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***Environmental impact assessment:  
sewage treatment plant for Port Said***

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## **PREFACE AND ACKNOWLEDGEMENTS**

Environmental impact assessments (EIA) have been extensively prepared and used over the last 15 years. Their wide application clearly indicates a need to ensure that environmental considerations are included in the decision-making process. However, particularly in developing countries, the procedures established for EIA in developed countries have met much criticism.

Realizing the shortcomings of these procedures and responding to frequent requests for a simple and practical, but still adequate approach to EIA, the Oceans and Coastal Areas Programme Activity Centre (OCA/PAC) of UNEP has attempted to formulate procedures, supplemented with guidelines, which could be used in preparing EIAs for typical development projects in the context of legal agreements supporting the UNEP Regional Seas Programme.

The procedures and guidelines advocated by UNEP <sup>al</sup> were tested through a series of concrete case studies. One of the first case studies and the way it was prepared is described in this document.

The analysis of the case study and the description of the procedures used in the environmental impact assessment (Part I and II of this document) were prepared by the Priority Actions Programme Regional Activity Centre of the Mediterranean Action Plan, with assistance of consultants (Messrs A. Baric and A. Jernelov). The guidelines for the preparation of the EIA document for the waste water treatment plant were originally prepared by Messrs A. Jernelov and U. Marinov, and modified for the specific situation in Port Said by Mr. A. Baric (Part III of this document).

The substantive part (Part IV) of this document was prepared by Mr. Mohammed Khaled Mostafa, Ministry of Development, New Communities, Housing and Public Utilities of Egypt. In the preparation of the document, he was assisted and guided by Messrs Y. Ahmad, A. Baric and A. Jernelov, consultants of the Priority Actions Programme Regional Activity Centre of the Mediterranean Action Plan and the Oceans and Coastal Areas Programme Activity Centre.

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## **PART I: ANALYSIS OF THE CASE STUDY**

The preparation of the EIA document was largely the result of the efforts of one person from one agency and had therefore in itself a limited effect with regard to experience in interministerial and interagency collaboration.

Furthermore, with regard to technical documentation, the informal but existing procedures for assessment of technical feasibility and environmental consequences in Egypt, require more details than the approach advocated here. Thus the field where the requirements for this type of EIA document, according to the guidelines, brought forward additional information, was in the biological/ecological sections. As a function of what was available or deducible, however, the document remained less strong in the environmental sections than in the technical ones.

The most important part of the procedure turned out to be the evaluation meeting with intense discussions of fundamental aspects of the EIA procedure and the content of the EIA document. As a consequence of the heterogeneity of the group and the highly different background experience of the participants, however, a few points of large importance remained unclear as can be seen from the recommendation of the meeting, where it was suggested that the EIA document be supplemented with considerations of alternative locations and of costing. Should this recommendation be followed, some of the bases for a simple and practical approach would be lost, and a much more elaborated procedure would result.

The discussions of these points during and after the meeting indicate that the Port Said Sewage Treatment Plant may be a broader case to fulfil the criteria for a project to be assessed with the methodology described in this document. The project should "not be unique neither in size nor scope".

## **PART II: PROCEDURES USED IN THE ENVIRONMENTAL IMPACT ASSESSMENT**

### **1. Background**

The fourth ordinary meeting of the Contracting Parties to the Barcelona Convention (Genoa, September 1985), when considering the workplan of the Priority Actions Programme Regional Activity Centre (PAP/RAC) of the Mediterranean Action Plan, "stressed the interest to develop suitable methodologies for environmental impact assessment, with a view to their introduction in coastal zone development planning" <sup>b/</sup>. The same meeting adopted ten targets to be achieved as a matter of priority during the second decade (1986-1995) of the Mediterranean Action Plan (MAP). Among these targets were <sup>c/</sup>:

- establishment, as a matter of priority, of sewage treatment plants in all cities around the Mediterranean with more than 100,000 inhabitants and appropriate outfalls and/or appropriate treatment plants for all towns with more than 10,000 inhabitants; and
- applying environmental impact assessment as an important tool to ensure proper development activities.

In response to similar requests from other meetings convened in the framework of the UNEP Regional Seas Programme, UNEP has developed a simple and practical approach to the environmental impact assessment (EIA) <sup>d/</sup> which might be applicable in the context of the legal agreements supporting that programme.

In consultation between PAP/RAC and the National Focal Point of Egypt for the Mediterranean Action Plan, the preparation of an EIA for the sewage treatment for the city of Port Said was among the first case studies selected to test the new approach to EIAs.

This chapter of the present document describes, step-by-step the application of the general approach advocated for the EIA procedure <sup>e/</sup>.

## **2. Request for building of a sewage treatment plant for the city of Port Said**

With the rapid growth of Port Said, the lack of a proper sewerage system and sewage treatment facility has become an ever-larger problem both from a public health and environmental point of view. The Ministry for Reconstruction therefore decided that a sewage treatment plant should be built for the city of Port Said.

## **3. Decision on the need for an EIA document**

The Egyptian Environmental Affairs Agency of the Cabinet of Ministers decided that an EIA document was required.

## **4. Guidelines for the preparation of an EIA document**

Building on the goals and principles of EIAs, adopted by the Governing Council of UNEP and endorsed by the United Nations General Assembly <sup>d/</sup> and on the procedures developed for a practical approach to EIAs <sup>e/</sup> the guidelines for the preparation of the EIA document for a sewage treatment plant were prepared by PAP/RAC with assistance of consultants (Part III of this document). The guidelines list the issues which were expected to be addressed in the preparation of the EIA document for the sewage treatment plant of Port Said.

## **5. Environmental impact assessment document**

The preparation of the EIA document was entrusted to the National Organization for Potable Water and Sanitary Drainage (NOPSWAD), of the Ministry of Development, New Communities, Housing and Public Utilities of the Arab Republic of Egypt.

Several consultations were held between the staff of the organization and of PAP/RAC's consultants during the preparation of the EIA.

The information used for the preparation of the EIA consisted of the following:

- climatological, geological, hydrological, water quality, and aquatic communities data, which were obtained from earlier measurements, as well as through limited sampling during the preparation of the EIA.

The EIA document was prepared during a period of 3 months, from June to September 1989, and involved an estimated time of 1 m/m (man/months) of a scientist and of 1 m/m of a technical staff. The EIA document as submitted for evaluation is reproduced as Part IV of this document.

## **6. Evaluation of the EIA document**

The draft of the EIA document was presented to the interregional workshop on the application of the environmental impact assessment procedure jointly organized in Cairo, Egypt, 19-22 November 1989, by PAP/RAC, OCA/PAC of UNEP and the Co-ordinating Unit for MAP, in co-operation with the Egyptian Environmental Affairs Agency of the Cabinet of Ministers.

The meeting was attended by 27 participants from 17 Ministries and Departments of the Egyptian government, 8 participants from private companies in Egypt and 1 participant from the Egyptian TV, 18 participants from governmental departments of 18 foreign countries, 2 participants from environmental NGOs and 4 staff members and consultants of UNEP (for a full list of participants, see Appendix).

The meeting was started by the presentation of the approach used in the preparation of the EIA and by the detailed exposition and discussion of the case study.

The main comments and suggestions offered at the meeting may be summarized as follows:

- (a) the general approach proposed by UNEP for the preparation of EIA's was considered as suitable in principle, although some amendments were introduced into the proposed procedures<sup>\*</sup>;
- (b) the guidelines used for the preparation of the EIA were considered, with some amendments, as sufficient general guidelines for the preparation of EIA's related to sewage treatment plants, but they should be supplemented with more specific guidelines tailored to the concrete case studies;
- (c) the presented draft EIA was considered, after some modifications, as adequate for the decision-making process: the suggested amendments included the following:
  - the EIA should not only compare the existing situation and the proposed site and solution but also identify the various alternatives which must be studied in this EIA report;
  - the economics of the project and of alternative management of wastewater should be considered;
  - concern was expressed that a comparatively high level of phosphorus, nitrogen, detergents and heavy metals in the treated wastewater could adversely affect Lake Manzala;
  - data on the content of heavy metals in the sludge and the method of its disposal and utilization should be provided;

In addition the EIA document was evaluated and accepted by the Egyptian Environmental Affairs Agency.

## **7. Decision by the authorizing authority**

The EIA as modified during the review and presented as Part IV of this document was accepted.

The first phase of the project is now in operation, while phase two is waiting for funding.

## **8. Monitoring of the impact of the sewage treatment plant**

As the project is not yet completed only the part of the monitoring programme of relevance for Part I of the project can be executed.

## **9. Re-evaluation of the environmental impact assessment**

Not yet applicable.

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<sup>\*</sup>The amendments suggested at the meeting are incorporated in the document listed under Note <sup>2/</sup>.

## Notes

- <sup>1a/</sup> UNEP: An approach to environmental impact assessment for projects affecting the coastal and marine environment. UNEP Regional Seas Reports and Studies No. 122, UNEP, 1990.
- <sup>1b/</sup> Report of the fourth ordinary meeting of the Contracting Parties to the Convention for the Protection of the Mediterranean Sea Against Pollution and its related Protocols. UNEP/IG.56/5, Part I, para. 89. UNEP, 1985.
- <sup>1c/</sup> Ibid. Part II, para. 17 (b) and (c).
- <sup>1d/</sup> Decision 14/25 of UNEP Governing Council; 17 June 1987. UNEP/GC/14/26, Annex I.

## **PART III. GUIDELINES FOR THE PREPARATION OF AN ENVIRONMENTAL IMPACT ASSESSMENT DOCUMENT FOR A SEWAGE TREATMENT PLANT IN PORT SAID**

### **1. Background**

Sewage treatment plants are constructed to transform the raw sewage into an easier manageable waste and to retrieve and re-use the treated sewage water.

The end products of a treatment plant are sludge and treated sewage water. Both products may contain, in addition to organic biodegradable substances and micro-organisms, non-biodegradable and toxic substances due to the contamination of sewage with industrial waste waters.

From the environmental standpoint the most important aspect of a sewage treatment plant is the proposed disposal or use of the sludge and the treated sewage water.

The most common adverse environmental effects on coastal waters, connected with disposal or use of the sludge and the treated sewage water, are caused by: microbiological contamination, oxygen depletion due to high load of organic faecal matter, eutrophication caused by nutrients, and toxic and non-biodegradable substances originating mainly from contamination of sewage by industrial wastes.

Some treatment processes (e.g. oxygenation ponds, aerated lagoons) may lead, under the influence of wind, to the spread of pathogens through air transport over considerable distances.

Most sewage treatment and disposal processes are a serious source of offensive odour.

Improperly constructed or operated sewage treatment plants and improper disposal or use of sludge and treated sewage water may become a most serious public health problem. Therefore, whatever level of treatment and method of disposal and use is approved, it should strictly comply with national standards and internationally accepted environmental quality criteria, taking into account the recipient environment and the biological targets which may be affected, specifically man.

Elements specifically recommended for inclusion in the follow-up monitoring and re-evaluation programme are: regular compliance with methods approved for sewage treatment and disposal, including for use of treated sewage water; seepage of contaminants from the treatment plants or sludge disposal sites into freshwater aquifers or coastal waters; wind transport of pathogens originating from the treatment plant or sludge disposal site; elements recommended for monitoring of submarine sewerage outfalls (see section 4.5) if such an outfall is part of the project.

## 2. Description of the proposed project

The proposed treatment plant should be described, accompanied by plans on a scale of 1:2500\*, including the following:

- Types of sewage to be treated (industrial, domestic, agricultural).
- Number of inhabitants to be served by the plant.
- Types of clients to be served, e.g. industrial, residential, commercial, hospitals.
- Quantity of sewage (cubic metres per day, per year).
- Quality of sewage to be treated, including suspended solids (mg/litre), settleable solids (mg/litre), pH, turbidity, conductivity, BOD (mg/litre), COD (mg/litre), nitrogen, ammonia, phosphate, oil, surfactants, and heavy metals such as arsenic, cadmium, copper, lead, nickel and mercury.
- Method to be used in treatment of sewage.
- Layout of the plant (including treatment facilities and service area).
- Use of effluents (agriculture, recharging aquifer, disposal to sea or to nearest river).
- Sludge quantity and quality.
- Method of sludge treatment and disposal.
- Chemical, physical and bacteriological characteristics of effluents such as suspended solids, settleable solids, pH, turbidity, conductivity, BOD, COD, nitrogen, ammonia, phosphate, oil, surfactants, and heavy metals such as arsenic, cadmium, copper, lead, nickel and mercury, total coliforms, faecal coliforms and faecal streptococci.

