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ALEXANDRIA WASTEWATER PROGRAM

MASTER PLAN UPDATE - 1992

FOR THE
ALEXANDRIA
GENERAL
ORGANIZATION for
SANITARY
DRAINAGE

WWCG
in association with
WARITH/ECG

USAID GRANT
NO. 263-0100

1

WASTEWATER CONSULTANTS GROUP

جماعة الإستشاريين للصرف الصحى

WWCG
IN ASSOCIATION WITH
WARITH/ECG

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Attention: Mr. Dan Vincent, Project Officer

Subject: Contract No. 263-0100-C-00-6051
1992 Master Plan Update

Dear Mr. Vincent:

Enclosed for your information and use are five (5) copies of the completed 1992 Alexandria Wastewater Program Master Plan Update.

This report reflects review comments received from USAID, AGOSD, and our Home Offices since issuance of the draft report on 6th January, 1993. The report also includes USAID suggestions and other comments obtained during the two (2) presentations in your Cairo Offices in mid-February, AGOSD review comments obtained during the workshop presentation at AGOSD's Offices during this same time frame, and comments received on the final recommendations chapter distributed last month.

WWCG appreciates the opportunity to have prepared and updated this important planning document. If we can be of further service to USAID and AGOSD in regards to the recommendations and implementation of the Phase II Program, please let us know.

WWCG will maintain on file 25 extra copies of this report for USAID use as required.

Very truly yours,

Henry F. Padgham
Project Director

Enclosures
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1992 MASTER PLAN UPDATE
ALEXANDRIA WASTEWATER PROGRAM

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PROJECTED AVERAGE WASTEWATER FLOWS

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CHAPTER 1

ALEXANDRIA WASTEWATER PROGRAM

CHAPTER 1

ALEXANDRIA WASTEWATER PROGRAM

PROGRAM OBJECTIVES

The Alexandria Wastewater Program is an ambitious planning, engineering, construction and training effort to improve public health and environmental conditions in the City of Alexandria. The program has been funded jointly by the United States Agency for International Development (USAID) and the Government of Egypt (GOE) since 1979.

From its inception, the objectives of the program have been and remain as follows:

- To eliminate the ponding and flooding of wastewater throughout the City, as well as the discharge of untreated wastewater to the beaches, by providing appropriate systems to collect and convey wastewater to treatment facilities
- To provide basic wastewater treatment and safe disposal of treated effluent
- To provide facilities for the treatment and safe disposal of wastewater sludges
- To expand the collection, treatment and disposal systems systematically to keep pace with development and population increases
- To upgrade the level of wastewater treatment or provide an alternative method of effluent disposal that is environmentally acceptable to the community and to USAID

PURPOSE AND SCOPE OF THIS UPDATE REPORT

A great deal has been accomplished toward the goal of full program implementation by upgrading and expanding the City's wastewater collection, treatment and disposal facilities and by developing operations and maintenance (O&M) capabilities for the Alexandria General Organization for Sanitary Drainage (AGOSD). By the end of 1994, the East and West Districts of Alexandria will be served by adequate sewerage infrastructure for the first time in modern history. This infrastructure results from the implementation of sewerage system plans that began with the 1978 "Alexandria Wastewater Master Plan Study" [Reference 1] and the 1979 "Final Environmental Impact Statement" [2] that followed this original work.

This 1992 Update Report is an extension of the original works noted above as well as subsequent program guidance documents, particularly:

- "Review and Update of the 1978 Alexandria Wastewater Master Plan", Wastewater Consultants Group, May 1981 [3]
- "Phased Implementation Plan for the Rehabilitation and Expansion of the Alexandria Wastewater System, Wastewater Consultants Group, July 1982 [4]
- "Phased Implementation Plan for the Rehabilitation and Expansion of the Alexandria Wastewater System, Wastewater Consultants Group, April 1990 [5]
- "Environmental Review for Sludge Mechanical Dewatering and Sludge/Solids Disposal", Wastewater Consultants Group, August 1990 [6]

As an extension of previous studies, this document reviews the background and status of the program, updates criteria, and addresses future infrastructure and institutional support components needed to fulfill program objectives. The principal focus of this report is directed toward potential and proposed future actions. The report provides a basis and justification for USAID's funding decisions to complete the Alexandria Wastewater Program as set forth in the 1981 "Review and Update of the 1978 Alexandria Wastewater Master Plan". Alternative program components are described and evaluated where applicable.

Program components are addressed in this report under two categories: current work and future program needs.

CURRENT WORK

Current work comprises those prioritized wastewater collection, treatment and disposal projects for which funding has been allocated. They are now either completed or in progress. When all current projects are fully completed at the end of 1994, they will provide urgently needed sewerage service and immediate environmental benefits to the East and West Zones of Alexandria. They represent projects that had to be implemented as an important part of the overall program but do not, in themselves, achieve the full objectives of the Alexandria Wastewater Program.

In general, "current work" involves the following activities:

- Construction of new sewers, pump stations and forcemains to convey the City's wastewater to one of two treatment plants

- Construction of the East and West Treatment Plants to provide primary treatment before discharge of effluent to Lake Maryout

- Construction of mechanical sludge dewatering and dedicated land disposal facilities for management of primary sludge generated at the two treatment plants

- Training of AGOSD's staff to operate and maintain all facilities provided under the program

FUTURE PROGRAM NEEDS

The future needs category involves program elements that, when incorporated into the current work, will fulfill the original intent and objectives established for the Alexandria Wastewater Program. In general, the future needs addressed in this report are associated with the following major aspects of a continuing program:

- Interim and final effluent disposal alternatives

- System expansion alternatives to accommodate population and industrial growth

- Sewerage service for Alexandria's Central Zone

- Continuing infrastructure and institutional support

PROGRAM COVERAGE

The primary study boundaries of the Alexandria Wastewater Program encompass the urban core of the City. These boundaries extend from Abu Qir in the east to the Noubaria Canal in western Alexandria. This coverage is consistent with that addressed in the May 1981 Master Plan Review [3]. However, the 1981 document also specifically included certain special studies concerning the expansion of sewerage services to area west of the Noubaria Canal in the future. This area is designated the "Outer West Zone" and includes the communities of Mex-Dekheila, Agami and Amria.

The limits of the East, Central, West and Outer West Zones are indicated in Figure 1-1.

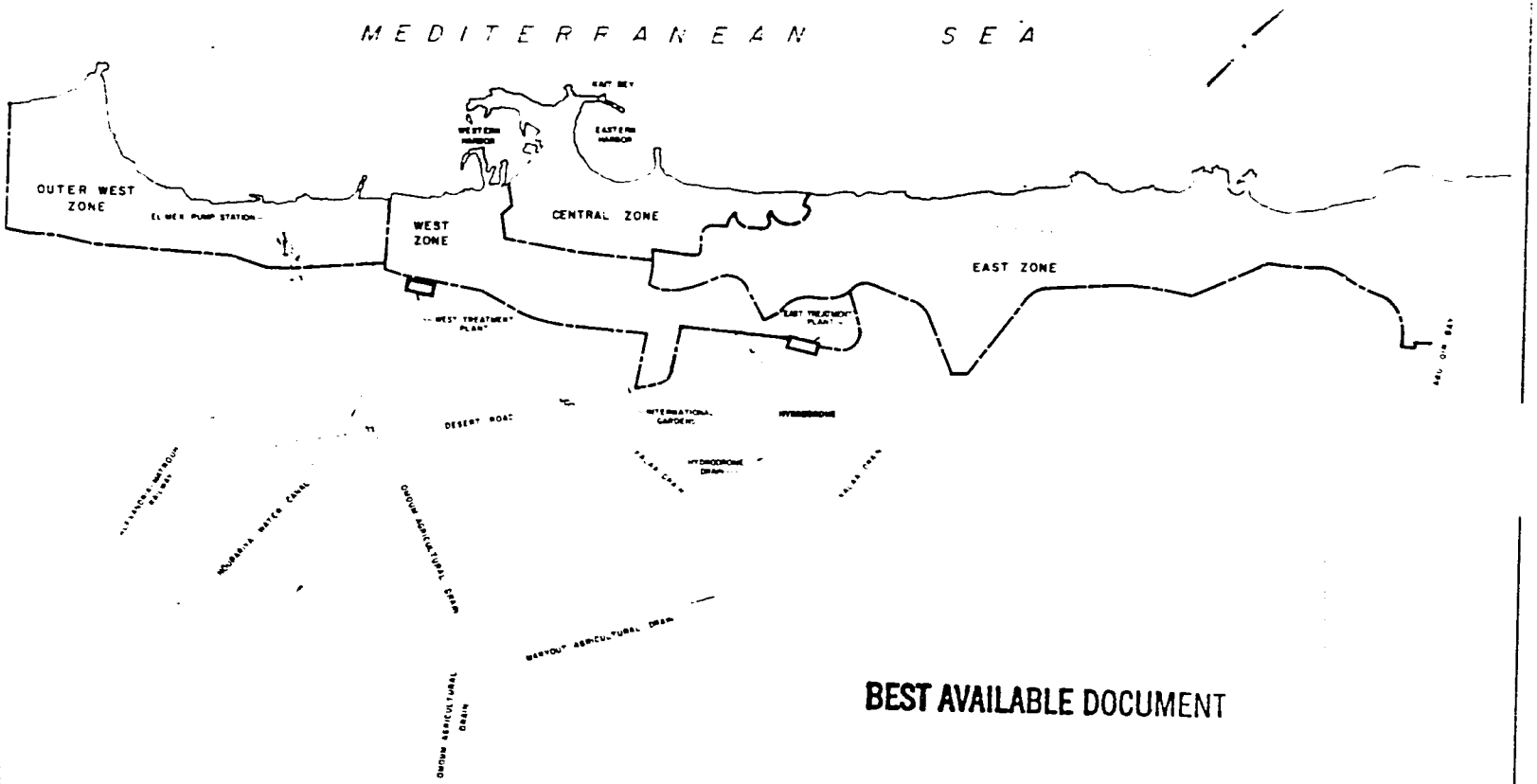

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FIGURE 1 —

DRAINAGE ZONE BOUNDARIES

CHAPTER 2

PRE-PROGRAM and PROGRAM HISTORY

CHAPTER 2

PRE-PROGRAM AND PROGRAM HISTORY

This chapter provides a brief background and historical overview of the Alexandria Wastewater Program. An appreciation of the broad development of the program and its major milestones will offer a foundation for making intelligent decisions concerning its future.

BACKGROUND

Until late in the nineteenth century, all wastewaters in Alexandria were discharged to local drains.

The City's first sewerage facilities were planned in 1908, primarily (but not entirely) as a combined sanitary/stormwater system, when the population of the City was about 360,000. Most collection systems were to be located in what is now the "downtown" central zone of Alexandria. A separate sewer system was proposed for the northern area of the City where sanitary flows would be pumped to the Mediterranean Sea through an outfall at Kait Bey. Wastewater flows that exceeded the capacity of this system would overflow to the shoreline at various points in the Eastern Harbor area.

In the late 1940's, the City was divided into the East, Central and West Zones for planning purposes to take advantage of natural drainage topography. East Zone wastewaters were to be treated prior to discharge to Lake Maryout via drainage canals. Central Zone flows were to be conveyed to the Kait Bey Pump Station, where treatment would be provided if needed before discharge to the sea. West Zone wastewaters were to be treated and discharged to a drain for final disposal to the sea via the El Mex Pump Station.

These plans were partially implemented but over a very long period of time. The Kait Bey Outfall and pump station were not constructed until 1954. The Eastern Zone collectors were constructed and extended in the 1960's to include population growth in the Sidi Bishr, Maamoura and Montazah areas. Changes in the Central Zone were made largely to increase the capacity of that system. Western Zone collectors were extended at about the same time to include the Wardeyane District, which extends to the Noubaria Canal. The East Plant was placed in partial operation as a secondary treatment facility in 1974 but operation of this plant did not last long. The primary treatment facilities of the West Plant were not completed until 1981 and were never placed in operation.

OVERVIEW OF PROGRAM HISTORY

This section summarizes the history of the USAID-funded Alexandria Wastewater Program by highlighting key events in its staged evolution toward achieving the environmental objectives established at the program's outset in 1978. The issues that influenced the development of the program most significantly are:

- Wastewater treatment plant locations and levels of treatment
- Interim and final effluent disposal points
- Sludge management

The substance of these issues, as represented in various key reports and studies, is outlined in chronological order below.

ALEXANDRIA WASTEWATER MASTER PLAN STUDY (MAY 1978)

In November 1976, the Egyptian Ministry of Housing and Reconstruction (MOHR) signed an agreement to conduct a wastewater master plan study for the City of Alexandria. This study was completed in May 1978. It presented recommendations for sewerage infrastructure development to meet the needs of an estimated 5.26 million Alexandria inhabitants (including Mex-Dekheila and Amria) in the Year 2000. The 1978 study was the beginning of the Alexandria Wastewater Program.

This 1978 study addressed three fundamental schemes for future effluent disposal: discharge to the sea; reuse by irrigation of cropland; and conveyance to Lake Edkou in the desert for evaporation. For the major developed areas of Alexandria, sea disposal incorporating a preliminary level of treatment and two 10-Km outfalls at Kait Bey and Sidi Bishr, was determined the most cost effective and viable alternative. The study also concluded that continued disposal of significant volumes of wastewater effluent to Lake Maryout (even with effective secondary treatment) is not a viable overall solution that would protect the Lake and shoreline of Alexandria.

With respect to treatment, the study recommended construction of the following facilities:

- Separate 4000 Ha evaporation pond for Abu Qir's industrial wastes
- Two preliminary treatment plants (screenings, grit and scum removal only) with 10-Km sea outfalls at Sidi Bishr and Kait Bey to serve the East, West and Central Zones of Alexandria
- Secondary treatment plant (upgraded East Plant with discharge to Lake Maryout) to serve the Nouzha area

- Separate anaerobic/aerobic lagoons with discharges to the proposed West Noubaria Drain and sea to serve Mex-Dekheila (370 Ha lagoon) and Amria (315 Ha lagoon)

The 1978 work also established a number of top priority projects for immediate implementation. These included the Ras El Soda and Sporting Pump Stations and forcemains that were completed in the 1980's.

ENVIRONMENTAL IMPACT STATEMENT (1979)

In accordance with USAID's Environmental Procedures (22 CFR 216), a draft Environmental Impact Statement (EIS) was prepared and released to USAID in April 1979. The EIS specifically addressed the recommendations contained in the 1978 Alexandria Wastewater Master Plan Study. Work in support of the EIS also included marine investigations in light of Master Plan recommendations in favor of sea disposal of wastewater receiving preliminary treatment.

As a result of the Final Environmental Impact Statement, which was issued in August 1979, the recommendations of the 1978 Alexandria Wastewater Master Plan Study were modified to provide primary treatment rather than only preliminary treatment prior to sea discharge. This substantial change would not only affect the costs of the improvements but also the suitability of the originally proposed treatment plant sites. Therefore, it was decided that a review and update of the original plan was needed to determine the full impact of the change.

MASTER PLAN REVIEW AND UPDATE (MAY 1981)

As a result of the higher total project costs resulting from the additional treatment required for sea disposal, WWCG's Review and Update of the Alexandria Wastewater Master Plan addressed alternatives to the basic sewerage concept recommended in the 1978 Master Plan. A land disposal system incorporating irrigated agriculture emerged as potentially attractive compared to the previously proposed sea disposal scheme.

This 1981 Master Plan Review (MPR-81) focused on the viability of wastewater reuse through farm land irrigation versus the concept of sea disposal of wastewater effluent as long-range alternatives for Alexandria. The two alternatives, sea disposal and land application, differed markedly in their approaches, results and costs.

Sea Disposal

In addition to the new sewers and pumping stations for collecting and conveying wastewater, the sea disposal alternative evaluated in 1981 included two major primary treatment plants and sea outfalls.

