environmental Affairs, is the supreme governing authority for the affairs of the EEAA and makes its general policy. The membership of the Board of Directors includes the following:

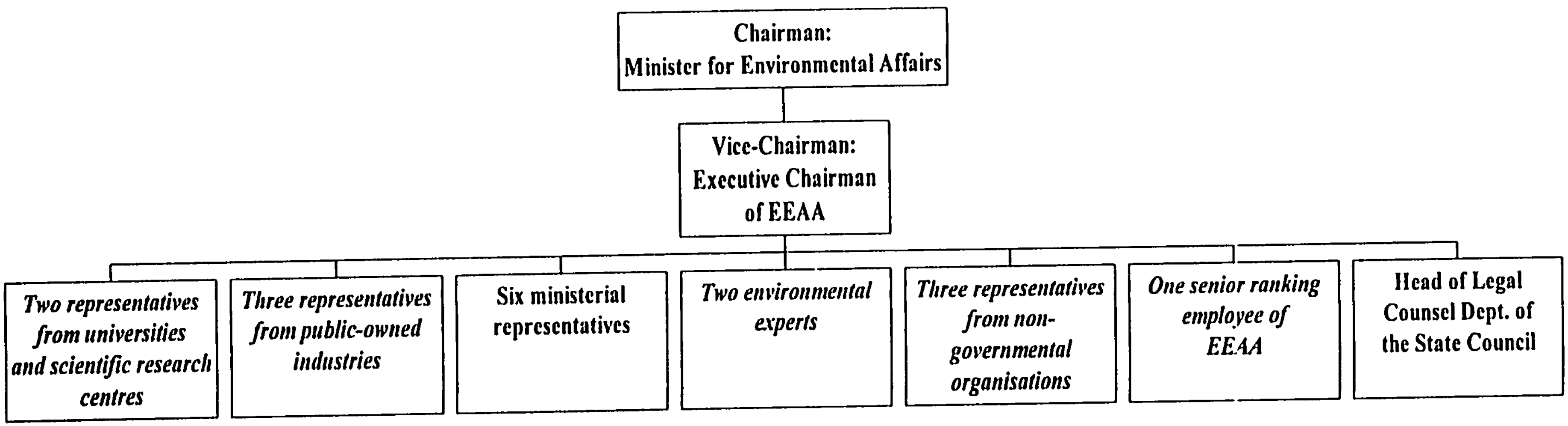
- a representative from each of six ministries selected by the Prime Minister from the ministries involved in environmental activities;
- two environmental experts, appointed by the Minister for Environmental Affairs;
- three representatives from non-governmental organizations, selected in agreement with the Minister for Environmental Affairs;
- three representatives from the public enterprise sector, selected by the Minister for Environmental Affairs; and
- two representatives from universities and scientific research centers, chosen by the Minister for Environmental Affairs (see Organigram 2).

All decisions require the support of a majority of the members in attendance at the meetings.

There are several components of Law 04/1994 that could have a favourable impact on the amount and concentrations of pollutants entering the River Nile:

(1) Environmental impact assessments are now mandatory for all proposed projects that require licenses (e.g. discharge licenses).

Organigram 2. The EEAA's Board of Directors as stipulated by Law 04/1994. Italics indicates representatives selected by the Minister for Environmental Affairs.



(2) An "Environmental Protection Fund" is to be established within the EEAA. Funding will come from three sources: government budgets, grants and donations from aid agencies, and fines and compensation for environmental damage. The EEAA will be responsible for regulating the Fund.

(3) In cooperation with the Ministry of Finance, the EEAA will establish, according to Article 17 of Law 04/1994, "a system of incentives that the Agency and competent administrative departments shall provide to other agencies, establishments, individuals and others who implement environmental protection activities or projects" (EEAA, 1994). The system of incentives is to be determined by the Board of Directors with final approval by the Prime Minister: possible incentives include soft loans, low interest bank financing, and free technical assistance (Hamza, personal communication).

(4) The EEAA is responsible for preparing an Environmental Disaster Contingency Plan. The plan will include the establishment of a central operations room that receives notification of environmental disasters and recruits the resources necessary to tackle the disaster. Environmental disasters are defined within Law 04/1994 as "accidents due to natural or man-made actions that lead to severe damage of the environment and require resources beyond local capabilities to confront" (EEAA, 1994). A task force will also be developed to follow up on the measures taken to confront the disaster. The task force leader will have the authority to implement activities aimed at mitigating the disaster in cooperation with the relevant agencies. Law 04/1994 makes it mandatory for public and private authorities or individuals to provide prompt assistance and support if requested.

(5) Article 89 of Law 04/1994 strengthens the fines that can be handed to violators of article 2 of Law 48/1982, and of the decrees issued for its implementation (e.g. failure to obtain a discharge license or failure to meet the terms of the license). Violators may face a fine of 200 to 20,000 L.E. In case of a repeat offence, the penalty shall be both imprisonment and a fine.

Criteria for Situational Analysis - Legislative Framework

The legislative framework was analyzed according to criteria set out in ESCAP, 1990; Perry and Vanderklein, 1996; Okun, 1991; Schmidheiny, 1995; and Tam and Thanh, 1990. The criteria consists of the following:

- Presence of legislation that addresses control of water pollution;
- Equitable enforcement of regulations;
- Legislation periodically reviewed;
- No overlapping responsibilities;
- Unambiguous legislation;
- Gradual introduction of standards;
- Personnel adequately trained to enforce regulations:
- Sufficient funds to enforce regulations;
- Enforceable water quality standards; and
- Sufficient personnel to enforce regulations.

Situational Analysis

Performance Standards. Law 48/1982 sets performance standards for industrial effluent and wastewater discharges. These "end-of-pipe" standards specify limits on pollutants discharged into the waterways (Perry and Vanderklein, 1996). Performance standards allow the companies and municipal facilities to determine for themselves how best to meet the standards, thereby encouraging innovation in tackling pollution problems (e.g. companies may choose to adopt a demand management strategy to reduce the waste generated versus purchasing more advanced treatment technology) (Schmidheiny, 1995). Egypt has yet to reap these benefits.

Representation on EEAA's Board of Directors. The EEAA's Board of Directors has a fairly diverse representation. However, there are two potentially serious weaknesses in the structure of the Board of Directors. Firstly, the Minister for Environmental Affairs appoints the majority of members. There lies a clear danger that only appointees who share the same views as the Minister may be appointed. Secondly, there are no representatives from private industry. Since Law 04/1994 directly affects them, they should have a say in the decision-making process. In addition, the input from private industry representatives into what pollution control measures can feasibly be implemented without crippling the companies would be highly valuable and could serve to increase the commitment of the private sector to protecting the environment.

Lack of enforcement. Considerable debate exists over whether the existing water quality standards are too stringent. International experts appear to be in general agreement that the standards are too strict to be enforceable while experts within Egypt believe that the standards are adequate (Abdelbary, personal communication, 1998; Abu Zeid, 1994; The Economist Intelligence Unit, 1998; Hamza, personal communication; Kelly and Welsh, 1992; Mancy and Welsh, 1992). There is, however, complete agreement among both parties that a primary weakness with the existing legislation is the lack of enforcement due overwhelmingly to financial and institutional constraints (Abdelbary, personal communication, 1998; Hamza, personal communication; Kelly and Welsh, 1992; Yehia, personal communication).