## 3. Description of the environment

A description of the environment of the site without the proposed sewage treatment plant should concentrate on the immediate surroundings of the proposed project. The size of the area described will be determined by the predicted effects of the proposed plant.

### (a) Physical site characteristics

- Site location on a map at a scale of 1:10,000 or 1:50,000 including residential areas, industrial areas and access roads.

### (b) Climatological and meteorological conditions

- Basic meteorological data such as wind direction and wind velocity.

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\*The scale of the maps given here is an indication and is not mandatory. Standard maps which are available in each country could be used.



- Special climatic conditions such as storms, inversions, trapping and fumigation, proximity to seashore, average yearly rainfall and number of rainy days per year.
- (c) Geological and hydrological conditions
- Geological structure of the proposed area, including hydrology and aquifers;
  - Existing uses of water bodies around the proposed site and the quality of the water.
- (d) Present land use of the site and its surroundings
- (e) Characteristics of the lake area which will receive the discharged treated sewage
- (f) Existence of endemic waterborne diseases

#### **4. Identification of possible impacts**

An assessment of anticipated or forecasted impacts, using accepted standards whenever possible, of short-term impacts associated with the activities related to the construction of the plant and long-term impacts related to the functioning of the treatment plant should be given, including the following:

- Odours and air pollution from the plant and from the disposal of effluents and sludge.
- Infiltration of sewage into topsoil, aquifer or water supply and impact on drinking water quality.
- Mosquito breeding and diseases transmitted by mosquitoes.
- Pollution of the lake Manzala.
- Flora and fauna.
- Solid waste disposal of sludge and other wastes.
- Tourist and recreation areas such as nature reserves, forests, parks, monuments, sport centers, beaches, and other open areas which would be impacted.
- Possible emergencies and plant failures, the frequency at which they may occur, and possible consequences of such emergencies.

#### **5. Proposed measures to prevent, reduce or mitigate the negative effects of the proposed plant**

This section should describe all measures - whether technical, legal, social, economic or other - to prevent, reduce or mitigate the negative effects of the proposed sewage treatment plant. In addition, it should describe parameters to be used to monitor the effects on a long-term basis, including the collection of data, the analysis of data, and the enforcement procedures which are available to ensure implementation of the measures.

# **PART IV: ENVIRONMENTAL IMPACT ASSESSMENT OF A SEWAGE TREATMENT PLANT FOR PORT SAID**

## **1. Introduction**

The Arab Republic of Egypt has initiated a programme to reconstruct and expand the basic infrastructure in the Suez Canal region. As part of this programme, efforts have been made to modernize and expand wastewater collection, treatment and disposal facilities in each of the major cities bordering the Suez Canal - Port Said, Ismailia and Suez. These improvements will enable the Suez Canal region to expand its economic development potential and accommodate future population growth in years to come.

The Ministry of Development, New Communities, Housing and Public Utilities through the National Organization for Potable Water and Sanitary Drainage (NOPWASD) has the responsibility for implementing programmes to improve the wastewater collection, treatment and disposal facilities in Port Said, Ismailia and Suez. It is presently carrying out the Canal Cities Water and Wastewater Project to achieve this objective. This programme is being financed jointly with funds supplied by the Government of Egypt and the United States Agency for International Development (USAID). NOPWASD is implementing the programme in cooperation with the Governorates of Port Said, Ismailia, and Suez and their respective Wastewater Departments.

Under Phase I of the Canal Cities Water and Wastewater Projects new wastewater collection systems have been constructed in each city. These systems consist of collectors, force mains and pump stations. Under Phase II of the Canal Cities Water and Wastewater Project new wastewater treatment and disposal facilities are to be designed and constructed for each city. The proposed project schedule calls for construction for the Port Said Wastewater Treatment Plant to begin in early 1991 with plant start-up in 1993.

Preliminary engineering design and construction management services are being supplied to NOPWASD by the joint venture of Black & Veatch International and James M. Montgomery Consulting Engineers Inc. of the United States in association with Sabbour Associates of Egypt under a USAID funded contract. Environmental Impact Assessments are being developed for NOPWASD and the joint venture by Dames & Moore International of the United States.

Under the Canal Cities Water and Wastewater Project-Phase II, Environmental Impact Assessments (EIAs) of the proposed new wastewater treatment plants for each city are in the process of being prepared. These Environmental Impact Assessments will consider all Egyptian laws and regulations that apply to this project. Environmental Impact Assessments are also required by USAID regulations for all projects which may have a significant effect on the environment. The preparation of EIAs ensures that environmental factors are integrated into the project planning process and that development activities are properly planned and local natural resources protected. In addition to encompassing the topics covered by the UNEP/WHO EIA guidelines, the EIA process includes a provision to carry out public scoping meetings in each of the affected communities. The scoping meetings provide a forum for interested parties to raise environmental concerns and issues for inclusion in the assessment process. In addition, factors such as appropriateness of the technology, system reliability, institutional support requirements and other factors pertinent to the continued success of the project will be included in the assessments.

Port Said is the capital city of the Governorate of Port Said. The city is located on the Mediterranean Sea coast at the northerly entrance of the Suez Canal. The Governorate's jurisdictional boundaries extend approximately 22 kilometres west of Port Said along the Damietta Road. The western boundary encompasses a portion of the eastern shore of Lake Manzala to a point roughly five kilometres south of El-Cap. At that point the boundary runs east across the Suez Canal and approximately eight kilometres into the Sinai. At that point the boundary turns northeast to Baloza and then north to the Mediterranean Sea which forms the northern boundary.

The majority of the land area encompassed by the boundaries of the Port Said Governorate is either open water or the shallow, brackish wetlands associated with either Lake Manzala to the west or Lake Malaha to the east of Port Said's Port Fouad District across the Suez Canal. The fact that Port Said is surrounded by open water and wetlands results in limited land availability for urban expansion. For this reason, the Arab

Republic of Egypt initiated an urban land reclamation programme which has expanded the land available for new construction by means of hydraulic fill dredged from Lake Manzala.

The city of Port Said is also a "Free Zone" which means that no import duties are charged on goods purchased within the city boundaries. This has increased the economic growth of Port Said.

The Port Said Governorate is bordered to the west by Damietta, Dakahliya and Sharkiya Governorates, to the south by Ismailia Governorate and to the east by the North Sinai Governorate. The city of Port Said is divided into five districts that include: El Arab, East, El Manakh, El Dawahi and Port Fouad. The Suez Canal divides the Al Arab, East, El Manakh and El Dawahi Districts from the Port Fouad District. These four districts comprise the west bank of the city while the Port Fouad District is considered the east bank of the city. From the standpoint of sewage collection and treatment Port Said's Port Fouad District is an independent entity unconnected to the proposed wastewater treatment plant discussed in this case study.

## **2. Description of the proposed project**

### **2.1 Primary design criteria**

The new wastewater treatment facility at Port Said, as with those to be constructed at Ismailia and Suez, is to be designed for projected population estimates for the year 2000. This will allow adequate time for the design and completion of construction, as well as another six to eight years for the planning, design and construction for future expansion.

The Port Said population was estimated to be approximately 400,000 in 1986 and 420,000 in 1989. The present estimate by the Governorate's planning officials for the year 2000 is 561,200, based on an assumed 2.7 percent annual growth rate although past projections of year 2000 population have been as high as 720,000, based on assumptions about immigration from other parts of Egypt. It is thought that at that time, approximately 547,000 people will be serviced by the new sewerage system, although this will be affected to a large extent by the growth of population in the unserved Port Fouad District 2/.

Wastewater flows have been projected in master planning studies on the basis of present domestic, institutional and industrial flows, and with some assumptions concerning future economic development of the area. Present industries in the area include port operations, construction, light industry, fishing and food processing; however, the domestic portion of the wastewater stream dominates the flow volume, and the wastewater characteristics can be considered to be representative of typical domestic sewage for this region. Wastewater strength is somewhat higher than that normally found in other countries due to lower per capita water consumption rates and lower amounts of rainfall.

The collection system constructed in Phase I of the Canal Cities Water and Wastewater Project is substantially complete. Inflow from storm water is not expected to significantly affect treatment operations because of the low rainfall in this area (see Section 3.2 Climatological and Meteorological Conditions). The per capita water usage at Port Said has been estimated to be between 150 and 200 litres per day. A groundwater inflow into the sewer system further augments the wastewater flows. A design flow of 150,000 cubic metres per day has been selected for Port Said (see Table 1). This is based on a 200 litres per capita per day consumption rate, and includes a 20 percent allowance for both industrial flows and infiltration. This implies an annual wastewater load for treatment for 54,750,000 cubic metres.

### **2.2 Wastewater characterization**

The design wastewater characteristics are also presented in Table 1. For design purposes, a biochemical oxygen demand (BOD) of 360 mg/l and total suspended solids concentration (TSS) of 380 mg/l has been used. These values are based on a recent wastewater sampling programme and represent total design loadings of 54,000 kg/day and 57,000 kg/day for BOD and TSS, respectively.

**Table 1: Design influent and effluent wastestream parameters  
for the proposed new Port Said wastewater treatment plant**

Item	Unit	Influent average	Effluent average
Flow	m <sup>3</sup> /day	150,000	
Biochemical Oxygen Demand (BOD)	mg/l kg/day	360 54,000	60 9,000
Total Suspended Solids (TSS)	mg/l kg/day	380 57,000	50 7,500

*Source:* Influent average values are based on results of an ongoing wastewater analysis programme conducted between December, 1988 and April, 1989 on a periodic basis at the existing Port Said Mazrah Wastewater Treatment Plant. Effluent averages are based on assumed aerobic lagoons treatment process.

A further characterization of wastewater at the existing Mazrah Wastewater Treatment Plant is shown in Table 2. Nutrient levels (nitrogen and phosphorus) are moderate to high for the wastewater strength. Total dissolved solids are moderately high for municipal wastewater, but should not impede biological nitrification given the normally high temperature and organic and nutrient loadings. No significant concentrations of heavy metals have been detected in preliminary sampling efforts, although low concentrations of lead and nickel have been measured. Measured sulfide concentrations in the existing wastewater are quite high, ranging between 5 and 12 mg/l.

The treatment facilities at Port Said are being designed to meet certain requirements and specifications for wastewater effluent established by Egypt's Law 48/1982 3/. The standards for wastewater effluent established by this law are enforced by the Ministry of Public Works and Water Resources. Wastewater and receiving water sampling and testing programmes in Egypt are administered by the Ministry of Health and its Environmental Health Center. Table 1 indicates the effluent concentrations of each pertinent parameter, where available.

## **2.3 Wastewater treatment alternatives**

Four treatment alternatives were considered for possible use at Port Said. They were aerated lagoons, conventional activated sludge treatment, trickling filters, and deep shaft treatment. An Alternative Treatment Study was recently prepared for NOPWASD which presents a comparison of the four alternatives and preliminary cost summaries. The study also evaluated plant operation and maintenance needs, land requirements, and treatment reliability.

Based on these factors, the Alternative Treatment Study has identified the use of aerobic lagoons as the preferred treatment alternative at Port Said.