A new 585 Ml/day plant, located at Ras El Soda, would serve the anticipated needs of eastern Alexandria. This plant would discharge effluent to the sea through a new 10-Km outfall at Sidi Bishr. First stage construction of the Ras El Soda Treatment Plant was scheduled to be completed at the time the Sidi Bishr Outfall was completed. This delay allowed considerable undesignated time in the Ras El Soda schedule. The second plant, located at the site of the existing West Treatment Plant, would have a 395 Ml/day capacity to serve western Alexandria. Effluent would be discharged to the sea through an 8-Km outfall at Kait Bey.

Sewage from the Nouzha area would be treated at the existing East Treatment Plant. This plant would be upgraded to a 45 Ml/day secondary facility with effluent discharge to Lake Maryout via the Kalaa Drain.

Treatment plants were sized for anticipated wastewater flows in the Year 2000. Outfalls were sized for peak flows expected in the Year 2030.

Land Application.

The land application alternative would combine wastewater collection, treatment and disposal with a large land reclamation irrigation project. In addition to the new sewers and pumping stations to collect wastewater, land application would require three major pump stations and an extensive pipeline network to convey untreated wastewater to the desert.

Sewage from western Alexandria would be pumped from a new pump station located at Gheit El Enab through a 33-Km forcemain. Sewage from eastern Alexandria would be pumped from a new station at Abu Soliman through a 38-Km forcemain. These flows would be combined at a Desert Pump Station and re-pumped through a 44-Km forcemain to the land application site located south of the El Nasser Canal between the Alexandria-Cairo Desert Road and the Noubaria Canal.

Wastewater treatment and reuse would take place on a 31,000 Ha site, which was unused desert at the time of the study. The proposed treatment and reuse system consisted of anaerobic lagoons, infiltration basins, groundwater recovery wells and a water distribution and irrigation system for agricultural crop production. The system was initially sized for anticipated wastewater flows through the Year 2000.

Conclusions

Significant conclusions of the 1981 Master Plan Review were:

- Both sea disposal and land application alternatives offer technically safe and acceptable solutions for wastewater disposal in the Alexandria area and both can meet the environmental objectives of the Alexandria Wastewater Program

- Implementation of either alternative would require considerable additional study prior to undertaking final design

- The choice between alternatives may be dictated by capitalization requirements, land acquisitions constraints, and the results of future field investigations

- Although sea disposal would be much less capital-intensive than land application, the present worth costs of both alternatives are essentially equal

- The concept of land application or beneficial reuse of wastewater effluent should be retained in any finally adopted long-range plan

- The interests of Alexandrians would be best served by the adoption of a phased implementation plan

PHASED IMPLEMENTATION PLAN (JULY 1982)

In accordance with the recommendations of the 1981 Master Plan Review, WWCG completed preparation of the first Phased Implementation Plan for the Rehabilitation and Expansion of the Alexandria Wastewater System in July 1982. The purpose of the 1982 report was to establish a phased program of design and construction to guide near-term decision making, to implement immediate pollution control improvements, and to retain flexibility with respect to long-term solutions.

The authors of the 1982 Phased Implementation Plan considered achieving the full objectives of the Alexandria Wastewater Program in three conceptual phases. The salient components of these phases are indicated below.

Phase I (Design Year 1990)

The priority objective of Phase I implementation decisions was to maximize program benefits as soon as possible. This objective would be achieved by providing "high rate" primary treatment at the existing East and West Plants and by building the necessary major sewerage facilities in the East and West Zones of Alexandria to convey wastewater to these plants.

Consequently, work proceeded immediately to design and construct the East and West Plants to their "initially developable" primary treatment capabilities, which were controlled by the capacities of the existing sedimentation basins at each plant. On an average wastewater flow basis, the maximum initial capacities of the East and West Plants were 325 and 175 Ml/day, respectively. The combined flow of 500 Ml/day represented approximately two-thirds of the 1990 service needs for sewered areas in the entire City.

Full city-wide service for Design Year 2000 flows would wait until both plants could be expanded in the next phase of construction.

Phase I plans called for mechanical dewatering of raw sludge on vacuum filters at the East and West Plants, followed by off-site composting. Phase I planning also recommended the concurrent evaluation of alternative sludge processing systems, including vacuum-assisted sand drying beds (on-site) and conventional sand drying bed dewatering (off-site). Suitable land for off-site sludge management facilities was yet to be identified.

In summary, Phase I facilities were intended to service the East and West Zones of Alexandria for expected flows through the Year 1990. The concept of providing secondary treatment for Nouzha area flows was reconsidered in light of service priorities; the Nouzha area wastewaters would be directed to the West Treatment Plant when connected to the system in the future. East and West Plant effluent would be discharged to Lake Maryout as an interim measure until permanent effluent disposal facilities could be constructed. To implement this decision for the East Plant, improvements to the Smouha and Hydrodrome Drains and the Kalaa Pump Station were recommended. Collection and treatment of Central Zone flows would be part of the Phase II construction program.

Phase II (Design Year 2000)

The continued development envisioned for the 1990's (i.e. completion of Phase II works by 1990) encompassed the following major program tasks:

- Complete design and construction of the second expansion of the East and West Treatment Plants (to average flow capacities of 500 and 485 Ml/day, respectively) as well as associated conveyance infrastructure to match estimated Design Year 2000 flows from the Outer East, East, Central and West Zones of Alexandria.

- Commence additional marine studies and initiate combined discharge of treated West and Central Zone flows to the sea through a new 8-10 Km Kait Bey outfall and diffuser system, sized with excess capacity for future connection of either the Outer West Zone or Smouha District flows.

- Initiate treatment of Central Zone flows at the expanded West Plant timed with the completion of the proposed new Kait Bey Outfall.

- Provide separate collection and treatment facilities for Mex-Dekheila and Agami with effluent discharge either to the dry lake bed, or to the proposed West Noubaria Main Drain, or to the new Kait Bey Outfall, as recommended in the 1978 Master Plan. This work would require additional funding commitments from USAID or from other local and/or international funding sources.

Phase II planning called for continuing discharges of East Zone flows to Lake Maryout after primary treatment at the expanded East Plant and discontinuing all West and Central Zone discharges to the Lake.

Phase III (Design Year Beyond 2000)

Conceptual planning for handling wastewater flows beyond the Year 2000 kept the sea and land application options open for long-term disposal of East Zone flows and also indicated the option of partial diversion of West and Central Zone flows to the land.

PREDESIGN REPORT FOR ALEXANDRIA SEA OUTFALL (NOVEMBER 1983)

As followup to the recommendations in the 1982 Phased Implementation Plan concerning marine disposal of primary effluent. WWCG completed a Predesign Report for Alexandria Sea Outfall in November 1983. This work was a comprehensive but preliminary feasibility analysis of the sea disposal option. WWCG's evaluation was based on previous studies, particularly marine data collected during the 1978 Alexandria Wastewater Master Plan Study.

The 1983 work revised previous sea disposal concepts by proposing that the outfall at Kait Bey be sized to accommodate all projected wastewater flows from the entire City of Alexandria through the Year 2030. Although additional marine studies are required for final design of this outfall. WWCG's analyses in 1983 confirmed previous statements that sea disposal of primary effluent is safe and that a properly designed outfall system will meet all existing environmental discharge criteria associated with such disposal.

This sea disposal alternative is discussed at greater length in Chapter 5 of this report.

SLUDGE DEWATERING ISSUES

The history of identifying a suitable and implementable sludge management system for Alexandria is complicated.

WWCG's 1982 Phased Implementation Plan made preliminary recommendations in favor of mechanical sludge dewatering at the East and West Treatment Plants using coil vacuum filters followed by composting at an off-site location to be determined. The Implementation Plan also suggested that off-site, non-mechanical dewatering be considered as an alternative to on-site mechanical dewatering. This recommendation was made in recognition of potential difficulties in operation and maintenance of the mechanical dewatering equipment as well as the high costs of electrical power and imported polymer. Consequently, in 1982, WWCG began a search to locate suitable sites for the non-mechanical dewatering (e.g. sand drying beds) as well as composting of raw primary sludges. Findings with respect to eleven potential sites were presented in

WWCG's "Off-Site Sludge Management Reconnaissance Study", May 1982 [7]. A chronological summary that illustrates the long and difficult process of eventual (although short lived) site selection and acquisition is presented in WWCG's "Basis of Design Report for the Sludge Management System", April 1987 [8].

In May 1986, WWCG was authorized to begin design of recommended non-mechanical sludge dewatering and composting facilities at Site 9N. Site 9N is located approximately 25 Km from the West Plant, near the Alexandria-Cairo Desert Road. The system consisted of the following elements:

- East Plant sludge conveyed to the West Plant by pumping into the extended West Zone Tunnel
- Combined East and West Plant sludges pumped to Site 9N with a single pump station through high-pressure steel 450-mm forcemains (one line for Phase I; total of two lines for Phase II)
- Dewatering of sludge on sand drying beds at Site 9N followed by composting of dewatered sludge
- Secondary treatment (biotowers and rapid infiltration) of sand drying bed filtrate at Site 9N and discharge of treated filtrate to a local drain

The total net drying bed area required to accommodate sludge generated from combined East and West Plant flows (585 Ml/day) during Phase I was approximately 560,000 m^2 (200 drying beds). The total net drying bed area required to accommodate Phase II sludge generated from combined East and West Plant flows (1010 Ml/day) was estimated to be 1,106,000 m^2 (395 drying beds).

After completing an Environmental Assessment (March 1987) and the Basis of Design Report (April 1987) for the sand drying bed facilities at Site 9N and partially completing final design, WWCG was informed in August 1987 that AGOSD would not be permitted to use Site 9N for sludge management facilities.

Since this design was stopped, WWCG studied numerous other combinations of sludge transport, dewatering and disposal to satisfy all agencies involved in the dilemma. These evaluations began with completion of the "Report on Sludge Management System Alternatives", December 1987 [9] and continued for the next three years. Through June 1988, WWCG evaluated five sand drying bed alternatives, four mechanical dewatering alternatives, one drying lagoon alternative, and one sea outfall alternative for sludge disposal. None was completely satisfactory.

The government of the day continued its adamant opposition to sand drying bed dewatering and the necessary site for this option (although recommended by WWCG over mechanical dewatering) was simply not available. Ultimately, all parties involved agreed

to approve mechanical dewatering of all primary sludge at the West Treatment Plant as the only implementable solution available. Consequently, Belt Filter Press mechanical dewatering facilities were designed for the West Treatment Plant; these are currently under construction. Site 9N was then approved for the disposal of dewatered sludge by land application methods (dedicated land disposal). These facilities are also currently under construction.

If sufficient and suitable land could be made available within a reasonable distance of Alexandria, WWCG would again favor this option over mechanical dewatering facilities. Land area requirements for such an option would be on the order of 145–150 Hectares to accommodate Design Year 2000 wastewater flows alone.

PHASED IMPLEMENTATION PLAN (APRIL 1990)

WWCG's Phased Implementation Plan for the Rehabilitation and Expansion of the Alexandria Wastewater System (April 1990) was prepared primarily to update the status and present recommendations and cost estimates concerning "Future Program Needs" to fulfill the environmental objectives of the Alexandria Wastewater Program. With minor exceptions, all of the projects presented therein were envisioned from the inception of the program.

The recommended major future program needs components were presented in general "downstream to upstream" order and categorized under five groupings of related work, as follows:

- Final Effluent Disposal
  - Mediterranean Sea Outfall
  - Predesign Evaluation: Land-based Outfall Conveyance Systems
  - Land-based Gravity Conveyance Systems
  - Outfall Pump Station
  - Land-based Outfall Forcemain

- Treatment Plant and Sludge Management System Expansions
  - East Plant Expansion
  - West Plant Expansion
  - Sludge Dewatering Facilities Expansion at the West Plant
  - Site 9N Sludge Disposal System Expansion

- Central Zone Sewerage System
  - Central Zone Tunnel
  - Central Zone Connections
  - Qabbari Relief Sewers

- Outer West Zone Basis of Design Report (BODR)

- Interim Effluent Disposal Improvements

The construction schedule associated with WWCG's "Future Program Needs" recommendations above contained the assumption that work could be authorized and begin in late 1990. With the exception of the Outfall and its associated land-based conveyance systems, essentially all construction work was scheduled to be completed by the end of 1995 or early 1996. The outfall facilities were planned for completion at the end of 1997. The schedule also showed that interim effluent disposal facilities to bypass Lake Maryout could also be on-line in early 1996, approximately two years before completion of the proposed outfall. Total costs (1990 basis) associated with the future construction work proposed was estimated to be $547.2 million and LE 219.4 million.

ENVIRONMENTAL REVIEW OF SLUDGE MANAGEMENT FACILITIES

In accordance with USAID's Environmental Procedures (22 CFR 216), WWCG completed an "Environmental Review for Sludge Mechanical Dewatering and Sludge/Solids Disposal" [6] in August 1990. This document addressed the environmental effects of the proposed mechanical sludge dewatering operations at the West Treatment Plant (WTP), trucking of dewatered sludge to Site 9N and the solids management system at Site 9N.

The study concluded that "there are no major areas of controversy regarding environmental aspects of this project". Mitigative measures were proposed to offset any impacts caused by the proposed sludge management plan.

CHAPTER 3

CURRENT PROGRAM STATUS

CHAPTER 3

CURRENT PROGRAM STATUS

The current USAID-funded Alexandria Wastewater Program consists of prioritized, immediate-need projects to convey wastewater from the East and West Zones of Alexandria to basic treatment facilities via new gravity collectors, pumping stations and force mains. The work also incorporates construction of primary sludge dewatering (Belt Filter Press) facilities at the West Treatment Plant and dewatered sludge disposal (pilot composting and dedicated land disposal) facilities at Site 9N. As an interim measure under the current program, effluent from the East and West Treatment Plants will be discharged to the Main Basin of Lake Maryout, which is the only option available for near-term implementation.

The only major work constructed under the current program outside of the East and West Zones is the New Sporting Pump Station and force main, which serves a portion of the Central Zone. Raw wastewater flows from the New Sporting Pump Station to the sea via the Kait Bey Pump Station and various overflows in the Eastern Harbor area. Central Zone flows should be diverted to the West Treatment Plant via the proposed new Central Zone Tunnel in the future.

STATUS OF CONSTRUCTION PROJECTS

The current status of all design/construction projects in the current Alexandria Wastewater Program is identified in Table 3-1. With the exception of the Smouha and Hydrodrome Drain Improvements, which are discussed below, all of these projects will be 100-percent complete and functional no later than the end of 1994.

The locations of these current program facilities are shown in Figure 3-1. The scope of and interrelationships among these various projects have been presented in many previous documents. Those that are currently under construction or completed are not discussed again here.

However, two projects listed in Table 3-1 are needed for proper completion of the current work. These, the Smouha and Hydrodrome Drain Improvements, are the only projects listed that are neither completed nor under construction. They represent "gaps" in the integrity of the program and should be completed under the current work or as early as possible in any future increment of the program.

SMOUHA DRAIN IMPROVEMENTS

The Smouha Drain improvements were designed by WWCG for construction under Contract 08-84/85. This original work, postponed indefinitely by AGOSD for lack of funds, comprised 452 meters of enlarged open drain channel sections and 735 meters of twin 2250-mm concrete pipe culverts with appropriate transition structures.

Work would begin just south of the New Smouha Pump Station and lead to the Hydrodrome Drain at the East Treatment Plant (ETP). The improvements would convey wet weather runoff and combined sewer overflows from the Smouha area south to the Hydrodrome Drain. Hydraulic improvements were required to accommodate these wet weather flows in order to prevent flooding of low-lying areas in the city such as Cleopatra and Saba Pasha, which have experienced severe flooding during winter storms in the past. Buried pipes were planned in the upper section of the Smouha Drain to limit public exposure to the combined sewer overflows.

Another important aspect of the Drain improvements relates to the operating water surface in the New Smouha Pump Station's wet well. WWCG's design called for a relatively low water surface to minimize flooding in the upstream collection system. The design also included an upstream weir to permit peak winter flows to bypass the station directly to the drain. Overall, system hydraulics required lowering the existing water surface in the drain near the pump station by about 2 meters. Consequently, the drain improvements are needed not only to reduce collection system flooding but to avoid operational problems in the New Smouha Pump Station.