Many industries are in violation of discharge requirements with a significant portion having not yet installed wastewater treatment facilities (Mancy and Welsh, 1992; El-Sherbini, personal communication). During 1997, the EEAA sent notification letters regarding Law 04/1994 to 1,000 companies responsible for an estimated 70% of the industrial pollution. By the December 31st deadline only 150 companies had prepared a compliance action plan (The Economist Intelligence Unit, 1998). The lack of compliance with Law 48/1982 and Law 04/1994 is primarily due to the high percentage of government-owned industries: establishments that provide a vital source of employment and affect all sectors of the economy. When the MPWWR or EEAA fines a public sector company for violating the regulations, another federal agency, usually GOFI, has to pay the fine indirectly through its facilities. The primary problem is that in most cases, non-compliance is due to the lack of financial resources available to these establishments to invest in adequate treatment systems. It can then be safely assumed that given the economic situation facing these public sector companies, there is no room within their operating budgets to pay the fines. Shutting down the companies for failure to pay the fines and failure to redress the violations is not feasible either, although it is stipulated in the legislation. A classic example is the government owned Helwan Iron and Steel Factory, one of the major industrial polluters. Closing the factory down would throw 10,000 people out of work and send tremors throughout Egypt's economy. Egypt's private sector is not yet capable of absorbing a significant amount of workers from the public sector (US AID, 1996). As Dr. Hamza, Senior Technical Advisor for the EEAA, professes: "In such cases [Helwan Iron and Steel Factory] – when the industry is strategic, highly polluting and has no opportunity to invest because of economic difficulties – it is meaningless to enforce any kind of law" (The Economist Intelligence Unit, 1998, 2). The message this sends is that while private owned companies would have to conform to the legislation, public sector enterprises will not be forced to comply with the regulations.

The EEAA is currently looking at ways of pressuring factories to comply with Law 04/1994 other than by closing them. Among the pressure tactics being considered is the involvement of non-governmental organisations and the media in planned activities against violators (Hamza, personal communication). Bad publicity can potentially hurt a company's image. Other developing countries are already experimenting with this method. Indonesia, for example, recently introduced an environmental performance rating system for factories. The results on the environmental performance of the various factories is disclosed to the public. Preliminary evidence suggests that the programme is having a sizeable impact on reducing pollution (World Resources Institute, 1998). In order for such a system to work in Egypt, the public must have some form of environment education.

There could be significant repercussions if the lack of, and inequitable, enforcement of Laws 48/1982 and 04/1994 is not redressed. A special fund was created within the MPWWR for the implementation of Law 48/1982. The source of funding is to be from fines and levies. The MPWWR cannot enforce the law unless it has an adequate amount of funding; however, it cannot acquire sufficient funding unless it enforces the law. The

EEAA is also in the same situation, although to a lesser extent. The Environmental Protection Fund does not rely solely on income from violators.

Setting standards that are impractical given current institutional arrangements, lack of appropriate technology, lack of adequate funds, and existing social conditions will, in the long term, cause more harm than good. Since compliance to the stringent standards is impossible for many establishments, the MPWWR and EEAA have had to relax enforcement. Such a practice, however, sets a precedent and leads to the loss of credibility in the legal system and to an atmosphere of complacency (Tam & Thanh, 1990). It is highly probable that the relevant parties will not take any future environmental regulations established by the Egyptian government very seriously. Furthermore, it will be exceedingly difficult for the Egyptian government to attract much needed foreign investment in the absence of a level playing field (i.e. no unduly privileged companies).

Revision of legislation. There are no requirements in Law 48/1982 or Law 04/1994 for the periodic review of the effectiveness of the legislation. Laws, however, operate within a dynamic society. Economic, political and social situations are constantly changing and in order for legislation to remain effective it needs to be continuously adapted to the new set of conditions. As Dr. Abdelbary, the director of the Nile Research Institute, points out: "Legislation needs to be oriented to the place it is being applied" (personal communication, 1998). A piece of legislation may seem strong on paper, but unforeseen problems can and do arise when regulations are implemented. A periodic review can serve to highlight the respective laws' strengths and weaknesses.

Law 48/1982 has not been revisited since it was originally passed by Parliament. Amendments to the Law are urgently needed in light of the MPWWR's strengthened institutional capacity. Although the MPWWR is the ministry responsible for enforcing the Law, it does not have the legal authority to prosecute a company for violating the standards using data gathered and analysed by the Nile Research Institute. Before the courts, the MPWWR can only use data provided by the MoH, as stipulated in the legislation. At the time the law was established, the NRI did not have the capability to monitor effluent and wastewater discharges. The MPWWR now has a fairly well-equipped water quality lab as part of its River Nile Monitoring Programme and a central water quality lab nearing completion. An interministerial committee has been formed to look into the revisions that are needed to Law 48/1982 (Abdelbary, personal communication, 1998).

Overlapping responsibilities. Significantly reducing industrial pollution is the EEAA's present priority. Law 04/1994 provides the EEAA with the authority to carry out field visits to companies to determine whether they are in violation of the regulations. The Minister for Environmental Affairs has repeatedly exercised this authority. Part of the focus of the spot checks conducted by the Minister and her staff is on the discharge of industrial effluent. This function brings the EEAA directly into the domaine of the MoH and MPWWR. Law 48/1982 accorded the MoH responsibility for monitoring industrial effluents to determine compliance with water quality standards. Under that same law, the MPWWR was given the mandate to inspect facilities to ensure that adequate treatment systems are in place. These overlapping responsibilities with the EEAA lead to the misuse of already scarce resources.

Prolonged grace period. The Egyptian government extended a grace period to companies to give them time to develop and implement action plans for compliance to Law 04/1994. Unfortunately, as previously mentioned, few companies took advantage of the opportunity and it may have reinforced the feeling among factory owners that action wasn't necessary (Thompson, personal communication, 1998).

Unpractical provisions and definitions. Both pieces of legislation suffer from vague, sweeping provisions and definitions. For example, article 4 of Ministerial Decree 9/1989 concerning the implementation of Law 48/1982 specifies: "Industrial wastes discharged into waterways must not contain any chemical, insecticide, radioactive material, or materials that float or could be harmful to humans, animals, plants, fish, or birds, which affect water potability, or domestic, industrial, or agricultural water use" (Kelly and

Welsh, 1992). What constitutes "harm" can be open to different interpretations. Moreover, almost any substance, given the right conditions, "[c]ould be harmful". Another good example is the working definition for water pollution set out in Law 04/1994: "Introducing any substance or energy into the water environment intentionally or unintentionally, directly or indirectly, harming living or non-living resources or threatening human health or hindering water activities including fishing and tourist activities causing deterioration of the quality of sea water for use, or reduction of amenities, or changing its properties" (EEAA, 1991). This definition is much too broad to be of practical value.