## **2.4 Wastewater treatment by the aerated lagoon process**

The following wastewater treatment processes are being evaluated as the preferred alternative:

### **Wastewater Treatment Unit Processes**

- Bar Screening
- Grit Removal
- Aerated Lagoons
  - Complete Mix Lagoon
  - Semi-Mix Lagoon
  - Polishing Pond

Chlorination  
 Post Aeration  
 Sludge Management  
 Sludge Drying Lagoons  
 Sludge Stockpile Area

**Table 2: Port Said wastewater characteristics**

Item	Average (mg/l)
BOD	360
COD	500
TDS	2000
TSS	380
VSS	300
NH <sub>3</sub> -N	45
TKN	60
PHOPHORUS	9
ALKALINITY	320
HARDNESS TOTAL:	380
CALCIUM	140
MAGNESIUM	240
CALCIUM	60
MAGNESIUM	60
SODIUM	200
POTASSIUM	40
CHLORIDE	730
SULFATE	200
SULFIDE	8
SI O <sub>2</sub>	2
CADMIUM	ND
CHROMIUM	ND
COPPER	ND
IRON	.4
LEAD	ND
MANGANESE	--
MERCURY	No
NICKEL	No
SELENIUM	No
ZINC	.2

ND - Not Detected

*Source:* Based on results of wastewater analysis programmes conducted between December, 1988 and April, 1989 on a periodic basis at the existing Port Said Mazrah Wastewater Treatment Plant 1/.

The preliminary design parameters for each element of the treatment process are presented in Table 3.

Support facilities to be constructed will include an electrical substation, a maintenance facility warehouse, and an administrative building which will include a well-equipped laboratory.

Figure 1 provides a preliminary layout for the proposed facilities. This layout includes the wastewater treatment facilities and the sludge drying lagoon. The plant will be linked to the existing Port Said Sewage Collector System by an influent force main and pump station, and an outfall pipe will direct the treated wastewater effluent into Lake Manzala.

**Table 3: Illustrative design parameters for Port Sald aerated lagoon wastewater treatment plant**

**Process Unit**

**BAR SCREEN**

Number of units	4
Capacity, m <sup>3</sup> /day each	100,000
Bar width, mm	15
Bar spacing, mm	19

**GRIT REMOVAL**

Aerated grit	
Number of units	4
Length, m	8
Width, m	5
Depth, m	4
Volume, m <sup>3</sup> each	160
Air supply, sm <sup>3</sup> /min each	5.2

**AERATED LAGOONS**

Complete mix lagoon	
Number of units	1
Length, m at bottom	155
Width, m at bottom	155
Depth, m	5.2
Freeboard, m	1
Sideslope	3:1
Hydraulic retention, days	1.0
Total volume, m <sup>3</sup>	151,765
Diffusor type, <sup>1</sup>	Static Aerator
No. of diffusers	3,600
Air supply, sm <sup>3</sup> /min	2,340
Partial-mix lagoon	
Number of units	1
Length, m at bottom	514
Width, m at bottom	257
Depth, m	5.2
Freeboard, m	1
Sideslope	3:1
Hydraulic retention, days	5.0
Total volume, m <sup>3</sup>	751,050
Diffusor type,*	Static Aerator
Number of diffusers	4,080
Air supply, sm <sup>3</sup> /min, average	2,610
peak	3,464

**AERATED LAGOONS (Cont'd)**

Blowers	
Total, Shp, average	7,063
peak	8,793
Polishing pond	
Number of units	1
Length, m at bottom	694
Width, m at bottom	347
Depth, m	3.0
Freeboard, m	1
Sideslope	3:1
Hydraulic retention, days	5.0
Total volume, m <sup>3</sup>	750,866

**CHLORINE CONTACT BASIN**

Number of units	2
Length, m	36
Width, m	17
Depth (sidewater), m	3
Volume, m <sup>3</sup> each	1,836
Rapid Mix	
Number of units	2
Volume, m <sup>3</sup> each	27
bhp, each	8.85
Chlorine, kg/day average	750
peak	3,000

**POST AERATION**

Diffused air	
Number of units	2
Length, m	8.5
Width, m	8.5
Depth, m	5.5
Volume, m <sup>3</sup>	397
Air supply sm <sup>3</sup> /min total, average	26
peak	55
Blower, bhp, average	38
peak	87
Number of diffusers, per basin	40

Source: Black & Veatch International/James M. Montgomery in association with Sabbour Associates, 1989.

\* Decision between surface aeration and submerged diffusers will be made during detailed design.

## 2.5 Sludge management

Based on the wastewater treatment system using aerated lagoons, the proposed Port Said Wastewater Treatment Plant will generate biological sludge. Estimated sludge volumes are shown in Table 4. No information is available on the quality of the sludge which will be produced.

For some treatment technologies, sludge must be thickened and stabilized before it can be efficiently disposed of or used as a soil amendment. Stabilization is a process which reduces the volatile organic content of the sludge; this process makes the treated sludge less odorous and reduces the risk of disease. Thickening and stabilization processes are not necessary with aerated lagoons, as these processes occur naturally within the lagoons. Sludge will be removed from the aerobic lagoon cells every 2 or 3 years. A sludge drying lagoon will be used to remove water from the sludge, making it easier to handle and dispose of the sludge.

From the drying area sludge will be removed by mechanical means to a disposal area where it will be stored for a minimum of 45 days. Following storage it will be moved to a final sludge disposal site outside of the city of Port Said or sold to agricultural operations as a soil conditioner.

## 2.6 Proposed site characteristics

Figure 2 presents a general map of the project area at Port Said. The proposed location of the Wastewater Treatment Plant (WTP) is to the west of the city, on a new strip of dredged fill land which has been specifically reclaimed for this purpose. Therefore, there is no other land use for this site.

**Table 4: Illustrative estimated sludge quantities  
for the proposed new Port Said wastewater treatment plant**

Item	Average quantity (kg/day)	Peak quantity (m <sup>3</sup> /day)	Average volume (m <sup>3</sup> /day)	Peak volume (m <sup>3</sup> /day)
Primary sludge	0	N/A	0	N/A
Biological sludge	42,600	N/A	2,130	N/A
Total sludge production	42,600	N/A	2,130	N/A

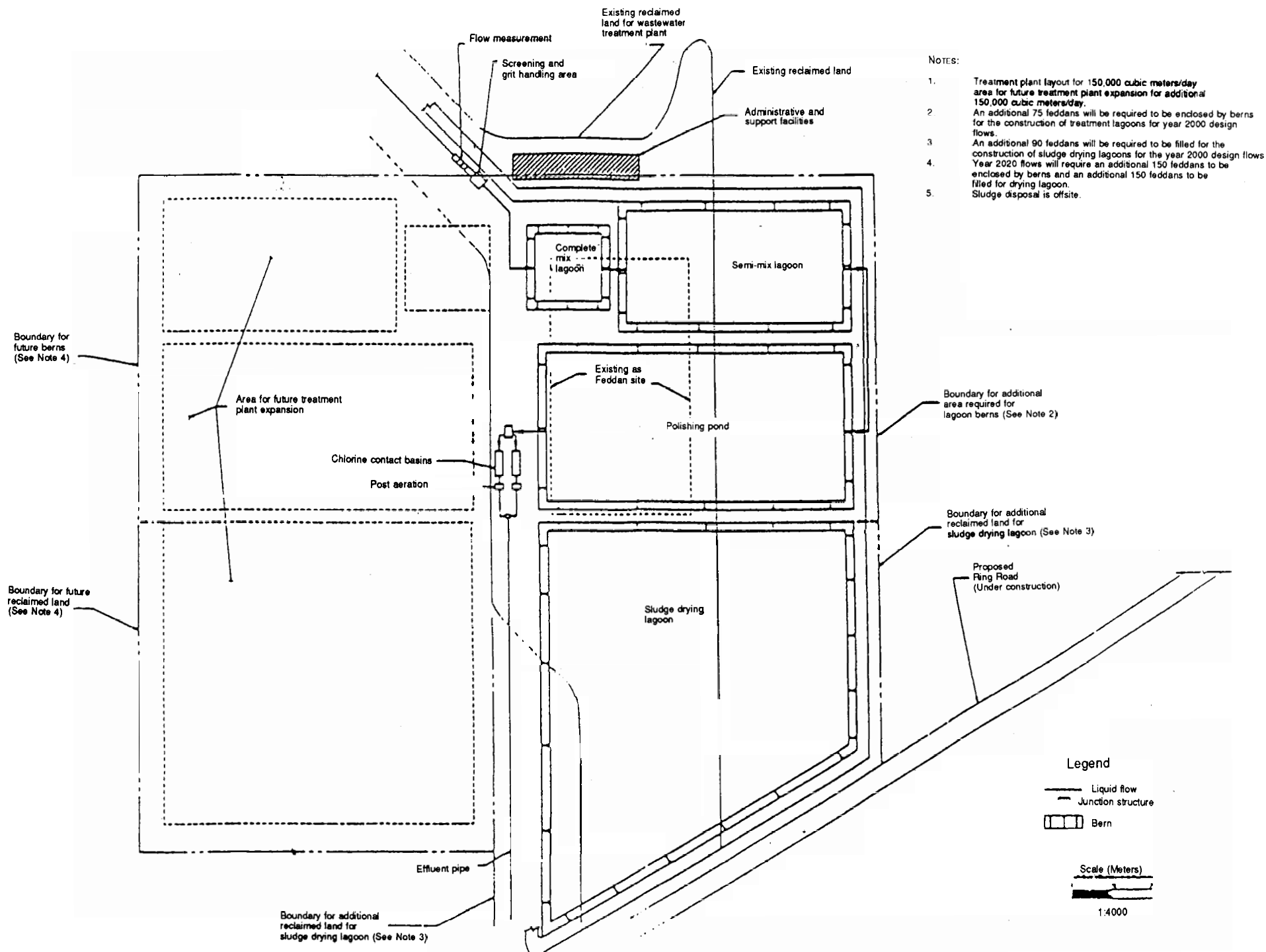
Source: Black & Veatch International/James M. Montgomery in association with Sabbour Associates, 1989.

N/A: Sludge accumulates in lagoon, and is cleaned out every 2 or 3 years. Peak quantity and volume do not apply.

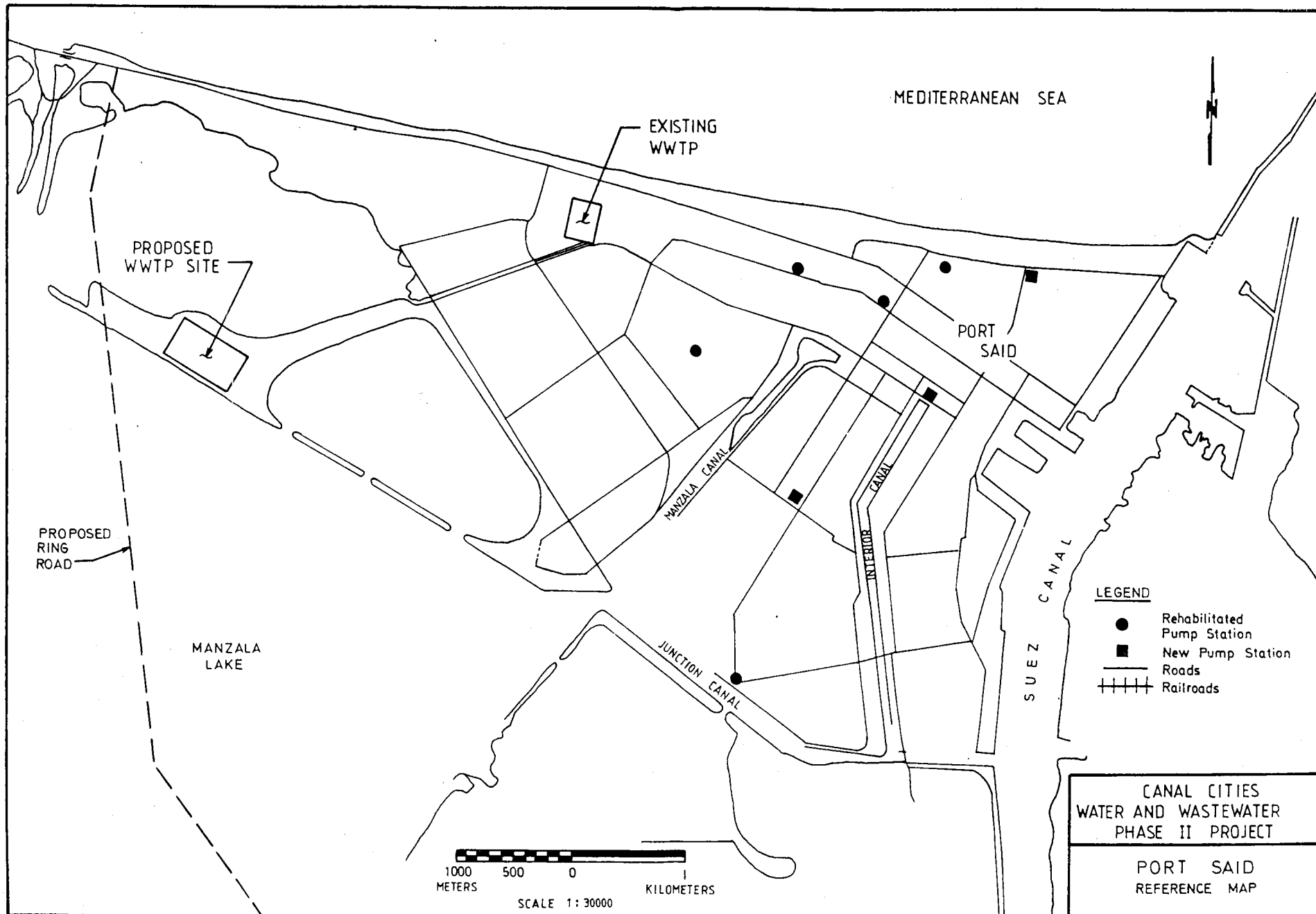
The existing Mazrah Wastewater Treatment Plan is to the northeast of the new site. This facility, which is a trickling filter plant, sustained war damage and is presently non-operational. Untreated wastewater presently bypasses around the existing Mazrah Plant via an open channel, and flows towards the northeastern shoreline of Lake Manzala, immediately to the north of the reclaimed land area on which the new plant is to be constructed.