WWCG completed a detailed design review of the entire Smouha and Hydrodrome Drain system in June 1990. This review resulted in several key modifications. The major proposed revision to the original design was to change to a single 2750 mm jacked pipe along the entire length of the project, approximately 1380 meters in length. The rationale for the recommended change was that it would reduce costs and improve constructability under the presently crowded conditions along the route of the Smouha Drain.

To date, the upper 580 meters of this revised system has been funded by USAID. Construction of this segment (about 42-percent of the total) should be completed by the end of 1992 or early 1993. The remaining 800 meters (58-percent) of the Smouha Drain Improvements is needed but has not been authorized due to lack of available funds.

HYDRODROME DRAIN IMPROVEMENTS

The Hydrodrome Drain Improvements were designed by WWCG for construction under Contract 06-84/85. The Hydrodrome Drain is an existing channel of variable geometry, approximately 4.3 Km long. It is the downstream extension of the Smouha Drain. WWCG's original design consisted of dredging and deepening this channel substantially to accommodate both the East Plant effluent and the full stormwater flow from the Smouha Drain. Contract 06-84/85 was never executed as designed.

Nevertheless, the Egyptian authorities have improved the Hydrodrome Drain since the design was completed in 1985. WWCG's June 1990 review of the Hydrodrome Drain revealed that only minor additional improvements are needed for the Drain to accommodate Design Year 2030 flows. These improvements consist of widening the Drain by about 6 meters and deepening it by 0.5 meters.

STATUS OF TECHNICAL ASSISTANCE ACTIVITIES

WWCG's Operations and Maintenance and Institutional Strengthening activities are critical to the success of the overall Alexandria Wastewater Program. The fundamental goal of this work is to provide AGOSD with the capability to manage, operate and maintain Alexandria's wastewater facilities in an efficient and environmentally safe way.

To achieve this goal, the principal objectives of WWCG's Technical Assistance Program are:

- To provide the necessary tools, spare parts and supplies for operating and maintaining facilities provided under the program properly
- To provide hands-on and site-specific technical training for AGOSD's staff in system operation and maintenance
- To assist in the development of a self-sufficient training and technical assistance organization within AGOSD
- To develop O&M management programs for AGOSD and assist in their implementation
- To assist AGOSD with start-up of all USAID-funded wastewater facilities

WWCG's progress to date toward achieving these objectives are summarized by program component and work category below. Activities under the currently funded program will be completed by the end of 1994. Similar support activities needed after 1994 are addressed in Chapter 6 of this report.

PUMPING STATIONS

- Completed O&M training activities.
- Turned over responsibility for further implementation of the TUMMS (Total Utility Maintenance Management System) computer software package to AGOSD.

- Ordered additional spare parts for all USAID-funded pumping stations, and provided for centralized storage of these parts.

- Completed an equipment condition assessment survey of all AGOSD pumping stations, which indicated the critical need to rehabilitate many of the old stations.

- Revised O&M Manuals for the Sporting and Ras El Soda Pump Stations.

COLLECTION SYSTEMS

- Organized and initiated effective operations of a Collection System Inspection and Cleaning Unit within AGOSD.

- Inventoried and evaluated AGOSD's sewer inspection and cleaning equipment, made recommendations for additional equipment and ordered needed spare parts.

- Trained AGOSD's staff in the safe and effective use of sewer cleaning equipment.

TREATMENT PLANTS

- Completed O&M task analyses for the East and West Treatment Plants and began orientation and general knowledge training.

- Ordered additional spare parts and tools for both plants, and provided for storage of these parts and tools at each plant.

- Completed O&M Manuals for both plants.

- Developed job descriptions, organization charts and staffing plans for both plants.

- Prepared start-up plans for both plants.

MECHANICAL DEWATERING AND SLUDGE DISPOSAL FACILITIES

- Completed O&M task analyses for both facilities.

- Began preparation of the Sludge Disposal Facilities O&M Manual.

- Completed list of additional spare parts and tools needed at both facilities.

TRAINING CENTER

- Established the AGOSD Training And Technical Information Center (TRATIC), which is responsible for the design, development, delivery and evaluation of all training for AGOSD's O&M staff.

- Trained two groups of AGOSD's trainers who are actively involved in training others.

- Maintains technical information, such as "Record-drawings" and related shop drawings of completed wastewater facilities.

TECHNICAL LIBRARY

- Inventoried technical and training documents.

- Developed a technical documents classification system as well as cataloging and circulation procedures.

- Identified and ordered library materials and supplies.

TWINNING

- Twinning is the linking of a foreign emerging and developing organization, such as AGOSD, with one or more US-based experienced and successful wastewater utilities for the purpose of skill development and cultural enrichment. More specifically, AGOSD professionals participating in US-based training and twinning activities will learn new skills and reinforce acquired ones in the areas of treatment process control, wastewater equipment, maintenance management, training, safety, and laboratory analyses.

- Developed "twinning" objectives, program and participant selection criteria.

- Conducted the first twinning program for six AGOSD pump station staff at the Orlando, Florida Wastewater Treatment Plant.

AGOSD CENTRAL MAINTENANCE UNIT

- Established the AGOSD Central Maintenance Unit (CMU), which is responsible for TUMMS, quality control, monitoring of maintenance services and providing specialized maintenance services to all of AGOSD's facilities.

LABORATORY

- Developed a Laboratory Quality Assurance/Quality Control (QA/QC) Program Manual and a Laboratory Procedures Manual.
- Developed comprehensive lists of equipment, chemicals and supplies needed for the treatment plants and central laboratory.
- Continued developing training materials

SAFETY

- Developed a Safety Program Manual and began implementation of the safety program
- Developed work safety lesson plans, learner's guides and training aids
- Specified and ordered safety equipment for all new facilities
- Inventoried, inspected and completed repair recommendations concerning existing safety equipment for pumping stations and collection systems

INSTITUTIONAL SUPPORT

At the time of preparation of this Master Plan Update, WWCG, AGOSD and USAID are finalizing Modification No. 11 to provide $2.1 million from 1993 thru 1994 for a modest Institutional Support Program at AGOSD. This Program was authorized by P/L No. 54.

Additionally, at AID's request, AGOSD is preparing an Action Plan for conversion to an autonomous utility. These activities will require additional technical assistance support from USAID. (See Chapters 6 and 8.)

TABLE 3-1
STATUS OF CURRENT PROGRAM PROJECTS
DECEMBER 1992

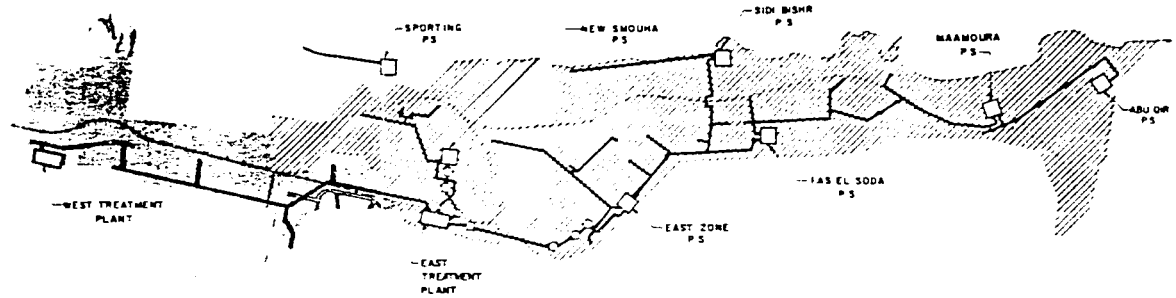
PROJECT	CONTRACT NUMBER	CONSTRUCTION ADMINISTRATION	ESTIMATED PERCENT COMPLETE (AS OF DECEMBER 92)	REMARKS
COLLECTORS AND DRAINS				
Smouha and West Zone Collectors	02–AID–83/84	WWCG	100	• 19 Km, 800–2750 mm
Abu Qir Collectors	08–82/83	AGOSD	95	• 7 Km, 300–1500 mm • 95% completed in early 1990
Abu Qir Laterals	08–83/84	AGOSD		• 29 Km, 150–800 mm • Installed length exceeds BODR
Sidi Bishr Collectors	45–82/83	AGOSD	100	• 5 Km, 1200–1500 mm
Sidi Bishr P.S. Conveyance	55–82/83	AGOSD	100	• 1.2 Km, 1000–1200 mm
Siouf Collectors	09–83/84	AGOSD	100	• 9 Km, 200–1000 mm
Smouha Collectors	34–81/82	AGOSD	100	• 6 Km, 200–2750 mm
Smouha Laterals	07–82/83	AGOSD	100	• 11 Km, 200–900 mm
Smouha Drain Improvements	07–AID–89/90	WWCG	30±	• 580 m, 2750 mm (Upper Portion)
Smouha Drain Improvements	–	AGOSD	Construction Needed	• 800 m, 2750 mm (Lower Portion)
Hydrodrome Drain Improvements	–	AGOSD	Construction Needed	• Portions of Work Completed by AGOSD

TABLE 3-1 (Cont.)
STATUS OF CURRENT PROGRAM PROJECTS
DECEMBER 1992

PROJECT	CONTRACT NUMBER	CONSTRUCTION ADMINISTRATION	ESTIMATED PERCENT COMPLETE (AS OF DECEMBER 92)	REMARKS
FORCEMAINS				
Smouha and East Zone Undercrossings	07–AID–89/90	WWCG	65 100	• Total of 8 Undercrossings • West Zone Tunnel Segments Nos. 1 and 2 (0.4 Km)
Abu Qir P.S. Forcemain	17–81/82	AGOSD	100	• 0.95 Km, 450 mm
P.S. 11E Forcemain	31–82/83	AGOSD	100	• 4 Km, 1200 mm
New Smouha P.S. Forcemain	08–84/85	AGOSD	100	• 1.5 Km, 1500 mm
East Zone P.S. Forcemains	09–84/85	AGOSD	95	• Total of 12.3 Km, Twin 1800 mm
Relief Forcemains for Pump Stations 6E, 7E and 8E	41–82/83	AGOSD	100	
PUMP STATIONS				
• Abu Qir	–	AGOSD		• 9.4 Mℓ/d Average Capacity
• Maamoura	01–AID–83/84	WWCG	100	• 35 Mℓ/d Average Capacity
• Sidi Bishr	01–AID–83/84	WWCG	100	• 59 Mℓ/d Average Capacity
• New Smouha	01–AID–83/84	WWCG	100	• 190 Mℓ/d Average Capacity
• East Zone	01–AID–83/84	WWCG	100	• 400 Mℓ/d Average Capacity
• Ras El Soda	–	CDM	100	• 117 Mℓ/d Average Capacity
• Sporting	–	CDM	100	• 22 Mℓ/d Average Capacity

TABLE 3-1 (Cont.)
STATUS OF CURRENT PROGRAM PROJECTS
DECEMBER 1992

PROJECT	CONTRACT NUMBER	CONSTRUCTION ADMINISTRATION	ESTIMATED PERCENT COMPLETE (AS OF DECEMBER 92)	REMARKS
Pump Station Surge Control:				
• Smouha	07–AID–89/90	WWCG	10	
• East Zone	07–AID–89/90	WWCG	10	
Existing P.S. Rehabilitation:				
• 1E, Industries, Old Smouha	02–82/83	AGOSD	100	
• 5E, 11E, 3W, Furn El Guraya	03–82/83	AGOSD	100	
TREATMENT PLANTS				
WTP Fill and Surcharge	22–83/84	AGOSD	100	
ETP Blower Installation	39–82/83	AGOSD	100	
East and West Treatment Plants	03–AID–83/84	WWCG	99	• 410 Mℓ/d ETP; 175 Mℓ/d WTP
WTP Mechanical Dewatering	04–AID–89/90	WWCG	70	• Belt Filter Presses (12)
Site 9N Sludge Disposal	05–AID–89/90	WWCG	60	• Composting and Dedicated Land Disposal
MISCELLANEOUS				
Engine Generators:				
• Maamoura P.S.	–	AGOSD	100	• Work by AGOSD
• New Smouha P.S.	–	AGOSD	100	• Work by AGOSD
• West Treatment Plant	04–AID–89/90	WWCG	0	• Change Order – October 1992



LOCATION MAP

LEGEND

- PUMP STATION
- UNDER CROSSING
- COLLECTORS & FORCEMAINS
- EAST ZONE DRAINAGE AREA
- WEST ZONE DRAINAGE AREA

0 0.5 1 2 3 4 5 km

SCALE 1:50000

1992 WASTEWATER MASTER PLAN UPDATE
ALEXANDRIA WASTEWATER PROGRAM

FIGURE 3 – 1

CHAPTER 4

UPDATE OF POPULATION FLOWS and LOADS

CHAPTER 4

UPDATE OF POPULATION FLOWS AND LOADS

Wastewater flow and load projections in the 1978 Master Plan and the 1981 Master Plan Update were based on population data available at that time and on estimates of water use and per capita wastewater production. Since that time, the results of another population census have become available and new studies of population and population distribution have been conducted. These more recent population data provide the basis for updating earlier projections of wastewater flows.

This chapter identifies and summarizes the original design flows and loads for major program components and presents the impact of more recent flow and load projections for each major wastewater component of the Alexandria Wastewater Program. The chapter also contains a re-analysis of design assumptions and criteria leading to the development of flows and loads for major program components to be executed in the next increment of work. A comparison of the current and original program schedules is also included with an explanation of the impact of delays encountered during execution of the current work, which will end in late 1994.

ORIGINAL DESIGN CRITERIA

This section reviews the development of the original design wastewater flows and characteristics that formed the bases of design for major program components under the current work program.

DESIGN WASTEWATER FLOWS

Original wastewater flows were based, in part, on census tract populations within the City of Alexandria in Years 1976 and 1980 provided by the Central Agency for Public Mobilization and Statistics (CAPMAS). The approximate boundaries of the census tracts are shown in Figure 4-1. Permanent city populations in 1976 and 1980 are indicated in Table 4-1.

The population projections that formed the bases of the original program components design are shown in Table 4-2. The projected permanent and seasonal populations in 1990 and 2000 shown were apportioned to drainage areas and zones within the city as indicated in Table 4-3 for Year 1990 and Table 4-4 for Year 2000. Boundaries of the drainage areas and zones are shown in Figure 4-2.

The Unit Domestic Wastewater Flow Rates used to calculate the Domestic Average Flows shown in Tables 4-3 and 4-4 were taken from the 1978 Master Plan. It was recognized, however, that these per capita contributions were lower than might be anticipated based on projected future water use. Consequently, the 1981 Master Plan Update recommended that a flow measurement program be included in the

preparation of future "Basis of Design Reports" (BODRs) that would precede the final design of wastewater facilities.

Industrial Average Flow figures shown in Tables 4-3 and 4-4 are projections of flows resulting from an extensive industrial waste study conducted in 1977 and presented in the 1978 Master Plan.

During the preparation of WWCG's Phased Implementation Plan in 1982, recommendations and criteria set forth in the 1981 Master Plan Update as well as more refined estimates from specific BODRs were consolidated into the design average wastewater flow projections presented in Table 4-5. In the determination of these flows, per capita domestic wastewater flow contributions were increased by 20 percent to address the concerns expressed in the 1981 Master Plan Update. A summary of per capita domestic wastewater contributions by service area is shown in Table 4-6.

It is customary in civil engineering design to size mechanical equipment for a 10-15 year life expectancy and basic structural components and pipelines for a 40-50 year service life. This concept was followed in establishing the design parameters for all facilities provided under the current work program.

When the 1982 Phased Implementation Plan was prepared, it was assumed that Phase I facilities would be completed to accommodate flows projected to the Year 1990. Phase II facilities were intended to be operational by 1990 and capable of handling flow requirements to the Year 2000. Delays that have occurred in the current program to date mean that some system components will be required to handle their total design flows as soon as they are commissioned. This will necessitate early construction of Phase II facilities to keep pace with flow increases. This subject is discussed more fully in a later section of this chapter.