Dissemination of legislation. To increase dissemination of Law 04/1994, the EEAA wisely chose to post it on the Egyptian Environmental Information Highway. Law 48/1982 is not available through the Internet.

Use of different policy instruments. Law 04/1994 facilitates the adoption of economic instruments and self-regulatory mechanisms through provisions for their use in combating industrial pollution. The EEAA was given considerable latitude to determine how to use these instruments. The Agency's primary response was to develop and administer the National Industrial Pollution Prevention Programme which serves as an umbrella for programmes that enhance industry's environmental management capabilities. Included under this umbrella is the National Programme for Environmental Management Systems whose purpose is to promote ISO 14000 certification. The largest project currently being undertaken through the National Programme for Environmental Management Systems is the Environmental Pollution Abatement Project (EPAP). The goal of the project is to provide industry with technical and financial assistance to carry out environmental initiatives. The World Bank is providing US $35 milllion, the European Investment Bank US $19.5 million, and the Finnish Government US $5.5 million. Considering the sums of money involved, EPAP has the potential to yield significant reductions in industrial pollution (CIDA and EEAA, 1997).

Recommendations

Expand membership and change selection process of the Board of Directors. The EEAA should expand the Board of Directors membership to include representatives from private-sector industry. Furthermore, the various sectors with representation on the Board (e.g. research institutes, public-sector industry) should be permitted to select their own members.

Periodically reassess legislation. An annex should be added to both Law 48/1982 and Law 04/1994 requiring the legislation to be periodically reviewed by a committee whose members would include representatives from the relevant administrative bodies.

Disseminate legislation electronically. The MPWWR should follow the EEAA's lead and post Law 48/1982 on the Egyptian Environmental Information Highway.

Provide training on how to enforce the legislation. Most of the EEAA's and MPWWR's inspectors are civil engineers who have little or no training in the enforcement of regulations, managing a regulatory system, or inspecting treatment facilities (Kelly and Welsh, 1992). It is unrealistic to expect them to adequately meet their responsibilities without prior training. Classroom instruction combined with field visits and workshops would be ideal as part of a training programme on implementing Laws 48/1982 and 04/1994. The workshops would provide the inspectors with the opportunity to share their experiences. Care must by taken by the Government of Egypt if assistance is requested and received from donor agencies. A training programme on how to implement the legislation will have limited usefulness if it is imported without modifications. Country specific technical, social, and economic issues require a tailor-made approach (Hamza, 1991).

Restructure the fund for enforcement of Law 48/1982. Funding for implementing Law 48/1982 needs to come from more than one source. A structure similar to that of the Environmental Protection Fund (i.e. three sources of funding) would be sufficient on condition that the Federal Finance Ministry provides the MPWWR with an adequate budget.

Set practical water quality standards. The current water quality standards need revising. Egypt's water quality standards should strike a balance between the need to protect the aquatic ecosystem from long-term environmental impacts and the economic, technical, and institutional capacity of the ministries to monitor and implement the standards along with the capability of establishments to comply. Revised standards may be more successful than the original set if they are developed in stages according to Egypt's rate of privatisation and industrialisation and equitably enforced.

DATA MANAGEMENT AND INFORMATION SYSTEMS

The value of data increases geometrically when it is collected, analysed, and disseminated in an efficient and timely manner and when it is shared with secondary users. A successful national water quality management programme requires an information infrastructure that facilitates this value-added process. In the absence of a well-developed information system, it easy to fall into a situation where the nation is "data rich, but information poor".

As described on the US EPA web page, "an environmental information system can be envisioned as a large array of environment related data series and other types of information, collected through networks of monitoring programs at multiple geographic scales which are integrated or coordinated at a number of levels" (US EPA, 1997B). At the most basic level, an information system brings together data from a patchwork of sources forming a larger, more comprehensive and coherent mosaic thereby improving the utility, accessibility and cost-effectiveness of the data. Advances in hardware and software (e.g. geographic information systems) have increased the volume and types of information that can be stored in an information system. Choices cover various kinds of quantitative and qualitative information, including both geographical and non-spatially referenced data, maps, summary statistics, and indices. A well-designed system can assist in the following capacities (not an exclusive list):

- linking existing water quality data to form more complete data sets;
- identifying duplication and gaps in the existing data collected by the various monitoring programmes;
- bolstering science and technology education by providing educators with real world data and information;
- improving quality of research results through access to more comprehensive data sets;
- reducing uncertainty about the outcome of proposed decisions and increasing management effectiveness;
- integrating data sets on a geographical basis (i.e. spatial nesting of water quality information) to support ecosystem-based decision-making;
- enabling better and earlier assessment of trends;
- setting priorities for water quality management;
- allocating scarce resources; and
- assessing success of water quality initiatives (Information Infrastructure Task Force, 1994A; Thompson, personal communication, 1998; US EPA, 1997).

It is up to the decision-makers, with input from the users, to determine in which capacity or capacities the system should function.

This section delves into how the Government of Egypt has maintained and disseminated its water quality data over the last few decades. It is characterized by a period of great accomplishment during the 1970s, followed by several years of regression during the 1980s and early 1990s, and potential progress during the mid- to late- 1990s. The GOE's experiences with water quality information systems can be broken down into three distinct chronological categories based on the presence, comprehensiveness, and time period of data management activities undertaken. These categories are as follows: past data management; present data management; and future data management. It is within this classification system that data management will be discussed.

Table 10 gives an overview of the information systems that have been used or could be used by the Government of Egypt for water quality management. As will be demonstrated, Egypt's use and development of information systems has been beset by a series of starts and stops.

Table 10. Overview of past, present, and future information systems used by the GOE.

Category	Start of Operation	Name of Information System	Developers	Original Funders	Is it in operation?
Past data management	1978	Water Quality Data Bank	University. of Michigan; Egyptian Academy of Scientific Rsch & Technology	Various external support agencies	No
Present data management	1996	Egyptian Environmental Information Highway	Regional Information Technology & Software Engineering Centre	UNDP Arab Fund	Yes, but no longer regularly updated
Future data management	2001 (est.)	Egyptian Environmental Information System	EEAA; Canadian consortium of companies	CIDA	In process of being developed

Past Management of Data

The first systematic and comprehensive endeavour to collect data on the River Nile and its branches was made in 1975 through a joint project of the Egyptian Academy of Scientific Research and Technology (ASRT) and the University of Michigan (Abdelbary and El-Shanshoury, 1991). By 1978, a comprehensive and extremely useful water quality information system had been developed, helping to place Egypt at the forefront of water quality management among the semi-arid nations of the world. The Water Quality Data Bank, as it was titled, was located at the National Research Center and supported with the latest computer equipment and well-qualified and trained personnel. The project, however, was heavily dependent upon donor assistance and no plans were made to sustain the Data Bank endogenously. As a result, all activities were terminated once the foreign funds had been exhausted. Equally significant, no agency within Egypt has a complete set of the collected data; it can be found only at the University of Michigan (Mancy and Welsh, 1992).