Untreated wastewater is discharged into the body of water between the northern shore of Lake Manzala and the reclaimed land. This area acts as an enclosed body of water with limited circulation. The lake discharges flow to the Mediterranean Sea via the El Gamil Outlet and a newly constructed outlet approximately eight kilometres west of the El Gamil Outlet. Mediterranean tidal effects produce the driving forces for any circulation of water leaving the lake system. The majority of water from the lagoon discharges through the El Gamil Outlet, into the Mediterranean Sea.

Fig. 1: Layout of the proposed facilities







Major new housing developments are under construction on the land east of the Wastewater Treatment Plant site. Industrial and commercial activities are located along the Suez and Interior Canals. It is planned that additional land will eventually be reclaimed to the west of the proposed Wastewater Treatment Plant site for new housing.

Tourism has not yet developed into a major industry in the Port Said area. However, several major tourist village developments are being planned. The major attractions here include the Mediterranean beaches and the duty-free shops. The beaches to the north remain relatively free of sewage pollution. Shellfish collecting along the coast is a common activity.

A major road construction project, the "Ring Road", is presently under construction using dredged fill from Lake Manzala. This road will allow traffic to bypass around the Port Said city limits, eliminating the need for through-traffic to pass through two customs stations and the city center of Port Said. The road will define a semi-circular arc from a point just east of the El Gamil Outlet to a point on the Port Said-Quantara road just south of the Port Said city limits. The construction of this road will completely enclose the "lagoon" into which sewage is presently discharged. An outfall pipe through the Ring Road's embankment is planned to allow the treated wastewater to discharge into the lake. The location of the outfall for the treated effluent has not yet been selected.

The Ashtum El Gamil Natural Protectorate has recently been established following concerns that natural resources in this area are being over-exploited. Natural Protectorates in Egypt are established by decree under authority of Law 102/1983 4/, in order to protect "areas of land or coastal or inland waters characterized by flora, fauna and natural resources of cultural, scientific, tourist or aesthetic value". The Ashtum El Gamil Natural Protectorate was established to protect international migratory waterfowl, fishing resources and archaeological ruins on Tanis Island. It includes approximately 730 feddans. The boundary of the Protectorate extends from the eastern side of the El Gamil Outlet to approximately 7 km west and 3 km south, including Tanis Island. Discharge from the proposed Wastewater Treatment Plant will have some influence on the Protectorate particularly in the area of the El Gamil Outlet, depending upon where the outfall is located and directed.

## **2.7 Alternatives for effluent disposal**

Four alternatives were considered for the disposal of the treated wastewater in the Port Said Water and Wastewater Master Plan for Port Said 5/. These alternatives were as follows:

- Land disposal by irrigation;
- Discharge to the Mediterranean Sea;
- Discharge to the Suez Canal; or
- Discharge to Lake Manzala.

Land disposal was rejected due to the lack of suitable land in the Port Said area. The only suitable land is on the east bank of the Suez Canal in the Sinai, and the costs and engineering difficulties associated with this alternative were considered prohibitive. Also, due to the treated effluent's significant dissolved solids concentration (greater than 1000 mg/l), the treated wastewater was considered a marginal resource for this purpose.

Discharge to the Mediterranean Sea was rejected by the Ministry of Development due to the potential for pollution occurring on local bathing beaches and the subsequent adverse impact on tourism. Egypt is a signatory of several international agreements which are aimed at reducing pollution in the Mediterranean Sea, including:

- The Convention for the Protection of the Mediterranean Sea Against Pollution;
- The Protocol for the Prevention of Pollution of the Mediterranean Sea by Dumping from Ships and Aircraft; and

- The Protocol Concerning Cooperation in Combatting Pollution of the Mediterranean Sea by Oil and other Harmful Substances in Cases of Emergency.

Treated effluent discharge to Lake Manzala was preferred over the discharge to the Suez Canal after the Port Said Water and Wastewater Facilities Master Plan Receiving Waters Study 5/ demonstrated that the natural assimilative capacity of Lake Manzala was significantly higher than that of the Suez Canal.

The assimilative capacity is measured as the amount of biochemical oxygen demand (BOD) that the lake ecosystem can support without reducing oxygen levels to concentrations which would stress and affect the survival of fish and other fauna in the environment. The Port Said Receiving Waters Study estimated the assimilative capacity of the Port Said area of Lake Manzala to be 6 mg/l. Field investigations found, however, that the environment was actually supporting oxygen demands in the order of 10 mg/l.

This study also recommended that effluent from Port Said's Port Fouad District, which is across the Suez Canal from Port Said's West Bank, use the Suez Canal as the receiving waters for its treated wastewater. Port Fouad's wastewater treatment is not included in the proposed project discussed in this case study.

## **2.8 Characteristics of the receiving waters for treated effluent**

The discharge of untreated sewage from Port Said into the northeastern corner of Lake Manzala has resulted in localized nutrient-rich conditions. This area appears to be acting as an inefficient lagoon treatment system, since it operates without control over the system's salinity, tidal effects and total flow.

The abundance of algae and other flora within the enclosed "lagoon" and in the vicinity of the El Gamil Outlet, and the absence of similar growth on the lake's other side, indicates that the nutrient-rich conditions are predominantly a result of the current sewage discharge.

Additional discharges of untreated sewage from the Kabouti area south of Port Said into the Interior Canal have resulted in similar nutrient-rich conditions in the Junction Canal, which connects the Suez Canal to the northeastern portion of Lake Manzala. Dissolved oxygen levels in the areas of raw sewage discharge are thought to be depressed, particularly during the summer months when lake circulation is restricted by weather conditions.

## **3. Description of the environment**

### **3.1 Lake Manzala - an overview**

Lake Manzala, considered the largest of Egypt's Delta lakes, has gradually decreased in area over the past century due to land drainage and reclamation. The area in 1981 was estimated to be 905 square kilometres; however, due to the presence of large islets in the lake, the actual area of open water is estimated to be 700 square kilometres. The lake is shallow, with an average depth of 125 cm and a maximum natural depth of 220 cm 6/. The depth may exceed 3 metres along the dredged navigational channels connecting El-Matariah to Port Said. The lake is traversed by numerous sandy and clay islets which divide the lake into basins which limit overall water circulation.

It has been estimated that the lake receives 6,660 million cubic metres of fresh and brackish water per annum from eight main sources. Most of the lake's water supply originates with the River Nile which reaches the lake from the system of irrigation drains carrying irrigation return water and treated and untreated wastewater from other cities. The Bahr Hadus Drain accounts for almost 50 percent of the lake inflow. The Bahr El-Bagar Drain and Sirwa Drain account for another 25 and 13 percent of the inflow, respectively. Rainfall accounts for less than 3 percent of the water budget. Due to the effects of the Aswan Dam virtually no direct flow now occurs from the Damietta Branch of the Nile into the lake 6/.

Water losses from Lake Manzala are due to evaporation (approximately 44 percent) and discharge to either the Mediterranean, Suez Canal or Damietta Nile Branch. The major discharge points from the lake are the El Gamil Outlet about 5 km west of Port Said, and a new outlet about 8 km west of El Gamil which

together discharge approximately 80 percent of the total lake outflow to the Mediterranean Sea. The other main outlet, the El Kabouti or Junction Canal, is about 3 km south of Port Said and is reported to carry approximately 17 percent of the lake outflow into the Suez Canal. Tidal effects are significant in the Port Said area, but do not greatly influence the overall water balance of Lake Manzala 6/.

### 3.2 Climatological and meteorological conditions

It is considered to be two seasons in this region: summer (May through October) and winter (November through April). Daily temperatures at Port Said normally range between 14° and 28°C. Approximately 83 percent of the annual rainfall (about 72 mm) occurs during the winter season. The average monthly temperature, rainfall, relative humidity and wind directions are summarized in Table 5. Wind directions are predominantly northerly although westerly winds are more common between December and March.

**Table 5: Port Said meteorological data 8/**

	Average daily temperature °C	Rainfall mm	Relative humidity %	Wind Direction/ frequency
January	14.77	12.4	72	WSW/19.5
February	15.3	11.3	67	WSW/14.0
March	17.3	8.5	67	W/14.7
April	19.7	2.7	69	N/19.9
May	22.6	2.6	70	N/31.2
June	25.4	trace	71	N/33.5
July	27.3	0	72	NNW/30.7
August	27.8	trace	72	NNW/31.5
September	26.7	0.2	69	N/35.7
October	24.9	7.3	68	N/25.7
November	21.4	9.1	71	NNE/17.9
December	16.4	17.6	72	WSW/18.9
Total		71.7		

*Source:* Norconsult A.S. in association with Sherif M. El-Hakim and Associates, Solid Waste Management Study - Suez Canal Region Feasibility and Design Study, August, 1981. Vol. 2, pg. 2-4 8/.

### 3.3 Geological and hydrological conditions

The terrain is flat with surface elevations only 1 to 2 metres above sea level. Much of the city is built on coastal sand dunes or reclaimed land between the Suez Canal, Lake Manzala and the Mediterranean Sea.

Subsurface soil testing indicates that most of Lake Manzala is underlain by a 2 metre layer of grey, very soft and highly plastic clay which covers a 4 to 12 metre layer of medium to fine grain, compact sand. This sand layer turns after a transition zone to another dense layer of clay. The clay layer stops within 3 km of the Mediterranean coastline. Most of the Port Said area is therefore constructed on a 7 metre deep foundation of sandy material.

Groundwater is at or near the surface (0.5-1.5 m) and contains high concentrations of sulfates and chlorides. It is considered unsuitable for human consumption or agricultural purposes. For this reason all load-bearing structures require dewatering and installation of secure foundations.

### 3.4 Water quality

The eastern third of Lake Manzala is fresh to brackish depending on the season, due to the location

of the lake outlets to the Mediterranean at El Gamil and the new outlet to the west, and El Kabouti (the Junction Canal) to the Suez Canal, the flow directing effect of the Matariya-Port Said channel and the predominant northwesterly winds. A transitional zone in salinity occurs along the northern lake shore, adjacent to the Mediterranean Sea, where TDS concentrations increase to saline concentrations (over 26,000 mg/l). Distribution of salinity in surface waters of Lake Manzala over a three month period in late 1981 are shown in Figures 3, 4 and 5. 7/

The nutrient levels (nitrogen and phosphorus) in Lake Manzala are quite high, particularly in the southern region of the lake where the Bahr El Bagar and Bahr Hadous Drains discharge to the lake. While the nutrient inputs around Port Said are also high, they appear to be more localized and small in relation to the overall nutrient balance in the lake system.