In keeping with the original design concept and having regard for the anticipated construction scheduling presented in Chapter 9, a Design Year of 2010 has been adopted for the determination of flows for which expanded facilities must be provided. In addition, the adequacy of structural components and pipelines constructed in the current work program will be reassessed in light of any changes in projected flows in the Year 2030.

DESIGN WASTEWATER CHARACTERISTICS

Wastewater characteristics are normally defined by chemical (COD) and biochemical (BOD) oxygen demands, various solids and nitrogen concentrations, and concentrations of other selected constituents. These include heavy metals, which can adversely impact treatment and final effluent disposal processes.

In Alexandria, industrial wastewater discharges influence these wastewater characteristics significantly. Certain industrial wastewater constituents will have to be removed before discharge to the sewer system because they can adversely impact

the wastewater treatment process, the ecology of the disposal environment, or the collection system itself. Tables 4–3 and 4–4 indicate an industrial contribution of approximately 50 percent of projected total wastewater flows in 1990 and 2000. A limited sampling program was undertaken during the 1978 Master Plan to determine the characteristics of wastewaters in the Study area. The results of the sampling program, carried out at six locations, are presented in Table 4–7. In certain cases, equalization of industrial flows may also be necessary to reduce the impact of peak industrial discharges.

UPDATED DESIGN CRITERIA

This section addresses the development of wastewater flow and load projections for the Phase II program and beyond and the establishment of a design year for major components to be provided as part of the Phase II expansion. Also included is a discussion that compares the original Pnase I design flows and schedule with projections for Phase II and the impacts on both Phases I and II of construction delays that have occurred to date.

DESIGN WASTEWATER FLOWS

As stated earlier, population projections for the Years 1990 and 2000, which formed the foundation for the design of wastewater facilities in Phase I, were based on census data from 1976 and 1980. Since the earlier projections, changes in population distribution occurred that could affect the sizing of wastewater facilities. Changes have also occurred in rates of growth in certain areas that could affect the timing of wastewater system expansions.

To address these changes and to update the basis of design for Phase II facilities, WWCG contracted with a team of University of Alexandria specialists to update population projections in Alexandria. The University team produced the report "Demographic Characteristics of Alexandria Population (Year 1980–2030)"[11]. Table 4–8, Projections of Alexandria Population by District – 1990 to 2030, is an extract from this report and has been used to update design wastewater flows through the Year 2030. Note that some significant differences in population projections have occurred as a result of the current survey, based largely on demographic shifts due to housing problems in certain areas, as well as lack of work opportunities. See reference 11.

Populations projected for the Years 1990, 2000, 2010, 2020 and 2030 shown in Table 4–8 were apportioned to appropriate sewerage drainage areas and zones within the city. To these apportioned populations were added estimated summer seasonal populations to give the "maximum" updated seasonal populations presented in Table 4–9. Refer also to Fig. 4–20 which uses these population figures to determine the Phase II projected wastewater flows.

Based on the populations projections shown in Table 4–9, the following procedures were used to develop the projections of total wastewater flows shown in Table 4–10:

- Domestic wastewater flows assume that 100 percent of the population is connected to the sewer system

- Unit per capita wastewater flows (prorated to the appropriate Design Year per Table 4-6) include domestic, commercial and governmental activities

- Industrial waste flows were based on flows established in the 1978 Master Plan, updated where appropriate by more recent studies during development of individual BODRs

- Where applicable, a special flow allowance has been used to include military installations, hospitals and recreational areas in accordance with the individual BODRs

- Infiltration rates have been determined by the use of standard infiltration curves

As noted above, the updated design wastewater flows shown in Table 4-10 incorporate the conservative assumption that 100 percent of the population is connected to the sewerage system. In presenting estimates of wastewater flows for the Year 1977, the 1978 Master Plan quoted a percent sewered figure of 85 percent for populations within sewered areas. This 85-percent figure is a reasonable assumption for conditions through the Year 2030. Therefore, design average wastewater flows have been modified in this report to reflect this realistic reduction in sewered population.

Examination of the population projections contained in Table 4-8 indicates a stabilization in the central zone of the program area, and a rapid increase in population in the eastern and western fringes. These increases are particularly apparent in the Montazah District with a projected population increase in excess of one million persons between 1990 and 2030. With such a dramatic increase in population, it is WWCG's opinion that sewer service will lag behind development. For this reason, we have assumed that, to the Year 2010, only fifty percent of the population in the Abu Qir and Maamoura drainage areas will be connected to the sewers. We have further assumed that this 50-percent figure will increase uniformly to a sewered figure of 85 percent by the Year 2030.

Therefore, WWCG has modified the total projected wastewater flows shown in Table 4-10 to reflect these assumed reductions in sewered populations. These modified flows, summarized in Table 4-11, form the basis of design of Phase II (Design Year 2010) facilities. The accuracy of these projections, which are derived for planning purposes only, depends predominantly on the accuracy of:

- Population projections

- Projections of water use and wastewater return

- Rate of development of sewerage connections

An overestimation of any or all of these will mean that facilities provided in Phase I and those proposed for Phase II will satisfy system needs for a longer period of time in the future. An underestimation will mean that facilities proposed for Phase II may be required earlier than planned or that the capacity of Phase II additions should be increased. In any event, we strongly recommend that a detailed study of flows tributary to the major pumping stations and the two treatment plants be initiated as soon as the Phase I facilities as a whole are commissioned. Only in this way can an accurate assessment of the future needs of the system be obtained.

Projected wastewater flows in the 1982 Phased Implementation Plan are compared with the revised flows proposed in this Master Plan Update in Table 4–12. This comparison illustrates the expected population stabilization in the Central Zone and the apparent migration of people to the east. A similar migration is also expected to the west but, in this case, primarily to areas outside the program area (e.g. Dekheila and Amria).

In order to compare the original bases of design of pump stations and treatment plants used in the design of Phase I facilities with revised flows resulting from this study, WWCG prepared a series of curves showing original and revised design flows for the period 1990 to 2030. These curves are shown in Figures 4–3 through 4–10. A comparison of the original and revised design flows by program element is presented below. The recommended Phase II average wastewater flow in the Year 2010 is also shown in Figures 4–3 through 4–10.

Abu Qir Pump Station (Figure 4-3)

The pumps that are currently installed in the Abu Qir Pump Station are multi–speed pumps. As a result, the pump station capacity varies from a minimum capacity of 2.7 to 17.5 Ml/day, with a planned average flow rate of 9.4 Ml/day. If the proposed modified flow regime discussed above develops as now predicted, the currently installed pumps in the Abu Qir Station should be adequate through the Year 2005.

The large population increase now projected in the Abu Qir service area, compared to the original population projections made in 1981, significantly influences future upgrading plans for this station. If the station is upgraded as planned in the original design, pump impellers would be changed and the new flow capacity range of the station would be 3.3 to 23 Ml/day with and anticipated average flow of 11.4 Ml/day. This upgraded flow capacity would only be adequate through the Year 2013 (rather than 2030 as originally planned) as indicated in Figure 4–3. The revised and updated Year 2010 Phase II average wastewater flow is also shown in Figure 4–3 as 10.2 Ml/day.

The force main and gravity sewer between the Abu Qir Pump Station and Maamoura Pump Station were designed for an equivalent average wastewater flow of 11.4 Ml/day. If this flow materializes, a second force main and gravity sewer will be needed by about Year 2015.

Maamoura Pump Station (Figure 4-4)

The multi-speed pumps that are currently installed in the Maamoura Pump Station provide a pump station capacity range of 12 to 62 Ml/day, with a planned average flow rate of 35 Ml/day. If the proposed modified flow regime develops, the currently installed pumps in the Maamoura Station should be adequate through the Year 2000.

The most recent population projections for this station's service area also significantly influences upgrading plans for this station. If the station is upgraded as planned in the original design, pump motors would be changed and the new flow capacity range of the station would be 15.3 to 76 Ml/day with and anticipated average flow of 43.7 Ml/day. This upgraded flow capacity would only be adequate through the Year 2011 (rather than 2030 as originally planned) as indicated in Figure 4-3.

The force main and gravity sewer between the Maamoura and Ras El Soda Pump Stations were designed for an equivalent average flow of 43.7 Ml/day. It is now expected that an average flow of 106 Ml/day could be realized by the Year 2030. It is also expected that the existing design flow will be realized in the Year 2010. Consideration should be given, therefore, to the need to increase these pipeline capacities during the Phase II expansion program. The revised Phase II flow for the pump station is 42.7 Ml/day as shown in Figure 4-4.

Ras El Soda Pump Station (Figure 4-5)

This pump station was designed and constructed by others in the early stages of the Alexandria Wastewater Program. It reportedly provides an average pumping capacity of 117 Ml/d. Based on original flow projections, these pumps would have been sufficient to handle flows through the Year 2000, which was the Design Year for Phase II facilities. Because of the population increases in the Abu Qir, Maamoura and Ras El Soda service areas now projected, the existing pumps are capable of handling flows to about the present date only.

If the flow increases in the Abu Qir, Maamoura and Ras El Soda drainage areas materialize, the capacities of the force main and eastern area collector conveying flows to the East Zone Pump Station may need to be augmented in Phase II. Some relief in the lower section of the gravity collector will result from an anticipated reduction in flow from the Sidi Bishr Pump Station. The need for, and design capacity of, any supplementary force main and gravity collector must be verified by careful flow monitoring when the complete system is commissioned. The revised and recommended Phase II average flow is 167.9 Ml/day as shown in Figure 4-5.

Sidi Bishr Pump Station (Figure 4-6)

The Sidi Bishr Pump Station was designed to handle an initial average flow of 59 Ml/d. The currently installed pumps are capable of providing a minimum to peak flow range of 41 to 98 Ml/d. The projected average flow tributary to this pump station in the Year 2010 is 61.9 Ml/d. This flow is well within the range of the initial pump installation. It appears, therefore, that no increase in pumping at the Sidi Bishr Pump Station

capacity will be necessary in the Phase II expansion program. This conclusion must be confirmed by flow monitoring at the pump station during the early part of the Phase II program.

East Zone Pump Station (Figure 4-7)

The capacity of the East Zone Pump Station was designed to handle flows from the Ras El Soda pump station as well as flows generated within the areas of Siouf Keblia – Abu Soliman, Sadat City, Mahmoudiya Keblia and Siouf Manshiya. It appears now that the earlier planned developments of Sadat City, Mahmoudiya Keblia and Siouf Manshiya will not materialize. As a result, the initial installed average capacity of 400 Ml/d is expected to be sufficient to handle flows through the Year 2015. The revised and recommended Phase II average wastewater flow is 369.2 Ml/day as shown in Figure 4–7.

New Smouha Pump Station (Figure 4-8)

The New Smouha Pump Station handles flows from an area in which populations are now expected to stabilize beyond the Year 2010. With this in mind, the capacity of 190 Ml/d provided in Phase I appears to be adequate to handle projected flows at least until Year 2016 and possibly beyond 2030 as indicated in Figure 4–8. The recommended Phase II average wastewater flow is 174.5 Ml/day.

East Treatment Plant (Figure 4-9)

The initial design capacity of the East Treatment Plant was based on the maximum "high rate" treatment capacity of the plant's eight existing clarifiers, 410 Ml/d. It was the intention at the time of preparation of the 1982 Phased Implementation Plan that design and construction of the expansion, to provide a total capacity of 500 Ml/d, would proceed immediately upon completion and commissioning of Phase I facilities. The 500 Ml/d facilities were expected to be on line in 1990 and provide treatment capacity to the Year 2000. The expanded capacity was later increased to 525 Ml/d.

As indicated in Figure 4–9 the present capacity of the Treatment Plant should handle expected flows through the Year 1995. The originally planned expansion will handle flows to the Year 2008 at design average flow rates and to the Year 2010 with only a marginal increase in design flow rate. This is based on a revised and recommended Phase II average flow capacity of 544 Ml/day.

A second expansion of the East Treatment Plant will be necessary in the future to handle flows projected in the Year 2030. The capacity of this expansion can be more accurately assessed during the course of the Phase II program. However, the need for further expansion in the future must be considered during the design and layout of facilities to be provided in Phase II.

Sporting Pump Station (Figure 4-10)

This pump station was designed and constructed by others in the early stages of the

Alexandria Wastewater Program. It reportedly provides an average pumping capacity of 22 Ml/d. As shown in Figure 4–10 this installed capacity is sufficient to handle projected flows through the Year 2030. A revised Phase II average wastewater flow capacity of 16.8 Ml/day is recommended.

West Treatment Plant (Figure 4-11)

The initial development of the West Treatment Plant was based on the treatment capacity of one "bank" of existing primary sedimentation tanks, 175 Ml/day. At that time, the initial design intention was that only flows from the West Zone Collector would be conveyed to the Treatment Plant. Flows generated in the Central Zone would continue to be discharged to the sea and flows from Nouzha to Lake Maryout. It was also intended that design and construction of expansion to provide a total capacity of 485 Ml/day would proceed immediately upon completion and commissioning of Phase I facilities. The expanded facilities were expected to be on line in 1990 and provide treatment capacity to the Year 2000.

Facilities to convey flows from the Central Zone and Nouzha to the West Treatment Plant, and the expansion of the treatment plant, should now proceed simultaneously in Phase II. Upon completion, the plant will provide primary treatment capacity of tributary flows projected for the Year 2013 as indicated in Figure 4–10. An average plant flow capacity of 475 Ml/day is recommended for Phase II in the Year 2010.

DESIGN WASTEWATER CHARACTERISTICS

No recent data are available on which to update design wastewater characteristics. Furthermore, the means of obtaining these data meaningfully will not be available until the two treatment plants are on line and a wastewater sampling and analysis program can be carried out.

For the purposes of this Master Plan Update, therefore, the earlier estimated values of 520 and 530 mg/L for BOD and Suspended Solids have been used in the sizing of facilities to be provided in Phase II. These sizes can be adjusted, if necessary, when more reliable wastewater characteristics data become available after startup of the Phase I facilities.

INDUSTRIAL WASTE LOADS

The 1978 Master Plan presented results of an extensive industrial waste survey conducted in 1977. That survey included field visits to the industries that contributed 90 percent of the industrial wastewaters generated in Alexandria. Estimates of industrial flows and loadings at that time, and projections for the future, were based on data gathered and industrial discharge practices recommended. Pretreatment recommendations were made in the 1978 Master Plan but these, apparently, have not been carried out.

The industries are distributed throughout the three zones considered in the development of the Alexandria Wastewater Program. As a result of this wide distribution, discharges of untreated industrial wastes to the wastewater system will adversely affect the collection, pumping and treatment facilities throughout the system. Furthermore, the presence of many of the industrial pollutants will severely limit and may preclude some of the wastewater effluent and sludge disposal options under consideration.

A subsequent report of recent investigations by WWCG titled "Industrial Wastewater Survey and Impacts on Alexandria Sewerage System", dated July, 1991, presents an updated assessment of the quantities and characteristics of industrial discharges throughout the Governorate of Alexandria. The reports seeks to identify the impacts of industrial discharges into the wastewater system and presents measures to mitigate those impacts.

The purpose of this section is to present a summary of the current and projected industrial waste problem its potential impacts on the wastewater system. Data employed in preparing this section were derived from the Industrial waste studies of 1977 and 1991.

INDUSTRIAL DATA SUMMARY

In the 1991 Study wastewater discharge data were obtained by questionnaire distributed to a total of 775 individual industries. These industries were categorized under 14 different groups, subdivided between public and private sectors.

Six industrial pollutant parameters were addressed in the 1991 study, as follows:

- Biodegradable Organics (i.e. BOD)
- Hazardous Organics
- Heavy Metals
- Settleable Solids
- Oil & Grease
- Inorganics

The current magnitude of the industrial waste issue in Alexandria is indicated by the findings of the 1991 industrial waste survey and study. These findings are summarized in Tables 4-13 through 4-15.

For the six categories of industrial pollutants noted, the information in Table 4-13 indicates the following for the East Central and West Zones of Alexandria:

- Industrial wastewater loads by pollutant category measured in the survey (Kg/day)

- Estimated percentage of actual total industrial load that is discharged to the Sewer System

A breakdown of the industries surveyed in 1991 by wastewater flow volume category is presented in Table 4-14. This table indicates that about 20 percent of the industries in Alexandria produce over 90 percent of the industrial waste flows discharged to the system.