Present Management of Data

As discussed in the section on capacity building, there are several agencies involved in water quality monitoring and management. Since the 1970s, however, there has been no central water quality database. Data from the varied water quality initiatives are scattered throughout the ministries, research institutes, and universities. No standardized methods for data collection, storage, or retrieval exist; various methods are used by the different agencies for data collection along with an array of formats for storage. Furthermore, the data is frequently utilized only for its primary purpose. Access restrictions to the data reduce the opportunity to use the information for secondary purposes. Water quality data and reports are usually available only to decision-makers, researchers, and internally. Very little raw data is given out to the media or the public for fear of misuse or misinterpretation. Instead, information pertaining to water quality is released in the form of published papers (El-Sherbini, personal communication).

The lack of an integrated information system undermines the effectiveness of water quality management in Egypt. It is difficult to determine where gaps or overlaps occur within the data-generating activities; quality control is inconsistent; decision-making is frequently made on incomplete data sets; and formal information exchange and dissemination is limited.

In the midst of this generally weak national information infrastructure, a project to develop and run a basic information system utilizing predominantly indigenous human resources emerged; advances in computer capacity and telecommunications made it possible. The project came to be known as the Egyptian Environmental Information Highway. The idea behind the Information Highway took hold following a significant event that occurred in 1995: the introduction of the Internet to Egypt. The project designers saw in this new technology the potential for facilitating communication amongst environmental scientists at all levels (i.e. local through to global) (Barsoum, personal communication A). The main objective, as stated on the Information Highway's homepage, "is to create an electronic network that connects all departments, centers and institutes that work in the field of the environment" (RITSEC, 1996). The benefits that can be accrued from the Information Highway are numerous: systematizing the process of environmental data communication, fostering collaboration among different agencies, reducing redundancies in data collection, disseminating up-to-date information, and providing a medium for the exchange of information (Barsoum, personal communication A; RITSEC 1996).

The creation of the Information Highway was a multi-stakeholder, consensual decision-making process. The Regional Information Technology and Software Engineering Centre (RITSEC) spearheaded the initiative. The Centre is funded by the UNDP and the Arab Fund and hosted by the GOE through the Cabinet of Ministers (Barsoum, personal communication B). One of the first steps taken by RITSEC was to form a steering committee comprising representatives from the private sector, non-government organizations, and government. RITSEC then provided the committee members with an environmentally focused Internet course. Upon completion of the course, the steering committee met weekly to define the contents of the Information Highway and to collect and add the information. The various representatives provide most of the data on the site, although anyone is permitted to register an event on the events page (Barsoum, personal communication A). The home page <www.ritsec.com.eg/ritsec/env/highway/>, now up and running, is exceptionally well designed. It is particularly user-friendly, well organized, and accessible to any Internet user (see Appendix B for illustration of site). Noteworthy is the use of local expertise in the development and running of the information system. Unfortunately, the information on the site is quickly becoming outdated. RITSEC has exerted some effort to ensure that the Highway is continually updated. The project, however, was financed only by RITSEC and it has no more financial resources for sustaining the highway. The Centre is currently trying to develop various fund-raising activities in order to acquire the financial resources needed to maintain the site. The Government of Egypt has failed to see the importance of the Egyptian Information Highway and consequently has not provided any grants for the site (Barsoum, personal communication A). Instead the GOE has thrown its support behind a several year, multi-million dollar, CIDA funded project to develop an Egyptian Environmental Information System (described below).

Future Management of Data

In July 1991, the Egyptian government, recognising the need to strengthen the national information infrastructure, approached CIDA for assistance in the development of an Egyptian Environmental Information System (EEIS). By 1995, a Memorandum of Understanding between the governments of Egypt and Canada had been signed. The EEIS project was awarded to a consortium of Canadian companies, led by Roche International, which currently acts as the Canadian Executing Agency. In Egypt, the lead government agency is the EEAA. According to the inception report, the goal of the project is "to enable GOE decision-makers to improve the formulation and implementation of timely and appropriate environmental policies, legislation, programs and projects affecting sustainable development in Egypt, especially land and water resources. The EEIS project-specific purpose is to enhance the capacity of the EEAA to retrieve, process, analyze and disseminate environmental information for environmental decision-making purposes" (CIDA and EEAA, 1997, 11). Upon completion of the project, there will be an EEIS network infrastructure in place to connect the secondary and tertiary nodes in the participating agencies with the primary nodes at the EEAA. The operational EEIS will have at its core a GIS capable of integrating diverse data types (CIDA, 1997). The total cost of the project is Cdn $12.7 million. As of September 1998, only Cdn $1.9 million had been spent. The original start was September 1996 with an estimated completion date of December 2001. The five-and-a -half year project, however, did not get off the ground until January 1997 (Ahearn-Blais, personal communication).

Criteria for Situational Analysis - Data Management and Information Systems

Data management and information systems were evaluated accorded to the criteria from Information Infrastructure Task Force, 1994A; Information Infrastructure Task Force, 1994B; US EPA, 1997B; and USGS, n.d.. Strictly US sources were used since the

Americans are actively engaged in developing leading edge information systems utilizing the advances made in computer hardware and software (e.g. geographic information systems), along with new conceptual management techniques. The criteria are listed below.

- Data disseminated in an efficient and timely manner
- Central database available for water quality data (i.e. integrated information system)
- Standard data formats
- Data accessible to all stakeholders including media and the public
- Regular exchange of information
- Information systems permits the spatial nesting of information
- Quality control standards in place
- Use of indigenous resources
- Adequate funds available
- Personnel trained in data management and information systems
- Data easy to retrieve

Situational Analysis

Ecosystem Management. The geographic information system based EEIS could greatly facilitate ecosystem management. The conceptual framework of the EEIS is similar to that of the Pressure-State-Response/Effects model in that it is consistent with a hierarchical view of ecosystems, allowing for spatial nesting of the environmental information (US EPA, 1997B). Furthermore, the system will be able to accommodate data on the three main media for the transportation of pollutants: air, land, and water. The jurisdictional separation of soil, water, and air is based on artificial borders. Within an ecosystem, there are no boundaries between the three media. Pollution released into one phase can enter into another phase and vice versa (e.g. trace metals entering lakes from air-borne emissions). Thus, water quality cannot be adequately addressed without considering soil and air quality (the former having a greater baring on water quality in Egypt than the latter). The EEIS could prove to be a powerful tool in supporting integrated management.

Use of indigenous resources. The EEIS is heavily dependent upon international expertise, whereas the Information Highway has been designed and operated using predominantly local human resources.

Data collection. In 1994, the GOE enacted law 04/94, which charged the EEAA with managing environmental protection (CIDA and EEAA, 1997). The ministries involved in environmental data collection, however, have no legal responsibility to disseminate their data to the EEAA. Most of the data to be uploaded to the central information system will have to come from these other Ministries. At the present time, the EEAA has only a limited amount of environmental data, gathered mostly through Agency-sponsored projects. The EEAA is therefore attempting to establish agreements with each of these ministries, which would see them uploading the data they acquire from their respective environmental initiatives to the primary nodes at the EEAA (Cruden, personal communication). The EEAA may encounter difficulties in carrying out this task since many of the ministries are not very willing to give up their data. The ministries will need to be convinced that it is in their best interest to cooperate and collaborate. CIDA is attempting to use its ties to the Ministry of Public Works and Water Resources, gained through the Agency's sponsorship of the River Nile Protection and Development Project, and its links to the Egyptian Environmental Affairs Agency, acquired through its backing of the Egyptian Environmental Information System, to bring the EEAA and MPWWR closer together (CIDA and EEAA, 1997). The comprehensiveness and utility of the data stored in the EEIS will be seriously undermined if certain key agencies such as the MPWWR do not collaborate.