### 3.5 Aquatic communities

Lake Manzala is a highly dynamic aquatic system that has undergone considerable physical, chemical and biological changes during the past century. The lake has been gradually transformed from a largely marine or estuarine environment to a eutrophic freshwater system. This process has gradually altered the lake's aquatic communities to their present state. The Lake Manzala Study 9/ financed by the UNDP made a fairly complete set of ecological observations of the aquatic communities in the lake. These ecological observations are excerpted here.

The lake's phytoplankton community is dominated by diatoms, of which 11 species are represented, with the genera *Synedra*, *Nitzschia*, *Melosira*, and *Coscinodiscus* predominating. Twelve genera of green algae are found with the genera *Tetraspora*, *Scenedesmus* and *Pediastrum* predominant. Two genera of blue-green algae are recorded (*Spirulina* and *Anabaena*).

The lake's zooplankton community consists of at least 24 major zooplankton groups with the cladoceran species representing the largest number of total zooplankton. Three genera of cladocerans - *Diaphanosoma*, *Bosmina* and *Moina dubia* predominate. Copepods, ostracods, isopods and amphipods make up the rest of the community. In the northern sector near the Mediterranean outlet the marine copepod *Acartia latisetosa* was most abundant and the Cirripedia larvae (barnacles) and veliger larvae (bivalve molluscs) were also found along with the mysid *Macropsis* and the amphipod *Gammarus*.

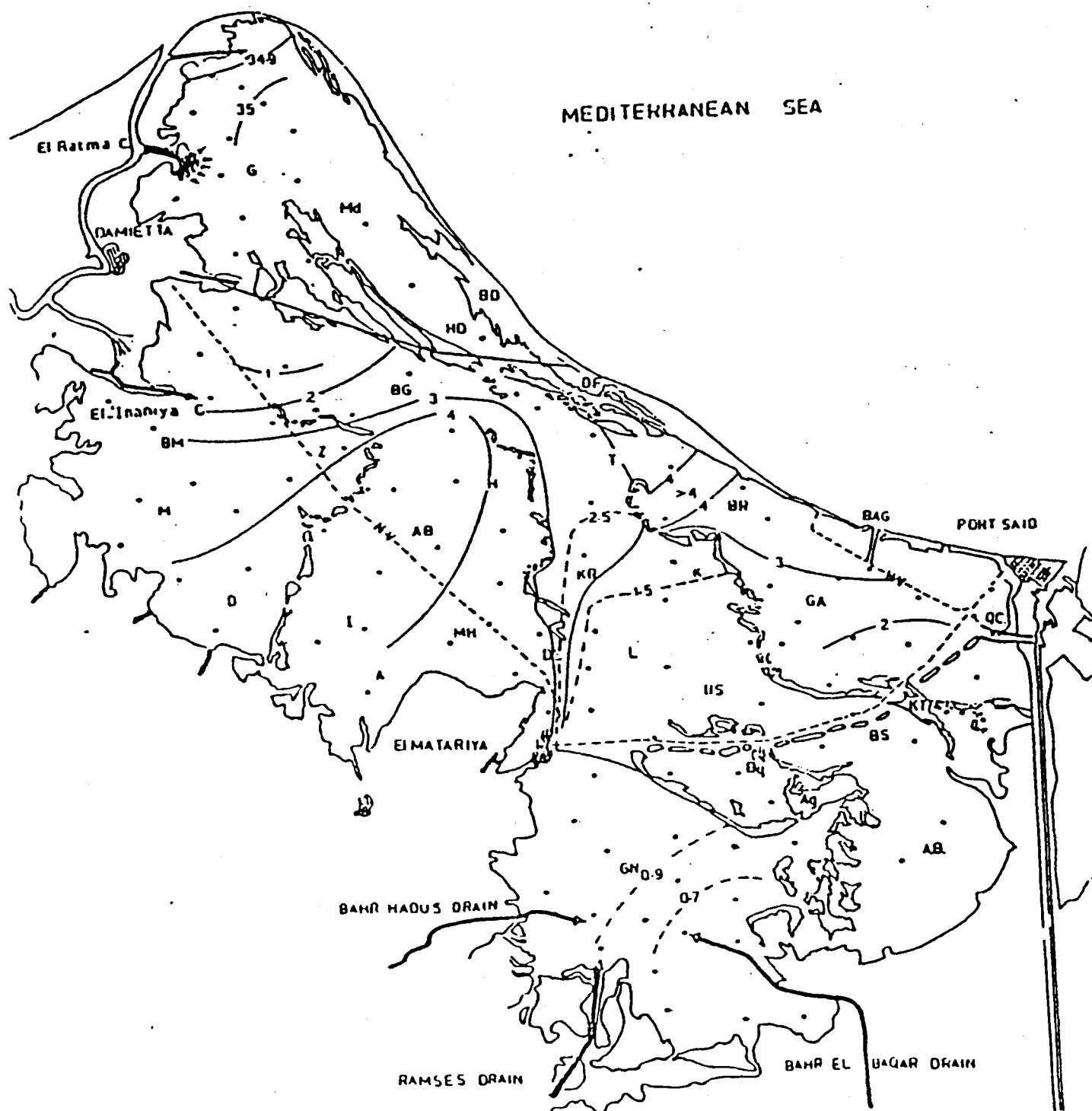
The lake's benthic fauna consists largely of bivalves and gastropod molluscs. In addition two species of annelids and six species of arthropods were found. Six species of benthic fauna are distributed extensively throughout the lake (the pelecypods *Pisidium*, *Cerastoderma glaucum* and *Abra ovata*, the gastropods *Melanoides tuberculata* and *Alvania* and the barnacle *Balanus*), with several notably *Cerastoderma*, *Abra* and *Alvania* being more abundant in areas of higher salinity.

The major species of aquatic macrophytes in Lake Manzala's northern region are *Phragmites australis* and *Typha domingensis* as the emergent aquatic plants and *Potamogeton pectinatus* as the submergent aquatic plants.

Emergent aquatic plants are also present in greater numbers of species. Species found include: *Juncus rigidis*, *Typha domingensis*, *Phragmites australis*, *Carex divisa*, *Scirpus littoralis*, *Cyperus laevigatus* and *Eichornia crassipes*. Plants typical of salty areas include *Halocnemum strobilaceum*, *Arthronemum glaucum*, *Salicornia herbacea*, *Salicornia fruticosa*, *Nitraria retusa*, *Frankenia pulverulenta*, *Cressa cretica* and *Tamarix nilotica*.

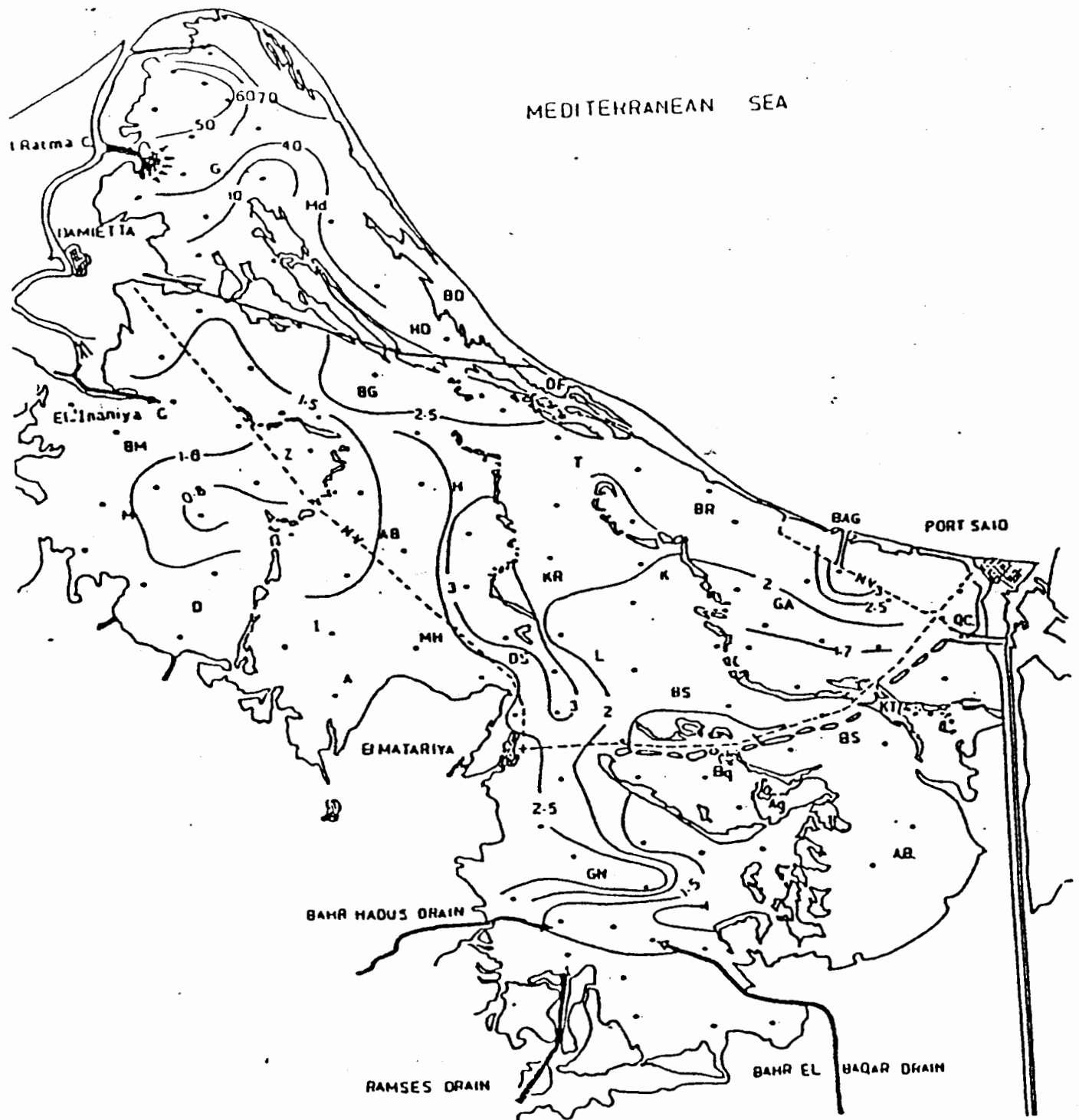
A large number of species found are not particular to the Lake Manzala habitats. This is the case of the numerous species found along the ditches and canals: *Polygonum salicifolium*, *Polygonum senegalense*, *Chenopodium ambrosoides*, *Ranunculus sceleratus*, *Potentilla supina*, *Centaurea pulchellum*, *Lippia nodiflora* and *Centaurea calcitropa*; and the species growing as weeds in numerous waste and roadside areas: *Portulaca oleracea*, *Stellaria pallida*, *Amaranthus viridis*, *Fumaria densiflora*, *Brassica nigra* and *Plantago major*.

Certain plant groupings are readily identifiable in the field. In the saline areas as seasonally inundated mud flats, salt tolerating species such as *Holocnemum* and *Salicornia* predominate. The typical appearance of such vegetation is a low mat of scattered plants.