The industrial flow and load information presented in Table 4-15 is essentially the same as that shown in Table 4-13, except that Table 4-15 addresses anticipated future conditions. The data in Table 4-15 represents projected industrial flows and loads that are expected to be discharged to the Alexandria sewer system during Phase II of the Alexandria Wastewater Program; see also Fig. 4-20.

The impacts of industrial discharges on Alexandria's sewerage infrastructure can be addressed qualitatively based on the data presented in Tables 4-13 through 4-15.

IMPACTS OF INDUSTRIAL DISCHARGES

Potential impacts of current discharges of untreated industrial effluent on the several components of the wastewater system are summarized in the following paragraphs. These impacts will continue and may become greater in the future unless early steps are taken to control industrial waste flows.

Impacts on the Collection System.

These include:

- Domestic effluent combined with industrial effluent with acidic or alkaline pH will contribute to deterioration of collection system pipes and fittings, particularly near the points of discharge of raw industrial effluent, before the industrial wastes are sufficiently diluted.

- The higher concentrations of oils and grease discharged with industrial effluent, together with suspended and settleable solids, result in the accumulation of slicks that in time turn into agglomerated masses that are difficult to remove, even with routine maintenance.

  Build-up of such masses within sewers will reduce sewer capacity, possibly causing street flooding with corrosive industrial effluent. Since many of Alexandria's streets are unpaved, more soil and grit will enter the sewerage system, thereby accelerating solids build-up.

- The often non-uniform discharges of industrial effluent as a result of industrial batch or semi-batch processes create situations of varying pipe velocities that enhance flushing in certain areas and cause sedimentation in others. Organic and inorganic sediments produce gases such as carbon monoxide, dihydrogen sulfide, aldehydes and volatile mercaptans and aromatics, which are known toxics.

  Gas bubbles can also cause cavitation of pumps handling these mixed effluents. As a result, more severe effects can be expected in pump stations handling higher proportions of industrial waste effluents.

- High-sulfate industrial effluent, such as textile and detergent manufacturing wastes, promotes the growth of sulfur bacteria, especially when anaerobic conditions prevail. This leads to the formation of highly corrosive sulfuric acid, which will severely shorten the service life of the collection system. Sulfates also promote the formation of the highly toxic hydrogen sulphide gas.

- Waste oils and detergents in effluents, in many cases from the same manufacturing company, can stabilize oil emulsions when the detergent concentration is high. When combined with detergents, the oil will be more difficult to separate in the oil traps installed in the plants ahead of final discharge to the sewer.

- Organic solvents discharged from laundries, chemical industries and car industries can cause the polymeric linings of collection system concrete and metal pipes to deteriorate.

- Many industrial effluents in Alexandria increase the dissolved organic and inorganic salt concentrations in the sewerage system significantly. An increase of about 500 mg/l of dissolved solids is expected as a result of the industrial contributions.

- Industry contributes significant amounts of scum and debris that must be removed by the pump station screens. This is especially true of the boiler houses of factories, garages, bakery shops and allied car industries.

Impacts on Treatment Plants and Sludge Facilities.

Summaries of estimated industrial waste contributions to the East and West Treatment Plants in Phase I are presented in Tables 4-16 and 4-17, respectively. Similar information is presented for Phase II in Tables 4-18 and 4-19. Potential impacts of industrial discharges on the treatment plants are:

- Industrial effluents will contribute approximately 18 percent of total flow to the East Treatment Plant in both Phases I and II. At the West Treatment Plant, industrial effluent will contribute approximately 35

percent in Phase I when only the West Zone is connected to the Treatment Plant. This contribution will be reduced to 21 percent in Phase II with the connection of the Central Zone and Nouzha. The major problem associated with these flows is the uneven pattern of discharge. Inadequate dilution of the industrial wastes may occur if the wastes arrive at the treatment plants during periods of low wastewater flow.

- Industrial wastes will contribute between 46 and 50 percent of the total sludge generated at the East and West treatment plants and more than 75 percent of the scum removed at both treatment plants. These materials will increase the difficulty of sludge dewatering and will add to the polymeric conditioning requirements for sludge dewatering. The consumption of polymer represents a major operating cost.

- Settleable solids generated by industries tend to contain more non-biodegradable matter, heavy metals and inorganic insoluble salts than those of domestic sewage. Therefore, the characteristics of the sludge generated at both plants will be more influenced by industrial constituents.

- Heavy metals and hazardous organics contributed by industry contribute to the toxicity of the sludge, as well as adding to its content of hazardous organics. This jeopardizes the important option for potential beneficial reuse of sludge.

- The industrial detergents, emulsified oils and organics will provide a protective shield for helminthic ova and reduce sedimentation. As a result, the effluent from both treatment plants will have higher infectivity from bacterial, viral and helminthic organisms.

- Toxicity induced by industrial residues will inhibit biological activity in the composting process. Such toxicity will result in a compost product that has a higher potential to cause infections diseases especially if used directly after completion of composting. This in turn mandates longer sludge composting times to minimize the risk of disease when rewetting the composted sludge for application on agricultural land.

- The relatively high percentage of industrial contaminants in Alexandria's wastewaters at the present time significantly reduces the potential for effective secondary (biological) treatment.

Impacts of Industrial Effluents on Drains and Lake

- Industrial wastewaters will be partially treated at the East and West Plants with respect to suspended and settleable matter. Approximately 50–60 percent of the suspended solids, will be removed at the plants. The residual 40–50 percent, in addition to essentially all soluble

biodegradable organics, hazardous organics, heavy metals, emulsified oils and dissolved inorganics will pass through the treatment facility without measurable change. However, since many heavy metals are insoluble in wastewater, it is anticipated that about 30–50% of the heavy metals will be removed in the primary treatment process.

- Dissolved oxygen levels will continue to be low or nil in Lake Maryout and in the agricultural drains receiving these effluents due to the biodegradable loads discharged to them. Nevertheless, discharge of primary effluent will be a distinct improvement compared to the current situation, but the environmental degradation of Lake Maryout will continue, albeit more slowly. The partial removal of suspended solids material will, however, reduce the dredging required to keep the drains operating properly, but the drains still will suffer from odors as conditions, especially in summer, can turn septic. The oily floating scum, removed at the treatment plants will reduce the risk of fire hazard so often encountered in the drains.

- Substantial quantities of dissolved heavy metals and toxic organics will continue to be discharged to the drains and finally to Lake Maryout in the effluent of the treatment plants, since a significant portion of these materials pass through the primary treatment with no appreciable change.The Toxicity induced by them will hinder self cleaning processes in the drains and the Lake.

  The heavy metals and toxic organics have an extremely deleterious effect on the ecology of the Lake and its inhabitants and upon the local fishermen who rely on Lake fish for their livelihood. The impacts of both toxic heavy metals and toxic organics is observed in the Lake by its slow rate of self purification and continuous generation of toxic gases, particularly hydrogen sulfide.

TABLE 4-1
CENSUS POPULATIONS FOR 1976 AND 1980 CITY OF ALEXANDRIA

Census Tract	Permanent Population[a]	
	1976	1980
Gomrok	142,714	156,464
Labban	75,953	86,003
Karmouz	212,800	234,179
Mina of Alexandria	(b)	547
Ramleh	445,974	488,828
Montazah	311,941	336,706
Sidi Gaber	134,831	147,382
Attarine	75,007	82,238
Manshiya	44,834	49,129
Moharem Bey	336,343	368,386
Bab Sharky	215,850	236,265
Minyet El-Basal	228,083	249,505
Total City of Alexandria	2,224,310	2,435,632

Source: Central Agency for Public Mobilization and Statistics (CAPMAS)

(a) Population census data shown does not include seasonal population estimates.

(b) Included in Minyet El-Basal figures (501 people).

TABLE 4-2
ORIGINAL POPULATION PROJECTIONS - YEARS 1990 AND 2000

Census Tract	Permanent Population		Seasonal Population		Total Population	
	1990	2000	1990	2000	1990	2000
Gomrok	160,000	160,000	–	–	160,000	160,000
Labban	90,000	90,000	–	–	90,000	90,000
Karmouz	250,000	250,000	–	–	250,000	250,000
Mina of Alex.	1,000	1,000	–	–	1,000	1,000
Ramleh	600,000	700,000	50,000	54,000	650,000	754,000
Montazah[a]	818,800	1,400,000	205,000	214,000	1,023,800	1,614,000
Sidi Gaber	304,000	360,000	65,000	66,000	369,000	426,000
Attarine	85,000	85,000	–	–	85,000	85,000
Manshiya	52,000	52,000	–	–	52,000	52,000
Moharem Bey	406,900	449,300	–	–	406,900	449,300
Bab Sharky	261,000	288,100	100,000	106,000	361,000	394,100
Minyet El-Basal	260,000	260,000	–	–	260,000	260,000
Total City of Alexandria[b]	3,288,700	4,095,400	420,000	440,000	3,708,700	4,535,400

Source: Review and Update of the 1978 Alexandria Wastewater Master Plan

(a) Includes Sadat City
(b) Excludes Dekheila and Amria

TABLE 4-3
ORIGINAL 1990 WASTEWATER FLOW ESTIMATES

District	Area (ha)	Population[a] (1000's)	Unit Domestic Rate (lcd)	Domestic Average Flow[b] (Ml/day)	Industrial Average Flow (Ml/day)	Special Allowance[c] (Ml/day)	Infiltration (Ml/day)	Total Average Flow (Ml/day)
Inner Area								
Western Zone	1,068	576	105	60	92	–	13	165
Central Zone	1,322	933	125	117	28	4	21	170
Eastern Zone	4,306	2,061	118	243	130	4	33	410
Nouzha	266	25	83	2	25	–	2	29
Outer Area								
Abu Qir	1,100	75	112	8	132	2	18	160
Totals[d]	8,062	3,670		430	407	10	87	934
Source: Review and Update of the 1978 Alexandria Wastewater Master Plan								

[a] Includes seasonal population
[b] Includes domestic, governmental, and commercial uses
[c] Includes allowance for military establishments, hospitals, and recreational center
[d] Excludes Mex–Dekheila, Amria and unsewered areas

TABLE 4-4
ORIGINAL 2000 WASTEWATER FLOW ESTIMATES

District	Area (ha)	Population[a] (1000's)	Unit Domestic Rate (lcd)	Domestic Average Flow[b] (Ml/day)	Industrial Average Flow (Ml/day)	Special Allowance [c](Ml/day)	Infiltration (Ml/day)	Total Average Flow (Ml/day)
Inner Area								
Western Zone	1,265	602	125	75	110	–	15	200
Central Zone	1,322	1,016	136	137	34	4	20	195
Eastern Zone	4,660	2,741	122	334	189	4	35	562
Nouzha	521	30	100	3	36	–	3	42
Outer Area								
Abu Qir	1,480	106	108	12	150	2	10	174
Totals[d]	9,248	4,495		561	519	10	83	1,173

Source: Review and Update of the 1978 Alexandria Wastewater Master Plan

[a] Includes seasonal population
[b] Includes domestic, governmental, and commercial uses
[c] Includes allowance for military establishments, hospitals, and recreational center
[d] Excludes Mex–Dekheila, Amria and unsewered areas

TABLE 4-5
ORIGINAL DESIGN AVERAGE FLOWS - 1982

Zone and Service Area	Average Wastewater Flows–Mℓ/D[a]		
	Design Year 1990	Design Year 2000	Design Year 2030
EAST ZONE			
Abu Qir and Maamoura	10	17	63
Ras El Soda	95	102	124
Sidi Bishr	51	59	107
Siouf Keblia	135	136	167
Smouha	155	187	238
SUBTOTAL	446	501	699
CENTRAL ZONE			
SUBTOTAL	191	223	275
WEST ZONE			
West Zone Collectors	197	220	276
Nouzha	29	42	76
SUBTOTAL	226	262	352
TOTALS	863	936	1,326

Source: Phased Implementation Plan for the Rehabilitation and Expansion of the Alexandria Wastewater System, July 1982

(a) Excludes Mex–Dekheila and anticipated future developments of Sadat City, Manshyia Bahareyah and Amria

TABLE 4-6
PER CAPITA DOMESTIC WASTEWATER FLOWS

ZONE AND SERVICE AREA	PER CAPITA WASTEWATER FLOWS-Lcd[a,b]		
	Design Year 1990	Design Year 2000	Design Year 2030
EAST ZONE			
Abu Qir & Maamoura	118	130	160
Ras El Soda	118	128	160
Sidi Bishr	139	153	190
Siouf Keblia	118	130	160
Smouha	152	156	200
CENTRAL ZONE			
Collectors	150	163	195
WEST ZONE			
Collectors	126	150	180
Nouzha	100	120	160
Source: Original BODRs for the Various Sewerage System Components (circa 1982-83). WWCG			

(a) Unit domestic wastewater flows shown are 20-percent higher than those recommended in the 1978 Alexandria Wastewater Master Plan Study

(b) Unit flow figures shown exclude industrial, point source and infiltration flows, which are treated separately

TABLE 4-7
WASTEWATER SAMPLING PROGRAM RESULTS

CONSTITUENT	FLOW WEIGHTED AVERAGE – mg/L
pH	7
BOD_5	585
COD	1,245
Oil & Grease	396
Alkalinity (as $CaCo_3$)	390
Total Solids	1,216
Total Volatile Solids	530
Total Suspended Solids	552
Volatile Suspended Solids	390
Ammonia (as N)	29
Albuminoid Nitrogen	8
Chloride	730
Phosphate	10
Source: Alexandria Wastewater Master Plan Study, May 1978	

Note: Flow-composited GRAB Samples taken at six locations in May–July, 1977:

- East Treatment Plant
- Smouha Drain
- Industries P.S.
- Gheit El Enab Drain
- Qabbari Drain
- Kait Bay P.S.