Data users. The EEIS will be accessible to the ministries and research institutions involved in environmental data collection (i.e. government use only). CIDA would eventually like to see the GOE give NGOs access to the system (Cruden, personal communication). No plans are in place to make the information system available to the public and media. However, if NGOs are eventually given access to the system the information will indirectly get to the media and the public.

Recommendations

Provide funding to the Egyptian Environmental Information Highway. The government should consider funding the Information Highway for three primary reasons. Firstly, the system is well designed and already fully functional. Secondly, the Information Highway has no access restrictions and is a relatively low cost way of distributing information to the public and media regarding government activities. Thirdly, local experts who can make sure that the system is operated properly in the presence of a secure source of funds to run the Egyptian Information Highway.

Increase user access. The public, media, and industry should be given access to the EEIS. Realizing that certain data can be quite sensitive, the government may wish to define a hierarchy of network functions. The process would include determining levels of access, and identifying a "floor" or fundamental set of services that would be available to everyone (Information Infrastructure Task Force, 1994B). Filters to limit entry to the data (e.g. passwords) could then be developed and put in place for the different levels of clearance. An alternative option to giving non-government personnel direct access to the system is to link the Egyptian Environmental Information Highway to the EEIS. The Information Highway could then act as an ancillary system.

Meet established standards. Until the EEIS is up and running, each ministry should ensure that they meet the standards for spatial environmental data collection and quality control as set by the project team and that the data is saved in an acceptable format.

Establish a secure source of funds. Two separate, highly useful information systems have already been established in Egypt. One system, the Water Quality Data Bank, disappeared completely and the other, the Egyptian Environmental Information Highway, is slowly being brought to a halt, both situations due to the exhaustion of external funds. The GOE should earmark some money specifically for sustaining the Egyptian

Environment Information System once it is operational. This money could come from the Environmental Protection Fund; a fund that was legislated under Law 04/1994.

Develop and retain local capacity for operating the EEIS. The system is being established with a significant amount of international assistance. The end product will be an expensive, highly complex, and powerful diagnostic and strategic tool. The long-term success of the project will depend highly on the availability of local personnel capable of maintaining the system. The Canadian Executing Agency will be providing training in computer applications, geographic information systems, and environmental information management (CIDA, 1997). This training should go beyond providing the basic tools for operating the system to include more advanced skills such as troubleshooting. The threat of the system crashing and staying down for a prolonged period could then be minimized. Another area of concern that needs to be addressed is the retention of the personnel once trained. The EEAA, as previously mentioned, has a low complement of permanent staff members. In order to successfully sustain this project, the EEAA as the lead government agency in Egypt will require a larger budget in order to hire more permanent staff members. Long-term employees of the Agency could then fill positions in the training courses rather than consultants who take their skills with them once their contracts expire. In addition, a close partnership between the Canadian Executive Agency and local universities needs to be formed so that the local academic establishments may develop the expertise to teach the necessary skills. This would forego the need in the long term to bring instructors from outside the country to teach the courses and would ensure that a greater number of people have the requisite background to operate the information system.

EXTERNAL SUPPORT AGENCIES

Egypt has traditionally received heavy support for water quality management from external support agencies (ESAs). These ESAs fall into two categories: multilateral development agencies and bilateral development agencies. The multilateral agencies include UN organisations such as the UNDP, UNEP and WHO, and the international development banks. The bilateral agencies are the foreign aid agencies established by individual federal governments (e.g. CIDA, US AID). Over the past two decades in Egypt, ESAs have been involved in the transfer of technology, water quality research, exchange of information, training of personnel, and the development of facilities. The contribution from US AID alone amounts to US $2.6 billion invested since 1975 in urban water and wastewater infrastructure (US AID, 1998). Projects with ESA involvement have included the development of the Water Quality Data Bank funded by US AID, establishment of the Regional Information Technology and Software Engineering Centre supported by the UNDP and the Arab Fund, and the on-going River Nile Protection and Development Project financed by CIDA.

One of the primary reasons for the extensive international support the GOE receives is political: Egypt is a key stabilising force in the Middle East and plays a fairly vital role in the peace process (e.g. hosting high level meetings between Israelis and Palestinian officials). Unfortunately, a driving force behind foreign assistance that is highly political in nature tends to result in the implementation of assistance projects that don't necessarily address the needs of the recipient country (Okun, 1991). In Egypt, projects are frequently redone by separate aid agencies (El-Sherbini, personal communication). The government, although aware of this situation, welcomes any financial infusion it can receive. Notwithstanding the underlying goal of the ESAs, they have been and continue to be a major and predominantly positive force behind water quality management in Egypt.

Trends in foreign assistance

Changes are occurring throughout the ESA community that will affect the type and amount of aid that Egypt can expect to receive in the future. These trends are presented below.

- Increasing competition for funding, especially with the collapse of the former Soviet Union

- Declining number of water projects being financed due to escalating costs and increasingly scarce sources of untapped water
- Increasing requirements for environmental impact assessments as part of project appraisals
- Declining budgets for bilateral agencies
- Reduced lending by the international development banks (e.g. World Bank)
- Emerging focus on projects which contribute to sustainable development
- Shifting priorities from long-term overseas scholarship programs towards short-term, in-country training
- Increasing emphasis on participation of stakeholders and indigenous ownership of projects
- Dominant requirement for projects shifting from structural adjustment to capacity building
- Decreasing investments in large infrastructure projects
- Increasing pressure from tax payers, politicians, and lobby groups for greater accountability
- Greater emphasis on self-sustaining activities (Bolger and Qualman, 1996; Carrier and Parry, 1995; Grindle and Hilderbrand, 1994).

Implications for Egypt

The GOE will have to adapt to the current trends in foreign assistance. Indigenous and more diversified sources of funding will need to be secured. Local stakeholders will have to be given a greater role in the decision-making process and ownership of projects. High priority areas in water quality management will need to be identified to ensure that the reduced amount of aid available is utilised in the most beneficial manner (i.e. "do more with less"). Overall, the trends in the arena of foreign assistance could serve to push the GOE in implementing much needed changes to the national water quality management programme.

Recommendations

Throughout this document recommendations have been made regarding areas where the GOE could improve water quality management. This recommendations section deviates from the established format: the spotlight is turned on the donor agencies. In addition, this section has been split into two parts. The first part looks at the role that local experts would like to see ESAs play in Egypt. The second part provides the author's recommendations on how ESAs should operate in Egypt.

PART I

The question, "What role would you like to see international organisations and donor agencies play in water quality management in Egypt? In other words, what contributions would you like to see them make?" was posed to three high-ranking government officials. These officials were Dr. Abdelbary, director of the Nile Research Institute; Dr. El-Sherbini, head of the water quality division at the NRI; and Dr. Hamza, senior technical advisor for the EEAA[6]. The following represents their set of recommendations.