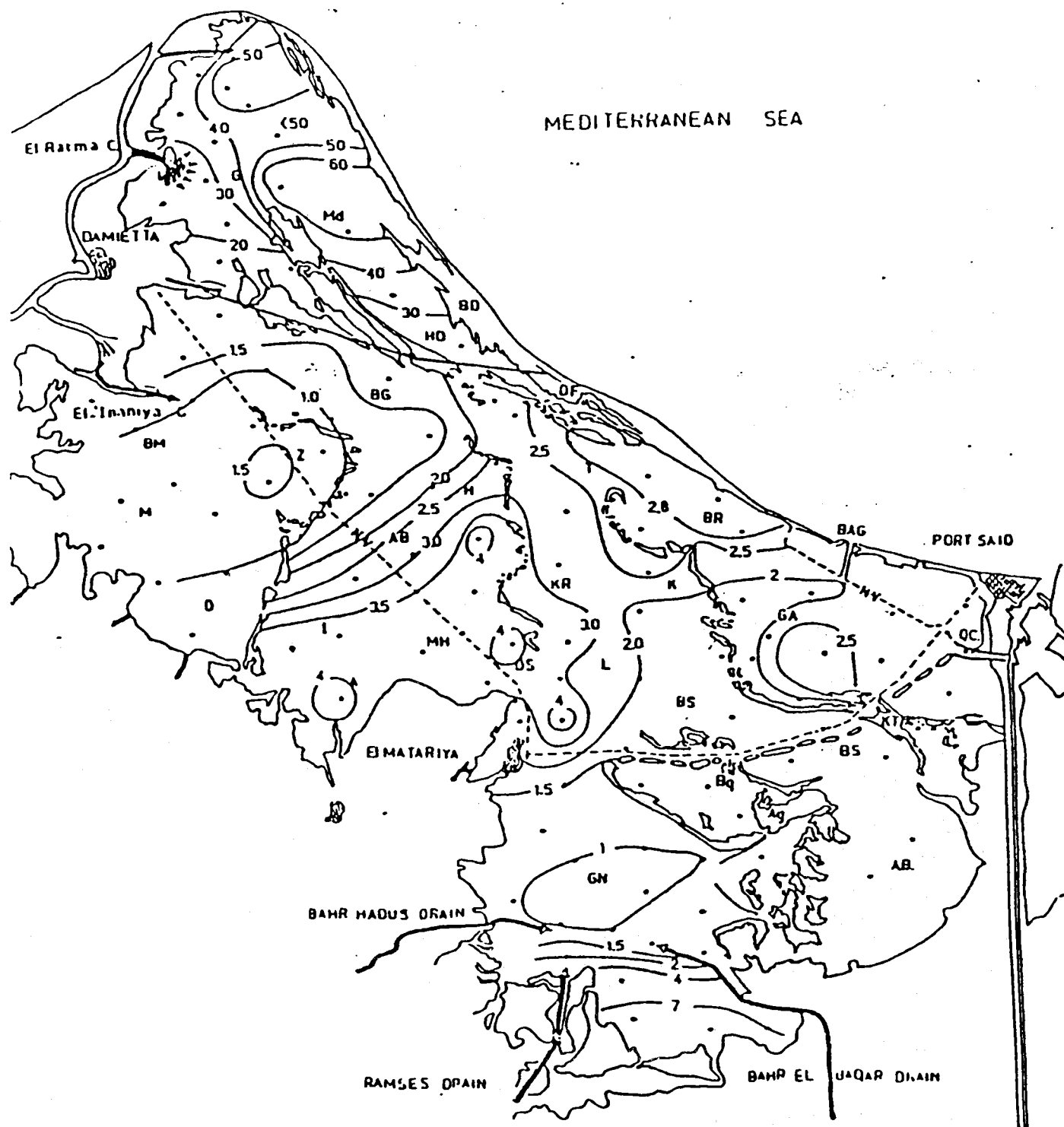
**Fig. 3: Distribution of salinity (%) in surface water of Lake Manzalah during October 1981**

Source: Dowidar, N.R., R. Drenner and G. Vinyard "Lakes Management Project: Lake Manzalah Study", USAID Cooperative Marine Technology Program for the Middle East, New Jersey Marine Sciences Consortium, Ft. Hancock, N.J. December 1982



**Fig. 4: Distribution of salinity (%) in surface water of Lake Manzalah during November 1981**

Source: Dowidar, N.R., R. Drenner and G. Vinyard "Lakes Management Project: Lake Manzalah Study", USAID Cooperative Marine Technology Program for the Middle East, New Jersey Marine Sciences Consortium, Ft. Hancock, N.J. December 1982



**Fig. 5: Distribution of salinity (%) in surface water of Lake Manzalah during December 1981**

Source: Dowidar, N.R., R. Drenner and G. Vinyard "Lakes Management Project: Lake Manzalah Study", USAID Cooperative Marine Technology Program for the Middle East, New Jersey Marine Sciences Consortium, Ft. Hancock, N.J. December 1982



Trees are scarce and consist primarily of date palm plantations, or other cultivated trees or small groups of salt tolerating *Tamarix nilotica*, rarely more than 10 m high. On the wet sites dense stands of reeds, rushes and other emergent aquatic plants occur. These reed communities represent one of the most typical vegetation types in the area. The tallest stands are formed by *Typha* and *Phragmites*, reaching up to five m. Less high but equally dense stands of *Juncus* and *Cyperus* are frequent. There are also extensive beds of submerged aquatic plants. *Potamogeton pectinatus* and *Ceratophyllum demersum*, in the deeper water.

The lake's aquatic vegetation plays an important role in providing habitat for fish and bird species and as substrate for periphytic algae which serve as a food source for some fish species. Aquatic plants also possess an outstanding ability for assimilating nutrients and creating favourable conditions for microbial decomposition of organic matter. Such natural wetland and aquatic macrophyte ecosystems are increasingly used to treat different types of wastewater. Pollutants are removed by a variety of biological, physical and chemical processes 10/.

### 3.6 Fish

Fish types and populations vary according to the environmental conditions present in the lake. Productivity levels also vary greatly ranging from as low as 73 kg/feddan/year up to 1 ton/feddan/year. The Lake Manzala fishery is very important to Egypt. Total fish catch has been estimated to comprise more than 50% of the total catch in the Nile delta lakes 7/. Due to the gradual changes that have occurred in the lake's size, drainwater inflows and water quality over the past fifty years, Lake Manzala has shifted from being a relatively low productivity marine fishery (average yield of 38 kg/feddan) to a high productivity freshwater fishery (average yield of 254 kg/feddan). Near Port Said a marine species, the grey mullet *Mugil capito* predominates. Other species include marine gill head bream (*Sparus anratus*) and sea bass (*Dicentrarchus labrax*). *Tilapia* spp. are the dominant species in the southern areas of the lake where the water becomes less saline; mullet and catfish (*Caria lazera*) make smaller contributions in these regions 6/.

Large numbers of juvenile mullet and fry are harvested from Lake Manzala during spring and summer 11/. Formerly, mullet fry were caught in the El Kabouti Channel. However, the manager of the Raswa Fish Farm near Port Said reports that no fry have been found at that location since sewage discharges began in Kabouti. The eastern lake fishery sector adjoining Port Said accounts for roughly 30% of the lake output by weight and value 9/. There have been reports that there are a growing number of contaminated fish in the region 11/. There has, however, been no reported increase in sicknesses due to consumption of such fish.

Recent studies conducted by research scientists at several Egyptian universities have confirmed a relatively high incidence (40%) of nematode infestation in the bodies of fish (*Tilapia* spp.) collected at various locations in Lake Manzala 12/. This is an indication that discharge of untreated domestic sewage into the lake's waters from the drains and the lake's bordering communities such as Port Said, is likely to eventually result in adverse human health effects unless projects such as those proposed here are put into effect.

### 3.7 Birds

Lake Manzala is recognized as being an ecologically significant, internationally important wetland area for resident, migratory and wintering bird species 12/. Bird populations are very high during peak migration periods. There are a total of 32 bird species which are resident in Lake Manzala year-round, 9 species which are summer residents, 53 species which overwinter at the lake and 24 species which are migrants found only during migratory periods. Of the total of 118 species of aquatic birds, less than 40 breed around Lake Manzala.

In particular the wintering populations of shelduck (*Tadorna tadorna*), shoveler (*Anas clypeata*) and coot (*Fluica atra*) are of international importance. The number of waders is also notable including: avocet (*Recurvirostra avosetta*), ringed plover (*Charadrius hiaticula*), kentish plover (*Charadrius alexandrinus*), sanderling (*Calidris alba*), little stint (*Calidris minuta*), dunlin (*Calidris alpina*) and redshank (*Tringa totanus*). Based on a survey conducted during 1979 and 1980, the total number of waterbirds wintering on Lake Manzala and its adjacent marshes was estimated to exceed 300,000 (Meiniger and Mullie, 1981).

Bird hunting is an important economic activity in the Port Said region, and captured birds are sold in local markets for human consumption. Estimates of annual bird sales from Lake Manzala are between 85,000

and 135,000. The majority of these birds, wintering ducks and coots, are being illegally netted <sup>11/</sup>. This problem must be addressed with stricter control and public education efforts. However, the areas supporting migrating birds are largely in the central, southern and western regions of Lake Manzala and thus do not appear to be directly impacted by the proposed Wastewater Treatment Plant project.

### **3.8 Existence of endemic waterborne diseases**

The public health hazards resulting from inadequate wastewater collection, treatment and disposal have long been known <sup>13/</sup>. In Port Said, traditional practices of household waste disposal combined with a largely inoperable wastewater collection and treatment system have contributed to the present situation where discharge of untreated wastewater is made into Lake Manzala. Human waste has many direct and indirect adverse consequences for human health. Most of these occur when water-related diseases are transmitted from ingestion or contact with contaminated water and food.

While data on the incidence of waterborne diseases in the Port Said region of Lake Manzala is not presently available, the city's potable water supply which is withdrawn from the Sweetwater Canal and treated, presumably helps to safeguard the city's population from many disease risks. However, a variety of bacterial infections represent the most common source of hospital admissions in Egypt, particularly among children. There are seasonal increases in enteric infections due to higher temperatures and the consumption of raw and uncooked seasonal vegetables. After bacterial infections, in importance come infections caused by protozoans and viruses. There are also a number of water-related parasitic infections which produce serious adverse health effects. Schistosomiasis is not found in the northern region of Lake Manzala due to salinity levels which prevent the snail vector from surviving. Other parasitic infections prevalent in Port Said are not known, although there are significant populations of mosquitoes in the area. The health implications of these or other water-breeding insect-borne diseases are not known.

These various endemic waterborne diseases can all be combatted through: improved domestic hygiene, particularly in food preparation and personal cleanliness; removal of sources of infection through an effective wastewater system; and provision of potable water. It should be recognized that providing an effective sanitation programme to treat and dispose of human wastes will facilitate health improvements but will not bring about such changes unassisted. Improvements in solid waste disposal, provision of potable water to all urban residents and effective health education are also required.

### **3.9 Trends in the Lake Manzala region**

It is important in the process of environmental impact assessment to identify ongoing trends and determine the driving forces of change, particularly for coastal regions which tend to be subject to dynamic forces, and which are often ecologically sensitive and regularly experience man-made interventions. In this way the impacts of the proposed Port Said Wastewater Treatment Plant project can be accurately assessed and distinguished from other changes that may be occurring in the study area. It also assists in differentiating between the short and long term effects of the project. A complete discussion of the changes in Lake Manzala's character is beyond the scope of this paper. However, it is pertinent to highlight the following points.

Lake Manzala was originally formed by an alteration in Nile River flow patterns and land subsidence following an earthquake in antiquity. Several former branches of the Nile flowed through what is now the lake during historical times. More recently, Lake Manzala was a complex fresh water and salt water lake system which has over the last century become progressively less saline due to increases in freshwater supply via the Nile River and Egypt's system of agricultural drains.

Lake Manzala's unique shallow, wetland environments have also been gradually shrinking due to reclamation of land from the lake for agricultural and fish farming purposes. The area of the lake has decreased by more than 30% in the past thirty years. Today Lake Manzala would be classified as a brackish, shallow water, eutrophic, semi-tropical lake, which while it remains highly productive, is being affected by the cumulative processes of development which gradually reduce its size and character.

Soils and eroded rocks have been carried to the Delta region and land has been reclaimed from the lake by natural accretion. This land reclamation has been accelerated drastically by human efforts to create additional land for agricultural purposes over the last century. The land reclamation has increased Egypt's

agricultural production but has destroyed the habitat for migratory waterfowl and diminished the absolute size of the lake available to support fishery resources.

Associated with the increased agricultural land use, there has been an increase in the use of fertilizers, pesticides, and herbicides for agriculture. Increasing amounts of nutrients have entered Lake Manzala at the same time as the size of the Lake has been reduced, producing nutrient-rich conditions particularly in the southern regions of the lake. Portions of the lake are now eutrophic due to the poor distribution of these nutrients.

Pesticides are generally over-applied and have resulted in the accumulation of heavy metal residues, hydrocarbons and other toxic materials in lake bottom sediments. This is more of a problem in the southern regions of the lake, but it does not yet appear to have reached serious proportions.