TABLE 4-8
ALEXANDRIA POPULATIONS AND PROJECTIONS BY DISTRICT

CENSUS TRACT	1976 CENSUS	1986 CENSUS	1990		2000		2010 Projection	2020 Projection	2030 Projection
			MPU[a]	Projection[b]	MPU	Projection			
Montazah	311941	606690	818800	720000	1400000	1000000	1200000	1450000	1752000
Ramleh	445974	611887	600000	681000	700000	750000	850000	850000	850000
Sidi Gaber	134831	159303	304000	170000	360000	260000	372000	372000	372000
Bab Sharky	215830	203422	261000	199000	288100	200000	200000	200000	200000
Moharem Bey	336343	343012	406900	346000	449300	332000	332000	332000	332000
Attarine	75007	65376	85000	62000	85000	54000	62000	62000	62000
Manshiya	44834	37589	52000	35000	52000	29000	29000	29000	29000
Karmouz	212800	196280	250000	190000	250000	176000	176000	176000	176000
Labban	75953	64093	90000	60000	90000	60000	60000	60000	60000
Gomrok	142714	122342	160000	115000	160000	97000	84000	72000	72000
Minyet El-Basal	228083	298667	260000	330000	260000	430000	450000	540000	542000
Total	2,224,310	2,708,661	3,287,700	2,908,000	4,095,400	3,388,000	3,815,000	4,143,000	4,447,000

Source: Demographic Characteristics of Alexandria Population, October 1992

(a) MPU – Figures presented in the "Master Plan Update" (i.e. Review and Update of the 1978 Alexandria Wastewater Master Plan, May 1981)

(b) Projection – Updated estimates presented in the Report "Demographic Characteristic of Alexandria Population", October 1992

TABLE 4-9
UPDATED ALEXANDRIA SEASONAL POPULATION PROJECTIONS

ZONE AND SERVICE AREA	YEAR				
	1990	2000	2010	2020	2030
EAST ZONE					
Abu Qir	66,600	86,600	100,800	118,600	140,100
Maamoura	267,600	347,300	404,900	476,500	562,900
Ras El Soda	393,000	510,700	594,700	699,800	826,700
Sidi Bishr	336,000	389,800	443,900	472,800	507,800
Siouf Keblia	586,400	656,300	744,200	776,300	815,100
Smouha	346,400	411,300	495,800	495,800	495,800
CENTRAL ZONE					
All	1,002,800	993,400	1,006,400	1,009,700	1,010,000
WEST ZONE					
All Excluding Nouzha	656,400	730,400	764,400	833,200	834,700
Nouzha	54,500	60,900	63,800	69,800	69,900

Note: These population estimates are based on the permanent population projections presented in the Report "Demographic Characteristics of Alexandria Population" (October 1992) and on WWCG's estimates of seasonal (summer) population increases. Summer seasonal populations are included in the figures above

TABLE 4-10
UPDATED DESIGN AVERAGE TOTAL FLOW PROJECTIONS

ZONE AND SERVICE AREA	DESIGN AVERAGE WASTEWATER FLOW – MLD				
	1990	2000	2010	2020	2030
EAST ZONE					
Abu Qir Service Area	9.96	13.99	17.19	21.53	26.84
Abu Qir P.S.	9.96	13.99	17.19	21.53	26.84
Maamoura Service Area	34.44	48.86	60.61	76.58	96.08
Maamoura P.S.	44.40	62.85	77.80	98.11	122.92
Ras El Soda Service Area	93.37	116.37	137.66	163.47	194.27
Ras El Soda P.S.	137.77	179.22	215.46	261.58	317.19
Sidi Bishr P.S.	46.70	59.64	72.80	83.21	96.48
Siouf Keblia Service Area	109.78	130.73	154.93	170.17	186.82
East Zone P.S.	294.25	369.59	443.19	514.96	600.49
Smouha Service Area	124.40	150.19	186.99	194.93	202.86
Smouha P.S.	124.40	150.19	186.99	194.93	202.86
EAST PLANT	418.65	519.78	630.18	709.89	803.35
CENTRAL ZONE					
Collectors	201.12	212.62	226.75	238.69	248.85
WEST ZONE					
Collectors	211.81	253.22	272.64	305.52	314.42
Nouzha	16.33	19.46	21.22	24.20	25.13
West Plant	429.26	485.30	520.61	568.41	588.40
TOTAL CITY OF ALEXANDRIA	847.91	1,005.08	1,150.79	1,278.30	1,391.75

Note: Total average flow projections in this table:

- Assume 100-percent of population within city limits (per Table 4-9) is sewered
- Incorporate unit per capita wastewater flows per Table 4-6 (Domestic, Commercial and Governmental)
- Include industrial waste, special allowance and infiltration flows per 1978 Master Plan as updated by individual BODRs

TABLE 4-11
PROPOSED MODIFIED DESIGN AVERAGE TOTAL FLOW PROJECTIONS

ZONE AND SERVICE AREA	DESIGN AVERAGE WASTEWATER FLOW – MLD				
	1990	2000	2010	2020	2030
EAST ZONE					
Abu Qir Service Area	6.03	8.36	10.19	15.76	23.48
Abu Qir P.S.	6.03	8.36	10.19	15.76	23.48
Maamoura Service Area	18.65	26.28	32.47	53.34	82.58
Maamoura P.S.	24.68	34.64	42.66	69.10	106.06
Ras El Soda Service Area	86.42	106.56	125.20	147.70	174.43
Ras El Soda P.S.	111.10	141.20	167.86	216.80	280.49
Sidi Bishr P.S.	39.70	50.69	61.88	70.73	82.00
Siouf Keblia Service Area	99.39	117.92	139.42	152.71	167.25
East Zone P.S.	250.19	309.81	369.16	440.24	529.74
Smouha Service Area	116.50	140.57	174.50	181.24	187.98
Smouha P.S.	116.50	140.57	174.50	181.24	187.98
EAST PLANT	366.69	450.38	543.66	621.48	717.72
CENTRAL ZONE					
Collectors	178.59	181.34	200.49	210.67	219.31
WEST ZONE					
Collectors	199.40	236.79	254.29	284.27	291.88
Nouzha	15.51	18.37	19.94	22.66	23.45
West Plant	393.50	443.50	474.72	517.60	534.64
TOTAL CITY OF ALEXANDRIA	760.19	893.88	1,018.38	1,39.08	1,252.36

Note: The proposed total average flow projections in this table:

- Assume 85-percent of population within city limits (per Table 4-9) is sewered for purposes of domestic flow calculation (Except for Abu Qir and Maamoura Service Areas)
- Assume 50-percent of projected Abu Qir and Maamoura populations will be sewered in 2010, increasing to 85-percent in 2030
- Incorporate other assumptions shown in Table 4-10

TABLE 4-12
COMPARISON OF TOTAL DESIGN AVERAGE FLOWS

ZONE AND SERVICE AREA	AVERAGE WASTEWATER FLOWS-MLD					
	1990		2000		2030	
	1982 PIP[b]	1992 MPU[c]	1982 PIP	1992 MPU	1982 PIP	1992 MPU
EAST ZONE						
Abu Qir & Maamura	10	25	17	35	63	106
Ras El Soda	95	86	102	107	124	174
Sidi Bishr	51	40	59	51	107	82
Siouf Keblia	135	99	136	118	167	167
Smouha	155	117	187	141	238	188
EAST PLANT	446	367	501	452	699	717
CENTRAL ZONE						
Central Zone Collectors	191	179	223	188	275	219
WEST ZONE						
West Zone Collector	197	199	220	237	276	292
Nouzha	29	16	42	18	76	23
WEST PLANT	197[a]	199[a]	485	443	627	534
TOTAL STUDY AREA	863	761	986	895	1,326	1,251

(a) Figures shown under 1992 MPU columns are proposed modified design average total flows per Table 4-11; differences between Tables 4-11 and 4-12 are the result of rounding numbers.

(b) PIP - "Phased Implementation Plan" figures (1982).

(c) MPU - Design flows proposed in this "Master Plan Update" report (1992)

(d) Wastewater flow from the West Zone Collectors only is conveyed to the WTP in Phase I. Flows from the Central Zone and Nouzha are not included.

TABLE 4-13
INDUSTRIAL WASTEWATER LOADS
(PHASE I)

Parameter		East Zone	Central Zone	West Zone
Wastewater Flow	m^3/d	73,331 77%	32,150 100%	62,018 53%
Biodegradable Organics – Dissolved	kg/d	85,514 77%	37,062 100%	70,765 72%
Biodegradable Organics – Suspended	kg/d	28,653 76%	11,643 100%	37,842 68%
Hazardous Oganics – Dissolved	kg/d	3,614 81%	1,258 100%	2,808 53%
Hazardous Organics – Suspended	kg/d	2,622 80%	990 100%	2,228 47%
Heavy Metals – Dissolved	kg/d	810 79%	342 100%	527 59%
Heavy Metals – Suspended	kg/d	545 86%	142 100%	353 50%
Settleable Solids	kg/d	6,378 80%	3,233 100%	11,016 45%
Oil & Grease – Floating	kg/d	7,191 73%	2,242 100%	6,584 61%
Oil & Grease – Emulsified	kg/d	3,726 80%	554 100%	4,613 71%
Inorganics – Dissolved	kg/d	134,695 79%	54,890 100%	122,466 50%
Inorganics – Suspended	kg/d	46,054 82%	20,011 100%	32,468 23%

Source: WWCG Report – "Industrial Wastewater Survey and Impacts on Alexandria Sewerage System", July 1991

NOTES: Percentages indicate the estimated portion of actual total industrial load that is discharged to the sewer system.

TABLE 4-14
BREAKDOWN OF INDUSTRIES BY WASTEWATER FLOW VOLUME

Flow Range m^3/d	Number of Industries	Total Flow m^3/d
0–20	321	2,605
21–50	196	7,997
51–100	87	6,498
101–150	10	1,415
>150[a]	161	223,749
TOTALS	775	242,264

Source: WWCG Report – "Industrial Wastewater Survey and Impacts on Alexandria Sewerage System", July 1991

(a) Flows range between 200 and 29,800 m^3/d.

TABLE 4-15
ESTIMATED INDUSTRIAL WASTEWATER LOADS
(PHASE II)

Parameter	East Zone	Central Zone	West Zone
Wastewater flow m^3/d	94,000 99%	32,200 100%	70,900 60%
Biodegradable Organics – Dissolved kg/d	111,000 99%	37,000 100%	108,000 85%
Biodegradable Organics – Suspended kg/d	35,600 99%	11,600 100%	47,000 85%
Hazardous Organics – Dissolved kg/d	4,415 99%	1,258 100%	3,028 57%
Hazardous Organics – Suspended kg/d	3,200 99%	990 100%	2,448 52%
Heavy Metals – Dissolved kg/d	1,017 99%	342 100%	567 64%
Heavy Metals – Suspended kg/d	631 99%	142 100%	395 56%
Settleable Solids kg/d	7,800 99%	3,200 100%	12,360 51%
Oil & Grease – Floating kg/d	9,800 99%	2,250 100%	7,900 73%
Oil & Grease – Emulsified kg/d	4,600 99%	560 100%	6,900 92%
Inorganics – Dissolved kg/d	169,000 99%	55,000 100%	143,000 59%
Inorganics – Suspended kg/d	55,000 98%	20,000 100%	39,000 28%
Source: WWCG Report "Industrial Wastewater Survey and Impacts on Alexandria Sewerage System", July 1991			

NOTE: Percentages indicate the estimated portion of actual total industrial load that will be discharged to the sewer system

TABLE 4-16
ESTIMATED INDUSTRIAL WASTE LOADS TO EAST TREATMENT PLANT - PHASE I

Parameters	Design Loading Phase I Kg/d	Estimated Industrial Wastewater Contribution Kg/d	Percent of Total
Flow (m^3/d)	410,000	73,300	18
BOD	213,200	114,200	54
Heavy Metals	6,150	1,350	22
Settleable solids	41,000	6,400	16
Total Dissolved Solids	615,000	224,600	37
Oil & Grease	12,300	10,900	89

Source: WWCG Report – "Industrial Wastewater Survey and Impacts on Alexandria Sewerage System", July 1991

TABLE 4-17
ESTIMATED INDUSTRIAL WASTE LOADS TO THE WEST TREATMENT PLANT - PHASE I

Parameters	Design Loading Phase I Kg/d	Estimated Industrial Wastewater Contribution Kg/d	Percent of Total
Flow (m^3/d)	175,000	62,600	35
BOD	91,000	70,800	78
Heavy Metals	2,625	880	34
Settleable Solids	17,500	11,000	63
Dissolved solids	262,500	196,600	75
Oil & Grease	12,000	11,200	93

Source: WWCG Report – "Industrial Wastewater Survey and Impacts on Alexandria Sewerage System", July 1991

TABLE 4-18
ESTIMATED INDUSTRIAL WASTE LOADS TO EAST TREATMENT PLANT - PHASE II

Parameters	Design Loading Phase II Kg/d	Estimated Industrial Wastewater Contribution Kg/d	Percent of Total
Flow (m^3/d)	525,000	94,000	18
BOD	273,000	146,600	54
Heavy metals	7,875	1,650	21
Settleable solids	52,500	7,800	15
Oil & Grease	15,750	14,400	91

Source: WWCG Report – "Industrial Wastewater Survey and Impacts on Alexandria Sewerage System", July 1991

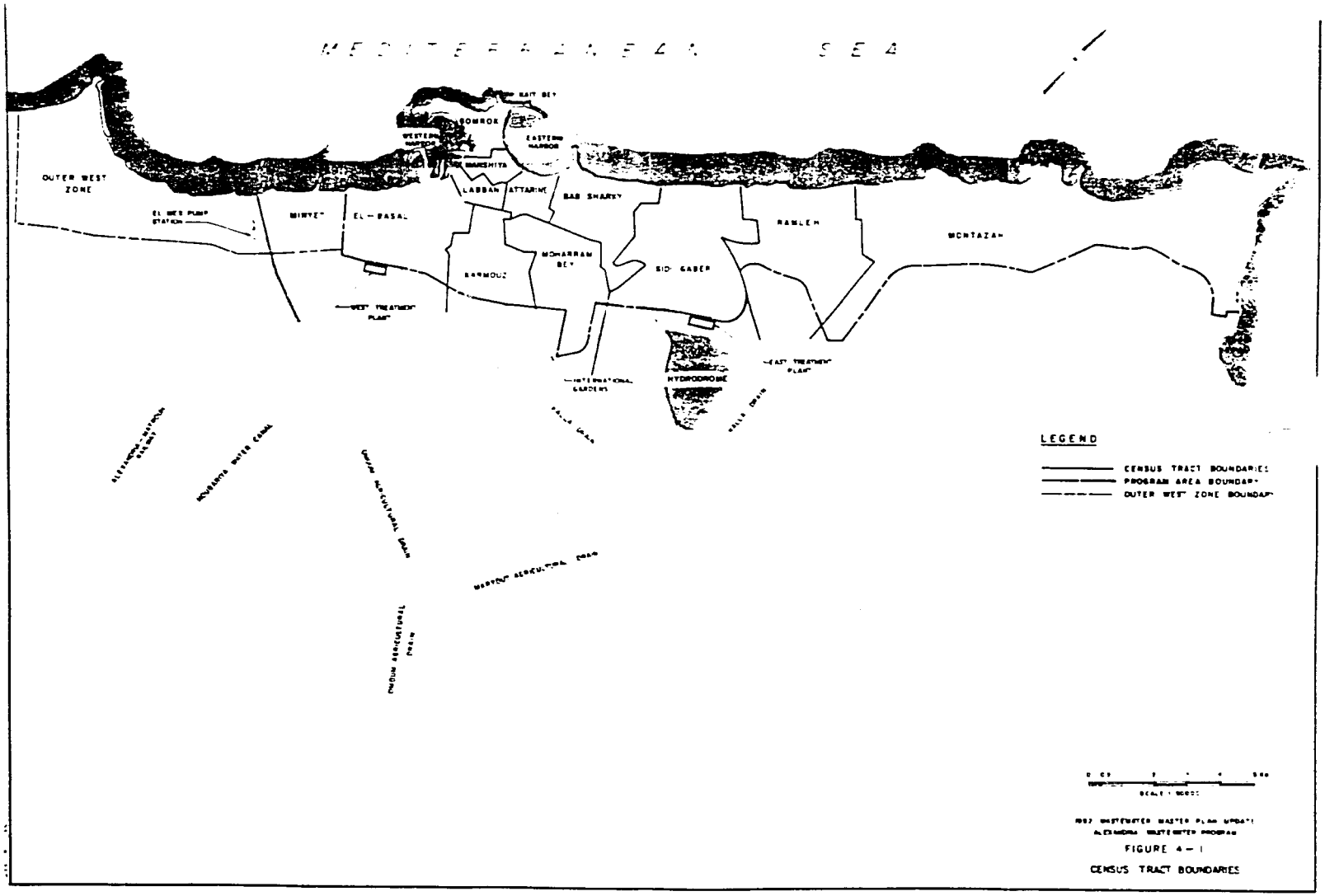
TABLE 4-19
ESTIMATED INDUSTRIAL WASTE LOADS TO WEST TREATMENT PLANT - PHASE II

Parameters	Design Loading Phase II Kg/d	Estimated Industrial Wastewater Contribution Kg/d	Percent of Total
Flow (m^3/d)	485,000	103,100	21
BOD	252,200	203,600	81
Heavy Metals	7,275	1,450	20
Settleable Solids	48,500	15,600	32
Oil & Grease	19,400	16,700	86
Source: WWCG Report – "Industrial Wastewater Survey and Impacts on Alexandria Sewerage System", July 1991			

Table 4-20
PROPOSED DESIGN YEAR 2010 POPULATION AND FLOW PROJECTIONS*

Tributary Area	Population (000's)	Unit Domestic Rate (lcd)	Domestic Average Flow (Mℓ/d)	Industrial Flow (Mℓ/d)	Infiltration & Special Allowance (Mℓ/d)	Total Average Flow (Mℓ/d)
East Treatment Plant	2784	138–171	353	94	97	544
West Treatment Plant	1834	133–174	260	103	112	475