- Provide substantive technical support, particularly demonstration projects
- Increase the transfer of appropriate technology (i.e. technology that can be operated and maintained with minimal external assistance)
- Include implementation as part of projects – Donor agencies should follow the research projects through to the implementation phase or plan for implementation of the recommendations (i.e. ensure that concrete benefits arise out of the research project). Executing companies have traditionally shied away from this requirement since it jacks up project costs.
- Provide more training, and not just in technical areas, but in areas such as interdisciplinary team skills as well.

[6] Both Dr. Abdelbary and Dr. Hamza report directly to their respective ministers.

PART II

The recommendations provided below were derived from the analysis of Egypt's water quality monitoring, capacity building, legislative framework, and data management and information systems. They represent ways in which ESAs could provide more effective aid.

Approach the Government of Egypt with support for a project to determine the costs of polluted water to the Egyptian economy vs. the benefits of "clean" water. Local experts suspect that pollution is placing a heavy burden on the economy (Abdel-Gawad, 1994; Abu Zeid, 1992). Current estimates of the cost of environmental degradation range as high as 10-20% of Egypt's annual Gross National Product (CIDA and EEAA, 1997). No formal study, however, has been done to determine the cost of pollution to the nation. The ESAs in supporting such a study could demonstrate to the GOE, through the project findings, that in the long term it is much less costly to invest in an effective national water quality management programme than it is to continue to allow the Nile to be a heavy recipient of untreated and partially treated wastewater.

Add to the criteria for project approval that there must be a component to develop indigenous sources of funding. Egypt must be able to demonstrate that it can continue the project after the donor funding has been exhausted.

Add to the criteria for project approval that there must be a component to improve communication and collaboration. Quite a bit of information is not being openly shared between ministries. Donor funded projects that are implemented by one ministry, therefore, do not always have access to all the information or expertise needed to derive the full benefits from the project. Moreover, the other ministries do not benefit from the project. ESAs can broaden the impact of their assistance by considering more favorably projects that include collaboration between several parties. The criteria for collaboration should not be confined to just between departments or between ministries, but also between government and universities, government and private sector industry, universities and private sector industry, etc. Proposals that have an action plan to improve communication and cooperation should also be strongly considered.

Consider providing funding for a follow-up on project activities. It is difficult for ESAs to know how effective their assistance was if no evaluation of the project is undertaken. Donor agencies should consider having evaluations conducted 1, 2, or 3 years after completion of donor assistance in the project. Not only would the evaluations help to determine how successful the aid was and if the indigenous resources were adequately developed to sustain the project, but also help to ensure that the same mistakes are not repeated in future projects.

Regardless of changes in the amount and type of aid that is provided to Egypt, one certainty is that ESAs will continue to play a significant role in water quality management.

CHAPTER FIVE - CONCLUSION

The former executive director of UNEP, Dr. Mostafa Tolba, commented that "fresh water – not oil – is becoming the dominant resource issue in the Middle East and worldwide" (1990, 57). The Arab Republic of Egypt has been fortunate. For thousands of years, the River Nile has been the lifeblood of the nation providing water for its people, agriculture, and industry. Rapid population growth and increasing industrialisation are pushing up water demands and threatening to send Egypt into a condition of water scarcity. Contributing to the situation are the rising amounts of pollution entering the River Nile from industrial, agricultural and domestic sources. The focus of the Government of Egypt has traditionally been on water quantity. Despite this emphasis on developing water sources to meet demand, the Egyptian government, with the assistance of external support agencies, has been involved in water quality management since the 1970s.

Mancy and Welsh (1992), two American researchers, concluded that the resources required to cope with water quality problems in Egypt were lagging behind real needs. Seven years later, inroads have been made. Progressive steps taken include the establishment of Law 04/1994 – Law for the Environment, the appointment to the position of Minister of Public Works and Water Resources an individual who is very familiar with the water quality management activities of the Ministry, construction of a central water quality lab for the National Water Research Centre, and the development of a comprehensive environmental information system (in progress). The overall conclusion regarding the state of Egypt's water quality management, however, is the same as that reached by Mancy and Welsh in 1992.

Egypt has all the basic elements for a successful national water quality management programme (i.e. monitoring programme, institutional capacity, legislative framework) except for a well-developed information infrastructure. Upon analysis of the various elements, three dominant issues emerged:

- heavy reliance on foreign assistance;

- insufficient budgets provided to the ministries to carry out their responsibilities; and
- inadequate cooperation and collaboration among agencies.

The root of Egypt's water quality management problems (e.g. lack of trained personnel) can be traced to the above. Nonetheless, the overall quality of the River Nile has yet to reach a critical level. A window of opportunity exists to proactively address the current weaknesses in the management framework. The three most important steps that can be taken to improve the status quo for each of the main water quality elements are as follows. The first two are aimed at the Government of Egypt, the third one is addressed to External Support Agencies.

(1) *Improve communication and collaboration.* Strong communication and collaboration between all stakeholders involved in water quality management would help to ensure that the limited human, material, and financial resources available are used in the most effective manner, resulting in more being accomplished. A commitment by all the ministries involved in environmental data collection to upload their data to the Egyptian Environmental Information System could greatly assist in this area.

(2) *Rigorously support education and training.* Adequate training and education are critical to ensuring personnel carry out their functions according to the standards needed to meet institutional goals. The Government of Egypt should develop its capacity, internally, in order to reduce its dependency upon external funds and foreign consultants. A transfer of learning from foreign instructors to local academics and increased partnerships between government institutions and post-secondary establishments are a requisite.

(3) *Provide financial support and expertise for a project to determine the costs of polluted water to the Egyptian economy vs. the benefits of "clean" water.* Water quality management in Egypt should not be heavily dependent upon external sources of funding. More endogenous sources of funding need to be developed. Results from a project to determine the costs of polluted water vs. the benefits of "clean" water may serve to

convince government decision-makers that, economically, it is in the country's best interest to rigorously support water quality management.

The other recommendations to emerge from the study into the State of Water Quality Management in Egypt are listed below. The Government of Egypt may wish to prioritise them according to the existing socio-economic and cultural conditions.

Water Quality Monitoring

Prioritise timing of sampling. Since the resources available are insufficient to allow for sampling runs during each of the four "hydraulic seasons" of the River Nile, the seasons should be prioritised according to when the Nile is most vulnerable to pollutants. Sampling during the period of lowest river flow should be given top priority.

Develop a preventive maintenance programme for the laboratory equipment. In order to ensure that the existing monitoring equipment in the Nile Research Laboratory continues to function properly and to intercept malfunctions, a preventive maintenance programme should be designed and implemented.

Greater biological surveillance. In the long term, the use of bioassays and biotic or diversity indices should be incorporated into the River Nile monitoring programme. In order to achieve this goal, significant investment into research on the structure and composition of aquatic communities within the River Nile ecosystem is needed.