The construction of the High Aswan Dam has had a profound effect on Egypt's biological resources in recent times. The dam created Lake Nasser, which covers 5000 square kilometres, and releases water for hydroelectric power generation, irrigation, navigation and municipal and industrial uses.

Since Lake Nasser reached its capacity in the early 1980's, dry years in the watershed of the Blue and White Nile Rivers combined with an increasing demand for Nile waters have reduced capacity to potentially critical levels. This has resulted in tightly controlled water releases for irrigation purposes. The amount of land runoff has decreased and nutrient concentrations being discharged to the lakes have consequently increased further as the water available for dilution of wastes grows smaller.

In parallel to the reduction in water flow, the High Dam has eliminated the deposition of approximately 73 to 91 million metric tons of sediment in the Nile Valley, and stopped the accretion process that has sustained the Nile Delta for tens of thousands of years. The result is the continued encroachment of delta land by the sea. This encroachment has begun at Damietta, and coastal protection projects are under way at Damietta and now Port Said. This appears to be following the pattern of events in other major river deltas, such as the Mississippi River in the United States, where the sea began to actively erode delta regions after the river became channelized and highly managed.

Other regional projects have been proposed that would have an effect on Lake Manzala independent of the Port Said WTP project. These include the Port Said Ring Road and land reclamation projects, proposals to expand fish farming along the Mediterranean shore of Lake Manzala, and the proposed El Salaam Canal Project. The latter project would cut across the southern end of Lake Manzala to deliver Nile water from the Damietta Branch of the Nile and several of the present agricultural drains to Qantara where it would be conveyed under the Suez Canal via a siphon and used to irrigate reclaimed agricultural land in North Sinai. It would have an important effect on lake hydrology. Such regional projects also need to be assessed independently of the Port Said WTP project.

The overall conclusion of this regional assessment is that the Lake Manzala region is subject to rapid and far-reaching physical changes associated with development and infrastructure projects. A balance needs to be achieved in planning for and executing such projects between maintaining Lake Manzala's unique aquatic ecosystems with its productive fisheries and internationally significant bird life; promoting economic development by maximizing the economic returns derived from the region's land, water and other natural resources; and developing an improved quality of life for the region's citizens by providing families from all income levels with safe water and wastewater disposal systems, adequate housing, and social services. The challenge for Egypt will be to balance the optimization of these objectives.

### **3.10 Trends in the Port Said area**

There have been several comprehensive studies of the Lake Manzala area and its resources (6/, 7/, 9/ and 12/). The Port Said Water and Wastewater Facilities Master Plan, published in 1979, specifically addresses the future needs for Port Said's planned developments and included a Receiving Water Study. This Study provides detailed information on water quality in the Port Said area from studies carried out in 1978.

A second study 7/, the Lake Manzala Study, was published in 1982. This document was developed to generate a land use plan and policy report for the Lake and its environs. Several follow-up studies were

completed between 1982 and 1988 6/, 9/ and 12/ and provide more recent data, although they are not focused explicitly on Port Said.

## **4. Identification of possible impacts**

### **4.1 Introduction**

The Lake Manzala region generally and the area adjacent to Port Said are characterized by a complex assortment of interacting, and often conflicting issues. The need for economic development and growth in the area must be matched with the preservation of the natural resources on which that development is based. For example, the fishing industry, a prime commercial activity in the area, is highly dependent on maintaining biologically acceptable levels of water quality, along with the health of the population of Port Said. Priority must therefore be given to providing new developments with suitable infrastructure to accommodate the growth and to simultaneously preserve the natural resource base on which economic growth ultimately depends. At the same time, consideration must be given to providing the best economic uses of available resources within sound, implementable and staged development projects.

When identifying the potential impacts of a new project, such as the proposed Port Said Wastewater Treatment Plant, the environmental impacts expected must be measured against the existing baseline conditions. Also, impacts may be beneficial, detrimental, and occasionally both where opposing interests or viewpoints exist.

In general, construction of a new Port Said Wastewater Treatment Plant will have a positive environmental impact on the city of Port Said and the immediate environment of Lake Manzala. It is expected to produce a long-term improvement in public health of the citizens of Port Said as well as to significantly reduce a source of chronic water pollution of an ecologically valuable portion of Lake Manzala. Specific impacts that are anticipated or forecasted are discussed in greater detail in this section.

### **4.2 Organic loading**

The immediate, and one of the most beneficial impacts of the new treatment plant's construction will be the cessation of the discharge of untreated sewage in the Port Said area. This can be expected to result in an increase in dissolved oxygen levels in the section of northeastern Lake Manzala adjoining the existing wastewater bypass canal, particularly during the summer months.

The lake's sediments are presently anaerobic and are generating hydrogen sulfide where raw sewage is presently discharged. Hydrogen sulfide is toxic to fish, and indicative of excessive organic loading and oxygen consumption by bacteria which places environmental stresses on fish and other biotic life. With the cessation of discharges of raw sewage to the lake, the bottom sediments will become more aerobic and hydrogen sulfide concentrations will be reduced or eliminated. As a result, local environmental conditions will improve which can be expected to benefit both the local population and local fishery resources.

### **4.3 Nutrient loading**

Construction and operation of the proposed treatment plant will make significant reductions in the existing nutrient loads from the untreated sewage. Reductions are expected to be in the order of 25 percent for nitrogen, and 10 percent for phosphorus. More importantly, however, is that the majority of nitrogen-ammonia will be converted via nitrification to nitrates. This will reduce ammonia concentrations to levels below those that have been reported to be toxic to mullet and other marine fish species in the lake. This should help to reverse or retard eutrophication occurring in the northeastern portion of Lake Manzala.

### **4.4 Faecal coliform reduction**

Only small reductions in total and faecal coliform counts, indicator organisms for human pathogens, can be expected through treatment processes with wastewater detention times less than 15 days. Chlorination of the trickling filter effluent would reduce the coliform counts to levels acceptable to the World Health

Organization for bathing beaches (200 MPN/100 ml).

Chlorination facilities are presently planned to be included in the plant. However, this matter is still under evaluation, as is the possible need for dechlorination facilities. Studies performed in the 1979 Receiving Waters Study showed relatively rapid (90 to 99 percent per day) die-off rates for coliform bacteria due to the high salinity and presence of scavenging micro-organisms. In this study, coliform concentrations were high near the untreated sewage discharge, but very localized. Coliform measurements at the El Gamil Outlet, the Mediterranean coast and Lake Manzala beyond the dike were all less than 100 MPN/100 ml.

It is unclear from available data how salinity patterns in the area of the proposed effluent discharge may have changed during the last decade. Seasonal peaks in salinity always seem to have characterized certain sectors of the lake (7/ and 9/), but the effect of increases in freshwater as well as the new Mediterranean outlet to the west of the El Gamil Outlet have not been properly evaluated. Nevertheless it seems clear that construction of the Port Said treatment plant will reduce or eliminate sources of possible human illnesses from contaminated fish or shellfish consumption.

#### **4.5 Odours and air pollution**

The available wastewater analyses indicate that sulfide concentrations are high, which could result in the release of a moderate amount of potential nuisance odours. In addition, these conditions create a highly corrosive environment for both the wastewater collection and treatment systems.

Visual observations of the presently untreated wastewater indicate that this wastestream is septic by the time it reaches the wastewater treatment plant. The wastewater is black, indicating the presence of sulfide and oxygen-deficient conditions. This is probably due to long detention times in the sewers resulting from the extremely flat terrain in the area. The characteristic hydrogen sulfide odour can presently be detected at the existing treatment plant and in its immediate vicinity.

Any odours that are produced by the proposed Port Said Wastewater Treatment Plant are likely to be significantly reduced over those resulting from the present open channel conveyance of raw wastewater directly into Lake Manzala. In addition, the site of the new treatment plant was created in order to isolate the plant away from major centers of population in Port Said, although some new housing is planned for reclaimed land areas within a 5 km radius of the proposed plant. The prevailing winds will help to ensure that any odours produced at the new plant do not create a public nuisance.

Sludge from the aerobic lagoons will be removed once every 2-3 years, spread in sludge drying lagoons, and allowed to dry in the sun. There is a potentially small odour problem from this operation, because the sludge will be stabilized by natural processes in the aerobic lagoons. However, the prevailing winds and the site's relatively isolated location should further reduce the low probability of adverse impact on the local population. There is also the potential for fly or insect breeding. Once the sludge is dry, it is relatively inert and odourless.

No air pollution problems are expected to be associated with the operation of the new Port Said Wastewater Treatment Plant. During the construction phase there will be some localized increase in air pollution resulting from the operation of construction equipment.

#### **4.6 Infiltration to soils, groundwater and water supply**

The provision of proper wastewater treatment facilities will reduce or eliminate any significant potential for infiltration of sewage into the soil and groundwater. As neither the soil nor the groundwater is of potential use for agriculture or potable water respectively due to the high salt concentrations, any infiltration that may occur is not anticipated to be a problem.

The Port Said water supply system is supplied with Nile water from the Sweetwater Canal. Since this is a completely separate supply system with no interaction with local Port Said surface or groundwater conditions, no significant adverse impact on water supply is foreseen.

## 4.7 Mosquito breeding and disease transmission

Mosquito larvae generally live in small, shallow water bodies where disturbance of the surface layer is uncommon. In the aerated lagoon treatment process, mixing occurs vigorously in the complete mix lagoon and also in the partial mix lagoon, although to a lesser degree in the latter. These lagoons would not be suitable habitat for mosquito larvae. The polishing pond, however, may provide suitable habitat for mosquito breeding.

The environmental assessment will evaluate various methods of mosquito control to ensure that environmentally sound measures are taken that permit the plant to produce no adverse effect on transmission rates of mosquito-transmitted diseases such as malaria.

## 4.8 Aquatic communities

The provision of adequate wastewater treatment at Port Said should produce an immediate improvement in water quality as described earlier. Improved water quality in the northeastern section of Lake Manzala should promote the restoration of a less eutrophic aquatic community. Since the aquatic community, particularly the phytoplankton, plays such a large role in allowing the lake to maintain its high assimilative capacity, it will be important to monitor changes in these biological communities over time. The only potential adverse impact of the new plant will be in the immediate vicinity of the plant's outfall. The effluent, although greatly superior to the current sewage discharges, will contain residual amounts of chlorine that can be harmful to lake biota. The effluent will also produce localized changes in water quality and circulatory patterns. These potential impacts are not viewed as serious but will require monitoring.

## 4.9 Fish

Examination of fish from Lake Manzala shows evidence of parasitic growth and malnutrition, factors which are indicative of environmental stresses, such as low oxygen levels, high inorganic activity, and reduction in phytoplankton populations 12/. As discussed above, treatment of the existing raw sewage discharge from Port Said will reduce some of the factors contributing to this problem.

Fish taken from the more polluted areas of the lake have in recent years been found to be infected with bacteriological diseases or micro-organisms of human origin (i.e. *Shigella* spp., *Staphylococcus* spp., *Streptococcus* spp., *Enterobacter* spp., *Mycobacteria*, and *Proteus* spp.) 12/.

While construction of a new Port Said Wastewater Treatment Plant cannot eliminate these problems for the whole of Lake Manzala, it will certainly contribute to a localized improvement in water quality in the northeastern corner of the lake. Improving levels of oxygenation and improved water quality should contribute to a healthier fishery in the local area of the plant. The plant will also help to protect mature marine shellfish populations from possible contamination. Immature populations that utilize the lake in the early stages of their life cycles will also benefit.

## 4.10 Birds

Although the immediate site vicinity of the proposed wastewater treatment plant has not been surveyed, the general value for Lake Manzala as a bird habitat should be improved as a result of the plant's construction. While a small amount of aquatic habitat has been lost through the construction of the plant site from dredged fill, the improved lake water quality resulting from the new plant will generally benefit bird populations. Polishing ponds often are used as loafing habitat by waterfowl, and the potential establishment of aquatic biota in the polishing pond may provide foraging opportunities for a few species. Many birds feed on invertebrates, fish and aquatic vegetation which will benefit from any improvement in lake water quality.