* Summary Table of Recommendations Presented in Chapter 4



1982 WASTEWATER MASTER PLAN UPDATE
ALEXANDRIA WASTEWATER PROGRAM

FIGURE 4 – 1

CENSUS TRACT BOUNDARIES

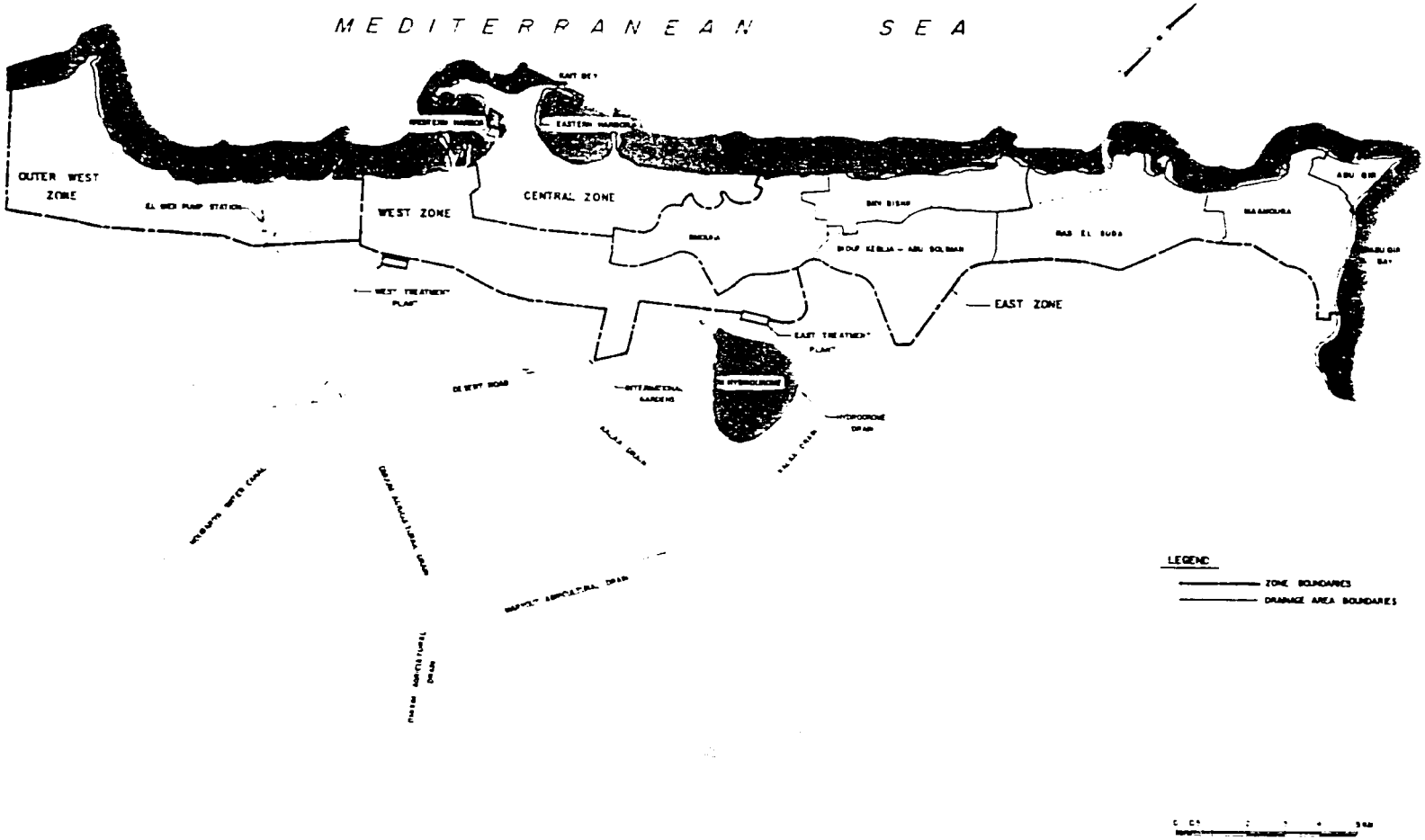
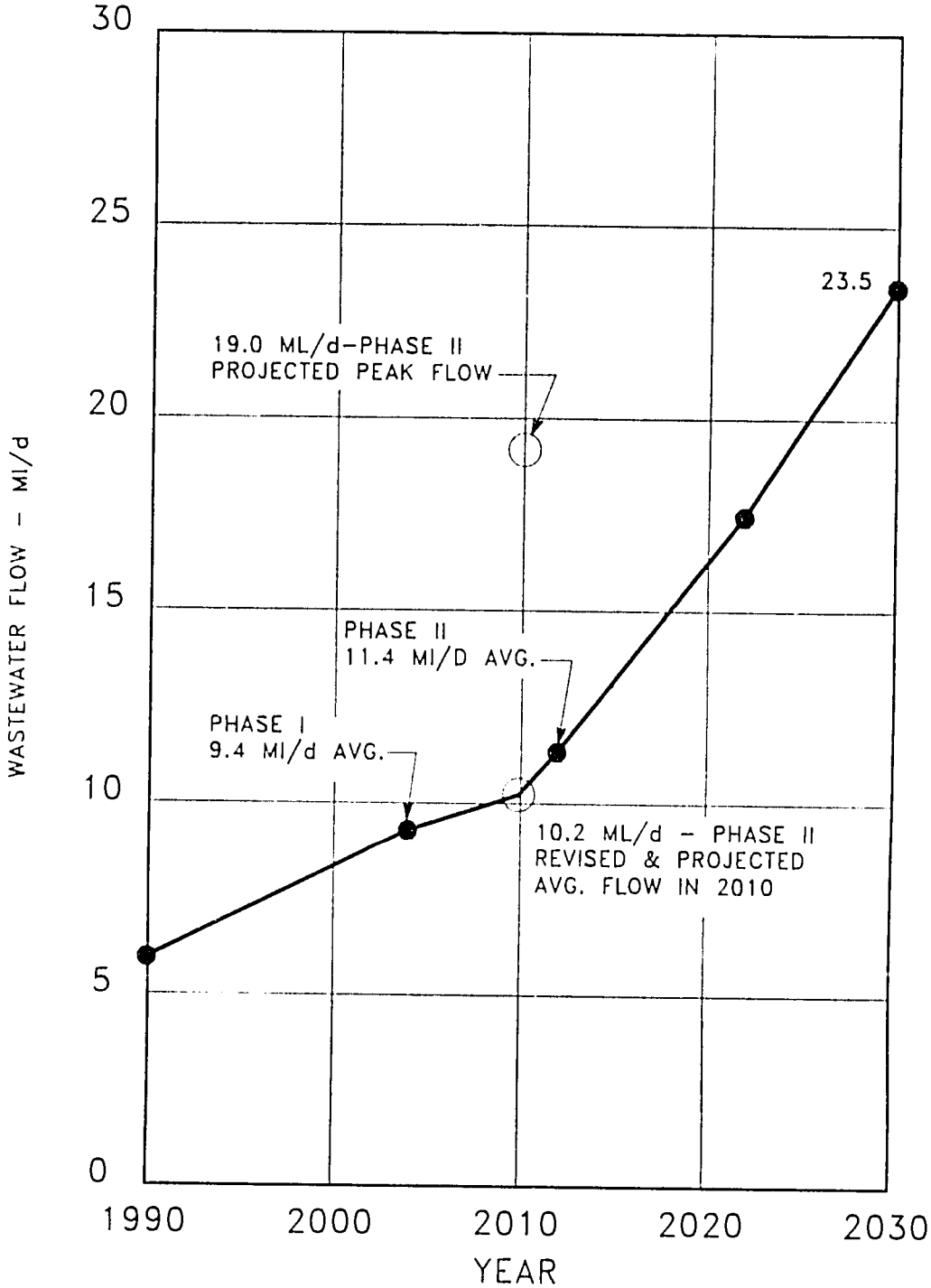