Broaden scope of the River Nile monitoring programme. The monitoring programme should gradually be revamped as more resources become available. The redesigned system should allow for stakeholder participation, include a process for continuous feedback, and track three types of indicators: Pressures placed on the River Nile; State of the Nile waters; Responses taken to alleviate the pressures or enhance the State. The steps that need to be taken to broaden the focus of the monitoring programme are listed below.

1. Determine the Valued Environmental Attributes of the River Nile.

2. Identify the Pressures on the River Nile and the Responses addressed at maintaining or enhancing surface water quality.
3. Prioritise the Pressures and Responses.
4. Develop criteria for selection of indicators for each category.
5. Collect and analyze data on the indicators.
6. Input information into an environmental information system accessible to decision-makers, managers, water users, and other interested stakeholders.
7. Provide feedback on the success of Responses in reducing Pressures and improving the State of the Aquatic Environment.

Review River Nile monitoring programme. The monitoring programme should be evaluated on a regular and systematic basis. The evaluation should include the following:

- identification of the strengths and weaknesses of the programme;
- determination of whether water users' needs and demands have changed;
- financial audit;
- process for receiving input from various stakeholders;
- determination of whether programme objectives are being met;
- reexamination of water quality objectives in light of changing social, political and/or economic conditions;
- identification of areas within the programme where efficiency could be increased;
- confirmation that the proper data is being collected to meet the existing objectives;
- assessment of conformity with government policies;
- assessment of the allocation of resources; and
- assessment of success of feedback processes.

Design and implement intralaboratory and interlaboratory quality control activities for data collection and management. A uniform approach for data storage and retrieval should be developed and promoted as part of a comprehensive quality control programme.

Perform quality assurance activities on an occasional basis. Quality assurance activities such as on-site quality control system surveys and performance audits should be carried out to determine whether the quality control activities are performing properly.

Capacity Building

Make a long term commitment to capacity building. Attempts to build capacity will be unsuccessful if the capacity is not sustained endogenously in the long term. Sustainable capacity building requires a commitment to continually invest in human resources and to develop indigenous and secure sources of funding.

Develop human resources. Training and education needs to be enhanced in order to improve the effectiveness at which personnel carry out their functions. A Training Needs Assessment has to be undertaken to identify gaps where skills training or upgrading are required to improve institutional performance. Upon completion of the assessment, a Skills Development Training Programme should be designed, implemented, and evaluated. Courses should target the main groups involved in water quality management. In situations where external consultants have to be brought in to teach courses owing to the lack of expertise locally, there should be a requirement that they partner up with a local university and that they provide local faculty members with training on how to teach the courses. This process could serve to gradually increase the level of expertise among the country's instructors and its water quality professionals and produce more qualified graduates.

Increase retention of staff. The benefits of a highly effective Skills Development Training Programme will be nullified if personnel have little incentive to remain working in their current capacity. To reduce staff turnover and loss of trained manpower, higher priority must be given to the following: provision of promotions based on good performance; use of non-monetary incentives; recognition of individual excellence; and inclusion of non-managerial staff in the decision-making process.

Increase transfer of learning. Training and education are of little value unless opportunities exist to apply them. Supervisors need to actively encourage trainees and recent university graduates to apply their acquired knowledge.

Foster closer relationships with post-secondary establishments. Ties between the institutions involved in water quality management and the establishments that provide post-secondary education need to be strengthened. Meetings between water quality managers from the public sector and representatives from the post-secondary establishments should be set up to discuss how the curriculum can be improved to provide more qualified graduates.

Develop a national strategy for water quality management. There needs to be a national strategy for water quality management to coordinate the activities of the various institutions and to increase communication and collaboration. Listed below are the steps to be taken to develop and implement such a strategy.

- Select national water quality objectives.
- Select indicators to be used in measuring progress towards national water quality objectives.
- Develop medium- to long-term action plans.
- Oversee implementation of plans.
- Monitor and evaluate progress towards objectives.
- Revise objectives or action plans as required.

Iterative feedback is essential throughout the process. All concerned stakeholder groups should have a voice in the development and implementation of a national water quality management strategy.

Legislative Framework

Expand membership and change selection process of the Egyptian Environmental Affairs Agency's Board of Directors. Most of the positions on the Board of Directors are appointed by the Minister. The EEAA should broaden the Board of Directors membership to include representatives from private-sector industry. Furthermore, the various sectors with members on the Board should be permitted to select their own representatives without influence from the Head of the EEAA.

Periodically reassess legislation. An annex should be added to both Law 48/1982 , Protection of the River Nile and Water Ways from Pollution, and Law 04/1994, Law for the Environment, requiring the legislation to be periodically reviewed by a committee whose members would include representatives from the relevant administrative bodies.

Disseminate legislation electronically. The Ministry of Public Works and Water Resources should post Law 48/1982 on the Egyptian Environmental Information Highway.

Provide training on how to enforce the legislation. Instruction on how to implement Law 48/1982 and Law 04/1994 needs to be provided to the personnel enforcing the regulations.

Restructure the fund for enforcement of Law 48/1982. Funding for implementing Law 48/1982 needs to be diversified.

Set practical water quality standards. Egypt's current water quality standards need to be revised. The revised standards should strike a balance between the need to protect the aquatic ecosystem from long term environmental impacts and the economic, technical and institutional capacities of the ministries to monitor and implement the standards along with the capacity of industries to comply.

Data Management and Information Systems

Provide funding to the Egyptian Environmental Information Highway. The Information Highway is an easy-to-use, well-designed information system. The government should consider investing in the Information Highway since it provides a relatively low cost way of distributing information and can enhance the sharing of information between ministries.

Increase user access. The public, media, and industry should be given access to the Egyptian Environmental Information System once it is developed. An alternative option to giving non-government personnel direct access to the system is to link the Egyptian Environmental Information Highway, which is accessible to anyone, to the EEIS.

Meet established standards. Each ministry should ensure that they meet the standards for spatial environmental data collection and quality control as set by the EEIS project team and that the data is saved in an acceptable format.

Establish a secure source of funds. Money should be earmarked specifically for sustaining the Egyptian Environmental Information System once it is operational. This money could come from the Environmental Protection Fund.

Develop and retain local capacity for operating the EEIS. The long term success of any information system depends highly on the availability of local personnel capable of maintaining the system. The Canadian Executing Agency is providing training to locals on how to operate and maintain the system. A concern is the retention of staff once trained. The government should provide the EEAA with a larger budget in order to hire more permanent staff members. Long-term employees could then fill positions in the training courses. In addition, a close partnership between the Canadian Executing Agency and local universities needs to be formed so that the academic establishments may develop the expertise to teach the necessary skills.

External Support Agencies

Add to the criteria for project approval that there must be a component to develop indigenous sources of funding. Egypt must be able to demonstrate that it can continue the project after donor funding has been exhausted.

Add to the criteria for project approval that there must be a component to improve communication and collaboration. ESAs should consider proposals that include collaboration among several parties more favorably as well as proposals that have an action plan to improve communication and cooperation.

Consider providing funding for a follow-up on project activities. Evaluations should be carried out after completion of donor assistance in the project to determine how effective the aid was and whether the indigenous resources were adequately developed to sustain the project.