Depending upon the location selected for the wastewater plant's outfall and the type of outfall constructed, there may be some adverse effects upon specific, localized areas of bird habitat. The effluent, although vastly superior in quality to raw, untreated sewage, will produce different changes in local water quality (i.e. dissolved oxygen levels, salinity, and temperature) that may alter food sources or habitats for birds.

#### **4.11 Ashtum El Gamil Natural Protectorate**

The provision of wastewater treatment at Port Said will reduce some of the adverse environmental stresses that presently affect flora and fauna within the declared Ashtum El Gamil Natural Protectorate. The Ashtum El Gamil Natural Protectorate was declared in June 1988 <sup>4/</sup> which established such natural protectorates as, "any area of land or coastal or inland water characterized by flora, fauna, and natural resources of cultural, scientific, tourist or aesthetic value." The Ashtum El Gamil Natural Protectorate was established to: (a) protect anadromous and catadromous fish that utilize the existing El Gamil Outlet and a newly constructed outlet to move between the Mediterranean and lake waters in connection with various stages of their life cycles; (b) protect resident, seasonal and migrating waterfowl which utilize the lake, including those found in the vicinity of the El Gamil Outlet and the northern lake section; and (c) preserve archaeological ruins in the vicinity of Tanis Island.

Despite the declaration of the Natural Protectorate, no clear boundaries have been established and a management plan for the area is not yet available. Nevertheless, the available evidence suggests that at present the Protectorate is more threatened by human fishing activity that is not in conformance with Law 124/1983 <sup>4/</sup> and human hunting of birds, than it is by the treated effluent resulting from a new Port Said Wastewater Treatment Plant. However, in the absence of good recent data on the populations of fish and birds in the area proposed for discharge of the effluent from the new wastewater treatment plant, it is difficult to assess the degree of adverse or beneficial impact. Depending upon the orientation of the outfall structure it may alter fish migration through the original El Gamil Outlet. It will affect the water quality within the Protectorate, although as mentioned earlier, this will likely represent an improvement over the ambient conditions associated with discharge of untreated sewage.

#### **4.12 Impact on bathing water quality and tourism**

Under normal conditions, the proposed treatment facility will stop the discharge of untreated sewage into Lake Manzala, and thereby reduce the possibility of beach contamination along the Mediterranean coast of Port Said. It should be noted that the major threat to the Mediterranean coastline is, and will remain, that due to oil spills and other pollution from shipping.

Tourism is likely to be enhanced as a result of a new Port Said Wastewater Treatment Plant. This is because it will allow expansion of tourist facilities and produce an improvement in Lake Manzala's water quality while safeguarding the Mediterranean Sea.

#### **4.13 Sludge disposal**

The sludge produced by the new Port Said Wastewater Treatment Plant will be air-dried on-site in sludge drying lagoons before being moved to a sludge stockpile area. The sludge drying and stockpiling process will also allow flies, mosquitoes and other insects to breed. The impact of these insect vectors is not expected to be great and will prove amenable to control if problems arise.

Suitable sludge disposal sites will be selected by NOPWASD in collaboration with the Governorate. Sanitary means of sludge disposal (such as landfills) will reduce adverse environmental impacts associated with the sludge. Any localized environmental problems with the sludge disposal site will be addressed through the site selection process and an environmental assessment. Removal of sludge by trucks will increase heavy traffic and associated noise in the Port Said area. The extent to which the local population will be affected depends on the location of the final site chosen for sludge disposal and the routes and times for truck transport.

If sludge disposal to agricultural enterprises is carried out, sludge quality will need to be monitored to ensure that human health is protected. The absence of significant quantities of heavy metals or toxic compounds in Port Said's wastewater indicates that pathogens and nematodes will likely be the major health concern. The health impact is likely to be slight to non-existent if proper sludge stockpiling, handling and soil conditioning procedures are followed.

#### **4.14 Possible emergencies and plant failure**

Operational difficulties may be experienced at plant start-up or during periods when equipment malfunctions, particularly the equipment providing aeration to the complete mix and partial mix lagoons. Under these conditions, the lagoons would probably remain intact. The effluent discharged under these emergency conditions would still be an improvement over the existing condition where raw sewage is discharged directly into the lake. Chlorination of the effluent could be increased under these conditions to kill pathogenic organisms if the need for chlorination is demonstrated.

The frequency of such incidents is likely to remain low as long as adequate training of operator personnel is maintained and supplies of spare parts are kept available and utilized as recommended to keep all units operational at close to design efficiency levels. The most likely impact scenario would be that large quantities of sludge would accumulate in the complete mix lagoon and undergo anaerobic processes. It would only be in the event of a loss of the lagoons for an extended time period that untreated wastewater would need to be bypassed directly into Lake Manzala. This would produce adverse impacts on lake water quality and fish and other biota during the period of the release and for a period of time thereafter.

### **5. Proposed measures to prevent, reduce or mitigate the negative effects of the proposed plant**

#### **5.1 Treatment plant failure**

Standby generators may be provided to generate power should there be a power failure. As noted previously, it is anticipated that the lagoons would remain operational even if the aeration equipment is taken off-line. This would reduce the discharge of sewage solids to Lake Manzala, as presently occurs. Chlorination of the effluent could also be increased during these periods to reduce pathogenic bacteria in the effluent.

Maintaining equipment in good operating order is of paramount importance in preventing equipment failure. Training programmes for plant operation and maintenance activities have been included as part of the project's technical assistance programme. Local authorities will have to make funds available for new equipment parts and training after the project's contractors have completed their obligations.

#### **5.2 Outfall location and design**

The location of the effluent outfall will be selected and designed so that the maximum dilution of effluent into Lake Manzala will be achieved. The discharge situation in Lake Manzala is complex and obtaining more information on the effluent's behavior will help to clarify its impacts. There are also a number of unstudied aspects of the current situation, such as the newly constructed outlet to the Mediterranean west of El Gamil which need to be considered. This will allow the placement of the outfall and design of an appropriate outfall structure of discharge network that mitigates any adverse environmental impacts on Lake Manzala and the Ashtum El Gamil Natural Protectorate.

#### **5.3 Plant odour, mosquitoes and other nuisances**

Odours from the plant are expected to be reduced from existing levels and not pose a major problem due to the location of the new site and the predominant north-westerly winds which would carry most odours to the south of Port Said.

Fly and mosquito breeding in the polishing pond and sludge drying lagoon can be controlled by chemical addition (for example, calcium hypochlorite or chlorine).

Noise from the plant is expected to be minimal, and the location of the plant and wind direction will reduce adverse impacts. Adverse impacts of heavy traffic to and from the plant on local street traffic and noise could perhaps be minimized by a future direct link to the Ring Road which is under construction.



## **5.4 Monitoring programme**

The best way to ensure that the new Port Said Wastewater Treatment Plant operates in a consistent and environmentally sound fashion is to provide for a rigorous monitoring programme. NOPWASD, in cooperation with the Governorate of Port Said Wastewater Department will initiate and maintain the programme.

A testing programme will be established to monitor the treatment performance and efficiencies within the treatment plant. Raw influent and treated effluent parameters to be monitored on a daily basis will likely include biochemical oxygen demand (BOD), total suspended solids (TSS), COD (as an indicator of BOD), ammonia nitrogen ( $\text{NH}_3\text{-N}$ ), trace ammonia as an indicator of nitrification, dissolved oxygen and pH. In addition, suspended solids measurements of primary effluent, and total dissolved solids (TDS) and faecal coliform counts will be regularly measured in the plant effluent. Sampling for heavy metals will be performed on a monthly basis and the sampling frequency increased if a significant concentration of heavy metals is detected. In this case, sampling of industrial wastestreams will be pursued to identify the source and to initiate a corrective programme to halt the discharge.

A well-equipped water wastewater quality testing laboratory will be constructed as part of the administration complex at the new Port Said Wastewater Treatment Plant. These lab facilities will be operated as an integral unit of the plant itself.

Sampling stations will be established in Lake Manzala in the vicinity of the outfall, the El Gamil Outlet, and Kabouti Outlet to monitor water quality in the receiving waters and to help assess the impact of the treated effluent on water quality. Sampling will be carried out twice weekly, for BOD,  $\text{NH}_3\text{-N}$ , TDS and faecal coliforms. Dissolved oxygen levels and coliform bacteria will also be monitored.

These data will be available, and occasionally tested in parallel by other national laboratories responsible for water quality issues and human health issues.

## **5.5 Enforcement and coordination procedures**

Under the authority of various legal and regulatory measures, several Egyptian Ministries and institutions share responsibility for monitoring the compliance of the new Port Said Wastewater Treatment Plant with applicable environmental standards. The Ministry of Public Works and Water Resources enforces the provisions of Law 48/1982 in conjunction with the Ministry of Health's Environmental Health Center which carries out a testing and monitoring programme. The Egyptian Environmental Affairs Agency is responsible for managing and enforcing Law 102/1983 establishing the Ashtum El Gamil Natural Protectorate. It is administered by EEAA and the Governorate of Port Said with assistance provided by the Egyptian Wildlife Service.

A number of other government organizations in addition to NOPWASD and the Ministry of Development, including the Ministry of Tourism, the Ministry of Industry's General Organization of Industrialization, the General Authority for Fish Resources Development, the Ministry of Agriculture, the Ministry of Planning, the Ministry of Defense, and the Academy of Scientific Research and Technology play some role in effecting the future of environmentally sound development in the Port Said region. It will only be through formalized procedures of communication and coordination that future environmental problems in the Port Said Governorate and the surrounding Governorates encompassing Lake Manzala will be satisfactorily resolved.

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## APPENDIX

### **Organizations and institutions which were represented in the interregional workshop on the application of the environmental impact assessment procedure Cairo, Egypt, 19-22 November 1989**

- Egyptian Environmental Affairs Agency, Cabinet of Ministers (Egypt): 2 participants
- National Organization for Potable Water and Sanitary Drainage (Egypt): 3 participants
- Ministry of Military Production (Egypt): 2 participants
- Ministry of Justice (Egypt): 1 participant
- Ministry of Information (Egypt): 1 participant
- Ministry of Foreign Affairs (Egypt): 2 participants
- Ministry of the Interior (Egypt): 1 participant
- Ministry of Agriculture and Land Reclamation (Egypt): 1 participant
- Ministry of Planning (Egypt): 1 participant
- Ministry of Public Works and Water (Egypt): 2 participants
- Ministry of Manpower (Egypt): 1 participant
- Ministry of Electricity (Egypt): 1 participant
- Ministry of Tourism (Egypt): 1 participant
- Ministry of Economy and Foreign Trade (Egypt): 1 participant
- Egyptian Authority for Investment: 3 participants
- Egyptian Traffic Department: 2 participants
- Egyptian Electric Company: 2 participants
- Radio and TV Broadcasting Company (Egypt): 1 participant
- Private companies (Egypt): 8 participants
- Public Works Department of the Ministry of Communications and Works of Cyprus: 1 participant
- Fisheries Department of the Ministry of Agriculture and Natural Resources of Cyprus: 1 participant
- France: 1 participant
- Ministry of Environment, Physical Planning and Public Works of Greece: 1 participant
- Ministry of the Environment of Israel: 1 participant
- Italian Institute for the Environment: 1 participant
- Technical Centre for Environmental Protection of the Libyan Arab Jamahiriya: 1 participant
- University of Madrid, Spain: 1 participant
- Tunisian National Agency for Environmental Protection: 1 participant
- Yugoslav Committee for Building, Housing and Environment of Croatia: 1 participant
- Colombian Planning Department: 1 participant
- National Commission of the Environment, Côte d'Ivoire: 1 participant
- Ministry of Health of Iraq: 1 participant
- Kenyan National Environment Secretariat: 1 participant
- Mexican Ministry of Urban Development and Ecology: 1 participant
- Environmental Protection Committee from Qatar: 1 participant
- Environmental Direction of Senegal: 1 participant
- Venezuelan Ministry of the Environment: 1 participant
- IUCN: 1 participant
- Euro-Mediterranean Centre on Marine Contamination Hazards from, Malta: 1 participant
- UNEP: 1 Junior Professional Officer
- UNEP and PAP/RAC: 1 consultant
- UNEP (Co-ordinating Unit for MAP and OCA/PAC): 2 staff members