Through the wise management of the quantity and quality of the Nile waters, the government can ensure that in the future the availability of suitable quality water is enough to support the nation's socio-economic development and that the demands from the different water users continue to be met. However, action by the Government of Egypt to enhance water quality management must be taken now if the lifeblood of the nation, the River Nile, is to be safeguarded.

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APPENDIX A – KEY INFORMANT INTERVIEWS: BASIC QUESTIONNAIRE

Key Informant Interviews - Basic Questionnaire

Water Quality Monitoring

- Are the goals and objectives of the monitoring program clearly stated?
  Yes No
- Who sets the goals and objectives of the monitoring program?
- i) What are the goals and objectives of the monitoring program?
  ii) Are they being met? Yes No
- How often is water sampling undertaken?
  Daily Weekly Monthly Annually Never Other (e.g. when resources are available)
- How often are water quality objectives revisited?
  Daily Weekly Monthly Annually Never Other (e.g. when resources are available)
- How often is the monitoring system reviewed?
  Monthly Annually Never Other (e.g. when resources are available)
- How many labs are available for water quality testing?
- Who is responsible for operating the laboratories?
- How were the water quality standards determined?
- Who are the users of the water quality monitoring data?
- Do you co-relate physical, chemical and biological quality data with quantitative date like water flow?
- Is there a QA/QC programme in place for the monitoring system?
- What are some of the problems faced in systematic sampling and analysis of water quality, if any?
- Is Egypt participating in UNEP's Global Environmental Monitoring System's Water Programme (GEMS/WATER)?

Data Management and Information Systems

- How is the data currently processed?
- Is the data analysed and evaluated in a timely manner?
- Is the water quality information easily accessible to the users?
- Is there a central database for water quality data and information?
- Are you familiar with the Egyptian Environmental Information Highway?

External Support Agencies

- Are foreign consulting firms selected based on their commitment to the development of Egypt's personnel, as well as on their technical expertise?
- What role would you like to see international organisations and donor agencies play in water quality management in Egypt? In otherwords, what contributions would you like to see them make?

Legislation

- Do you feel that the Egyptian legislation available is sufficiently enforced and adequately implemented for water quality management?
- Do you believe that the standards as set out in Law 48/1982 are too stringent?
  Yes No
  Please explain.
- Do you feel that the EEAA has enough resources to effectively implement Law 04/1994?

Capacity Building

- How would your rank the cooperation and coordination between the various Ministries?
  Poor Fair Good Excellent
  Please explain.
- Does the information from the research institutes flow to the implementing agencies?
- Do you have facilities available for training personnel in sampling, handling, and lab analysis of water quality? If so, once they are trained do they stay?
- Is water management taught at the university level or are the courses taught strictly technical?

- What role, if any, do NGOs play in water quality management?
- Are there any performance indicators in place to assess institutional performance?
- Are training or education courses offered to the employees? If yes, who determines which courses are needed and who provides them?
- Do you have access to enough skilled workers?
- Do you fell there is adequate communication between researchers?
- Do you feel that the Egyptian Environmental Affairs Agency is fulfilling its purpose as a coordinating link between the Cabinet of Ministers and the different ministries in the field of environmental actions?

Miscellaneous

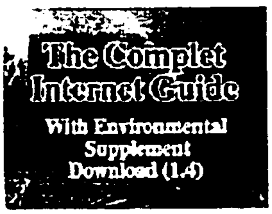
- What, in your opinion, is the greatest obstacle to implementing water quality management?
- What would you like to see done in the future?
- Are there opportunities for stakeholder input into the national water quality management programme?
- Is there a hazardous spill and emergency response program?
- Do you feel that there is adequate budgetary allocations for effective control of water and environmental pollution?
- Does a long-term water and/or wastewater management plan exist?
- A new Minister of Public Works and Water Resources was appointed during the summer. How do you feel this will change the way the Ministry is managed?
- If you could provide one main recommendation to the Minister of Public Works and Water Resources regarding water quality management, what would it be?

APPENDIX B – EGYPTIAN ENVIRONMENTAL INFORMATION HIGHWAY

ENVIRONMENTAL INFORMATION HIGHWAY

Our objective is to create an electronic network that connects all departments, centers and institutes that work in the field of environment. The estabishment of such a Highway will foster collaboration among different agency's components, systematize the process of environmental data communication, information networking and management. Although this page is developed especially for the egyptian environmentalists, it also links to key global environmental activities.

Through this site you will be able to visit many regional environmental organizations. If you are searching for an expert or a company, want to know the weather information, want to acquire data, ...etc, follow the services link. Moreover, the site is covering the on going projects in Egypt's Environment. To know about and register in any event visit the events page. Finally some of the local environmental news are compiled under News, and the HOT environmental links at Links. Your comments and requests are welcome. Visit the contact page, you will find all our contact information.



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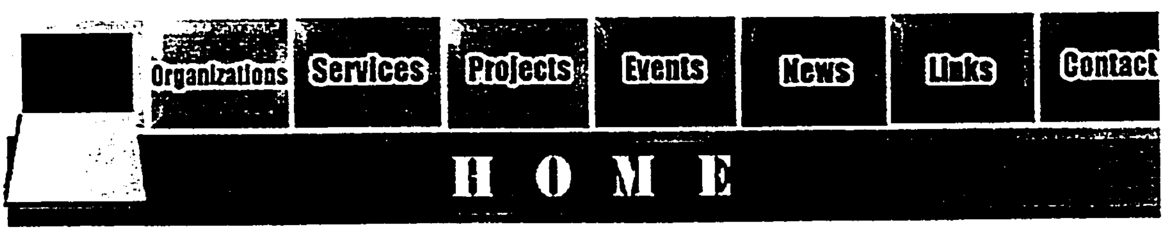
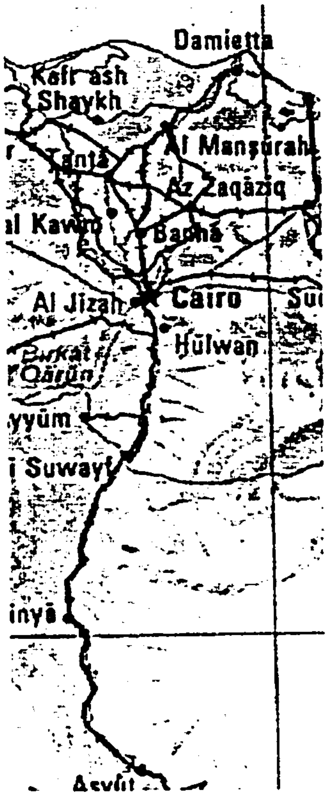


Home | Organizations| Services | Projects| Events | News| Links| Contact "



Environment

On-going Projects

Search Egypt's On-going Projects

Many projects are being executed in Egypt for environmental monitoring & protection, moreover, the country is running awareness/education projects, information projects and others. Those projects are funded by key donors and executed by various organizations. Below you can search for these on-going projects by themes.

Theme: Water Quality [Search]

Home | Organizations | Services | | Events | News | Links | Contact

PROJECTS

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Last Modified 1-11-1996