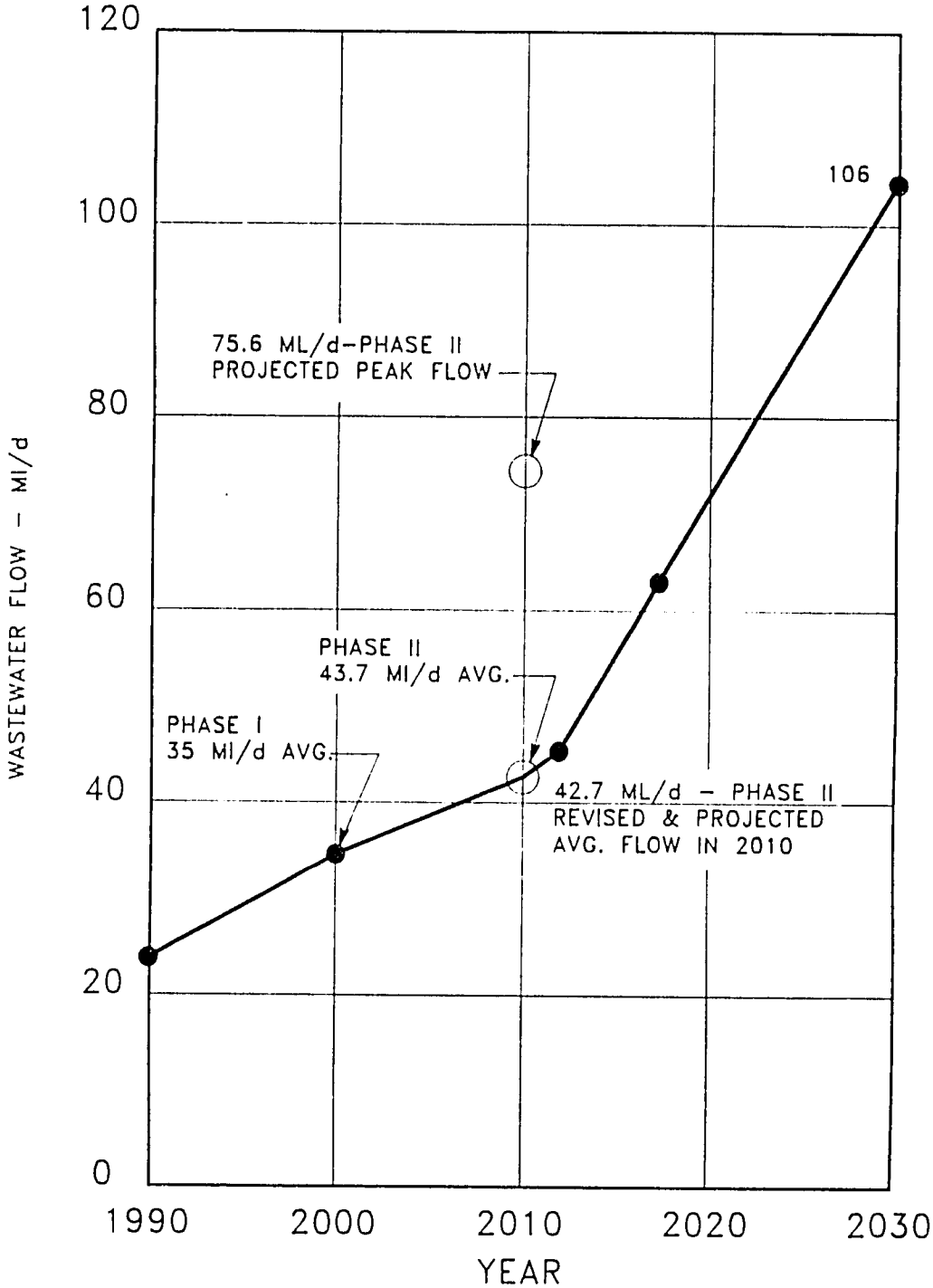
FIGURE 4 – 2

DRAINAGE AREA AND ZONE BOUNDARIES



1992 WASTEWATER MASTER PLAN UPDATE
ALEXANDRIA WASTEWATER PROGRAM

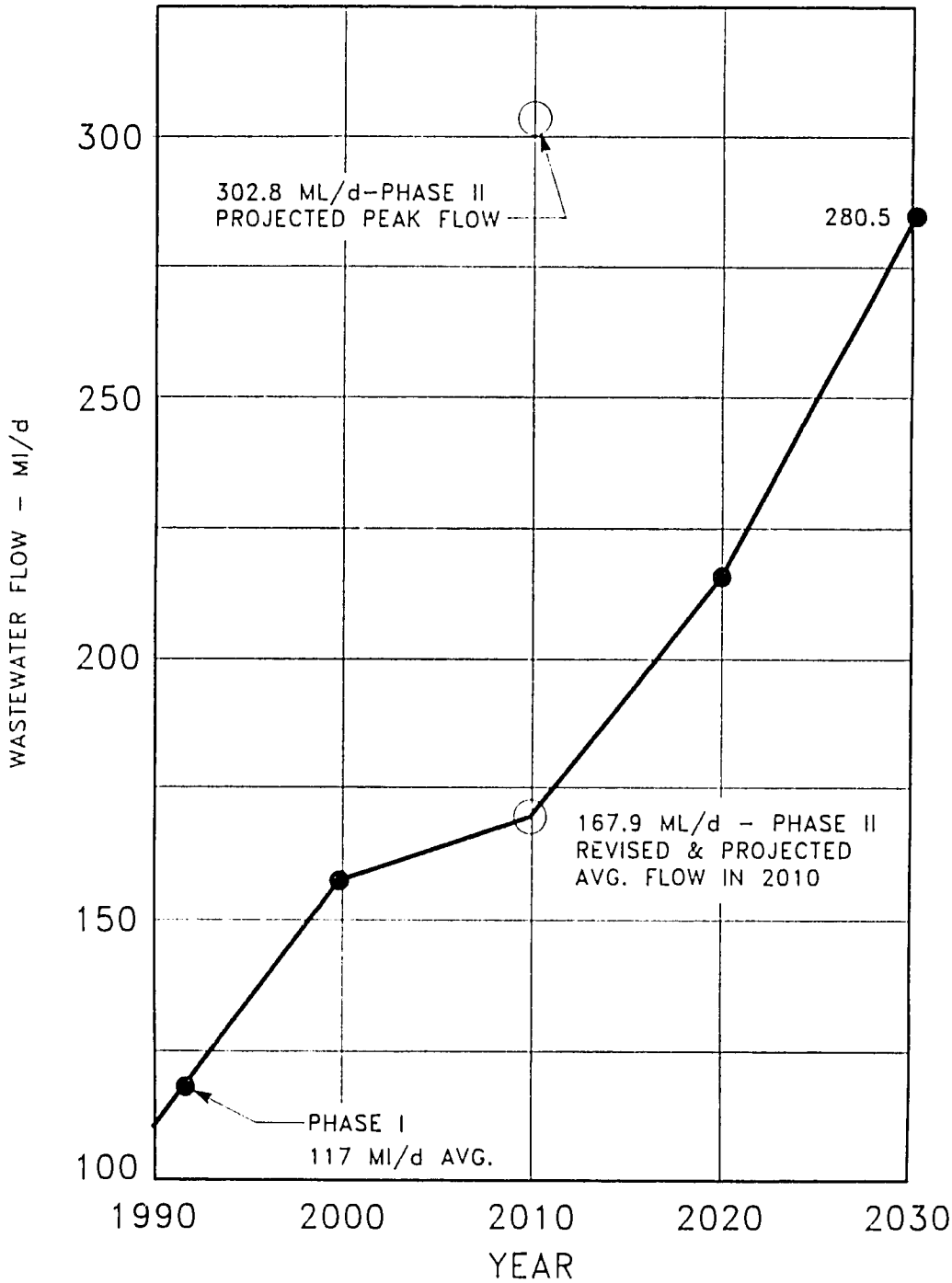
FIGURE 4-3
PROJECTED AVERAGE WASTEWATER FLOWS
ABU QIR PUMP STATION



1992 WASTEWATER MASTER PLAN UPDATE
ALEXANDRIA WASTEWATER PROGRAM

FIGURE 4-4
PROJECTED AVERAGE WASTEWATER FLOWS
MAAMOURA PUMP STATION

MASTER L/1



1992 WASTEWATER MASTER PLAN UPDATE
ALEXANDRIA WASTEWATER PROGRAM

FIGURE 4-5
PROJECTED AVERAGE WASTEWATER FLOWS
RAS EL-SODA PUMP STATION

MASTER L/2

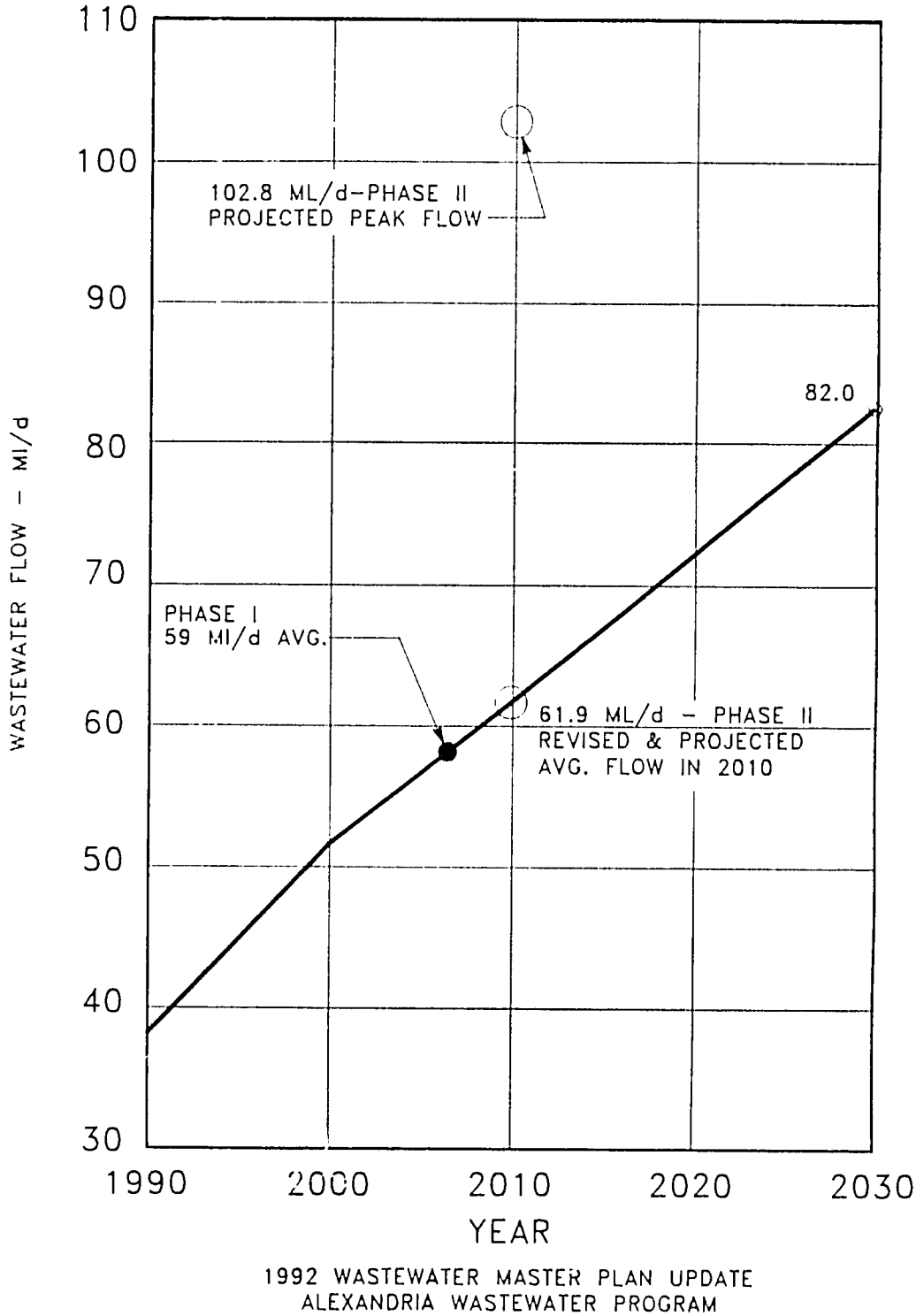
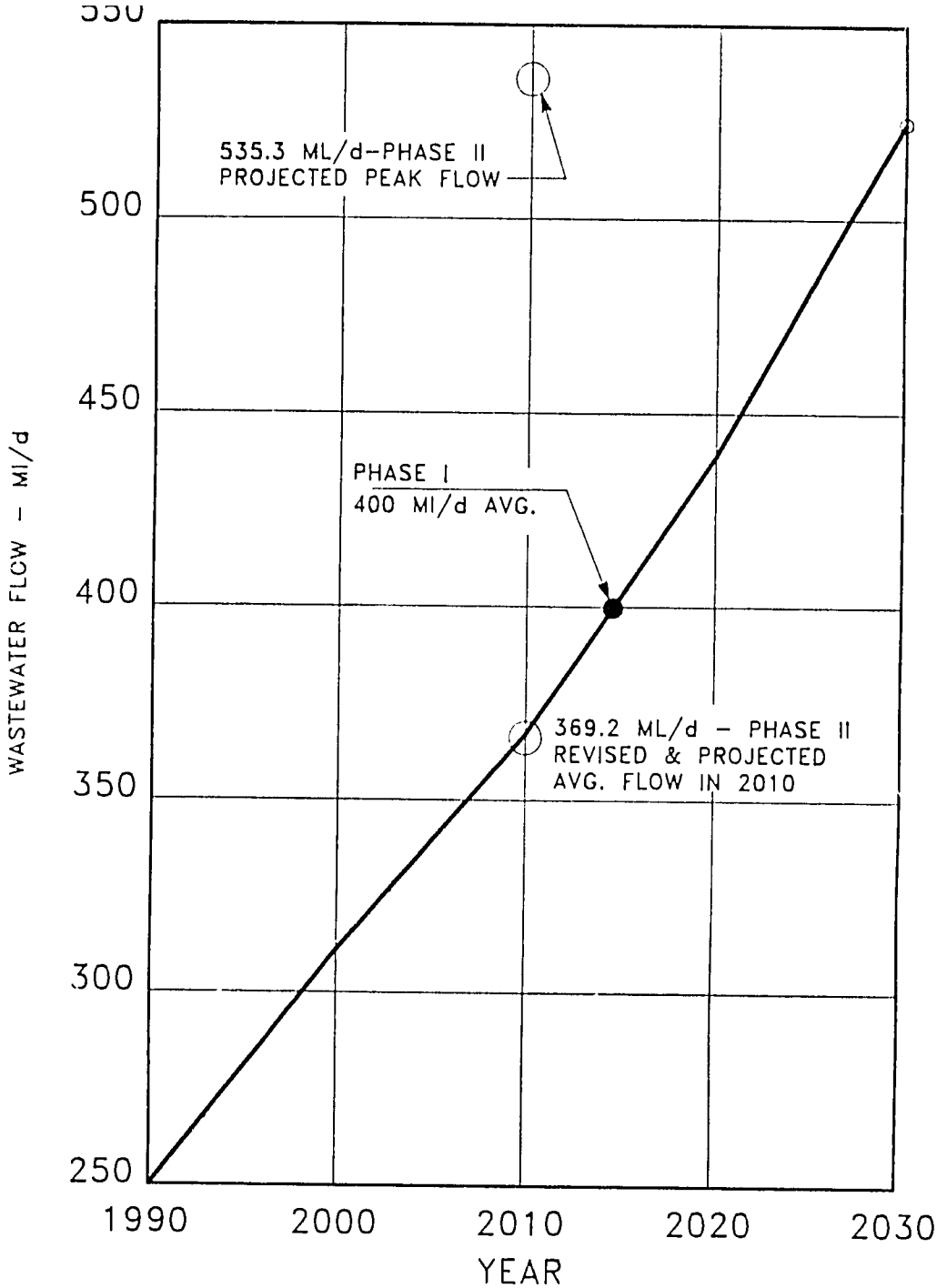


FIGURE 4-6
PROJECTED AVERAGE WASTEWATER FLOWS
SIDI BISHR PUMP STATION

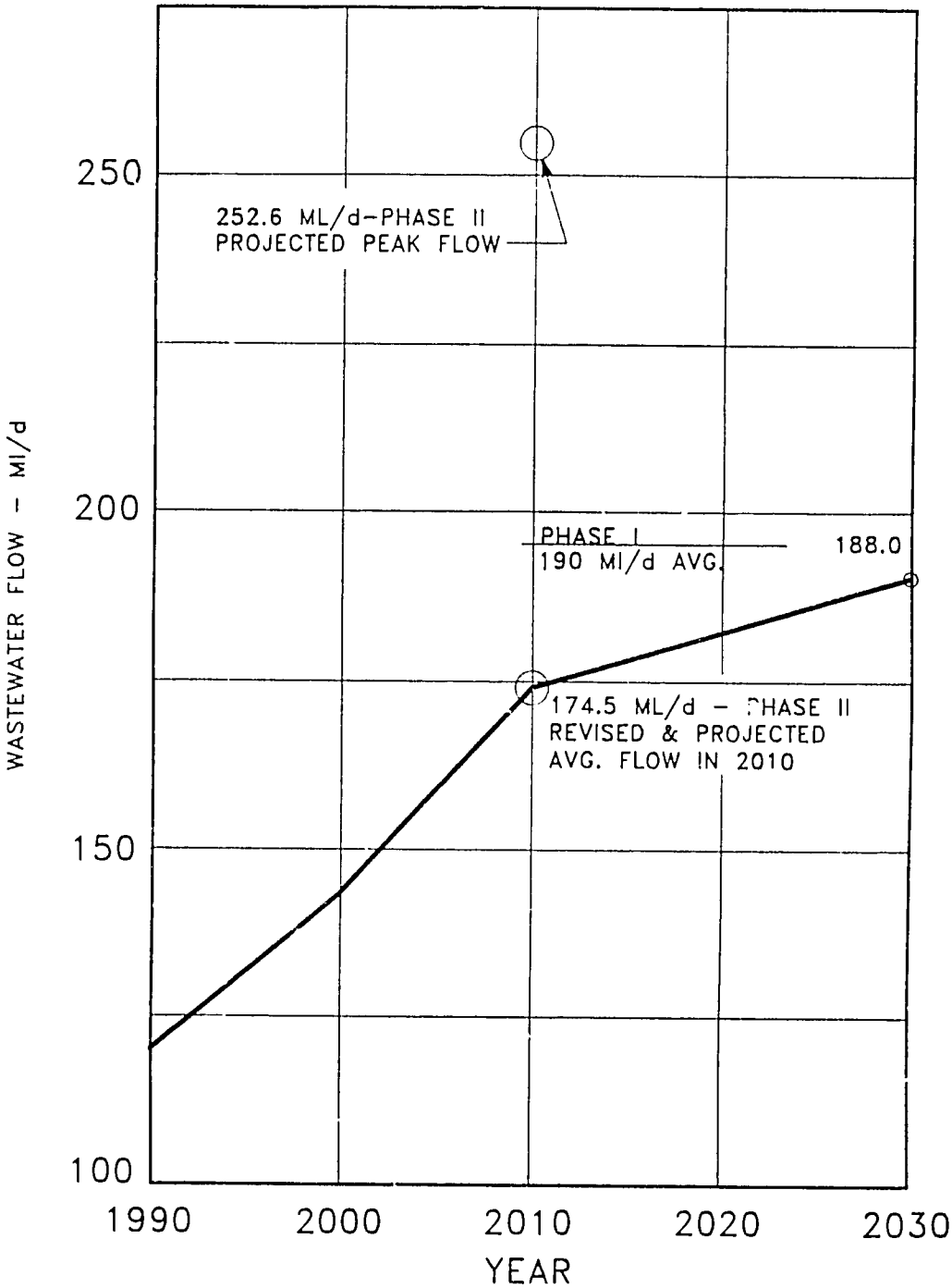
MASTER L/3



1992 WASTEWATER MASTER PLAN UPDATE
ALEXANDRIA WASTEWATER PROGRAM

FIGURE 4-7
PROJECTED AVERAGE WASTEWATER FLOWS
EAST ZONE PUMP STATION

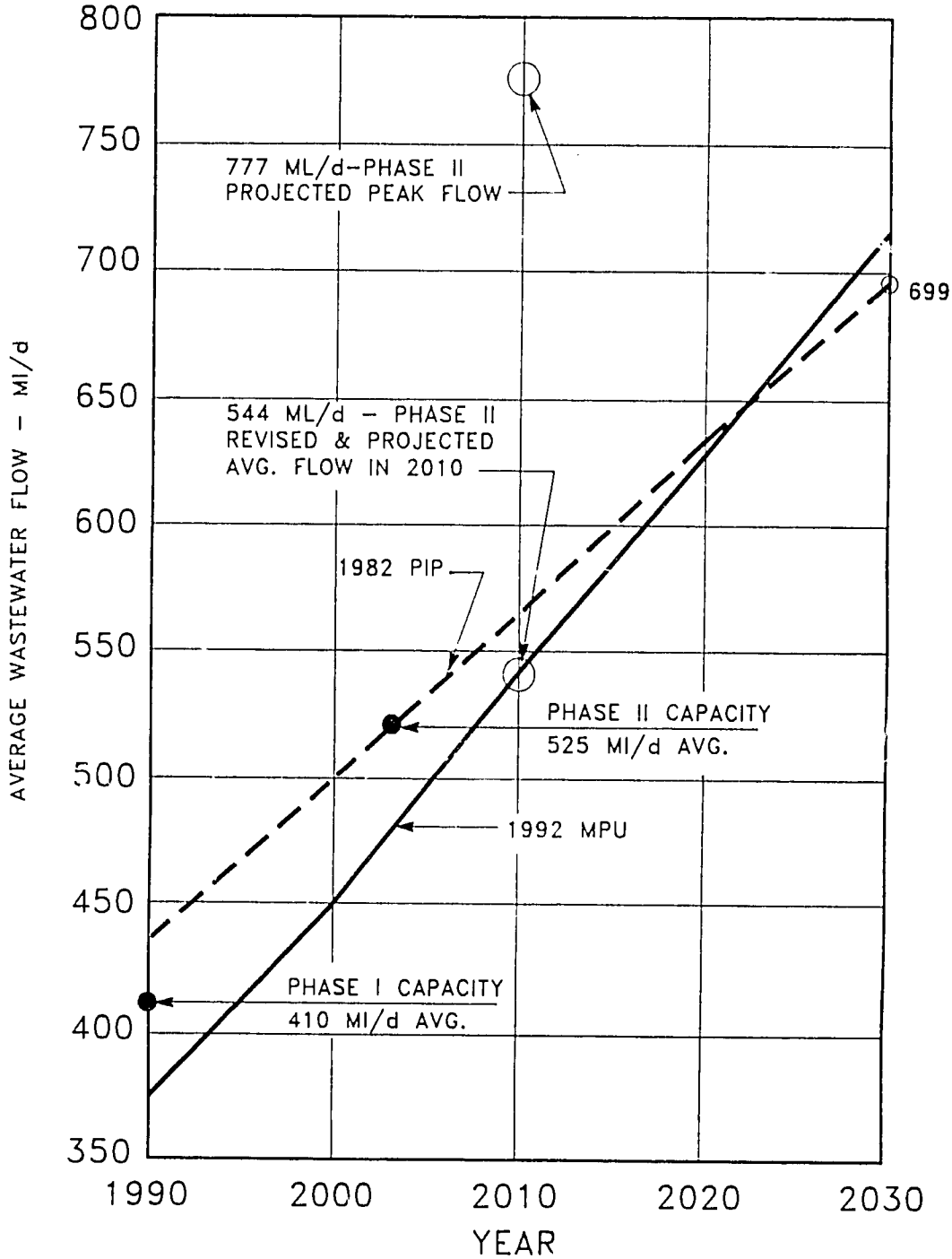
MASTER L/4



1992 WASTEWATER MASTER PLAN UPDATE
ALEXANDRIA WASTEWATER PROGRAM

FIGURE 4-8
PROJECTED AVERAGE WASTEWATER FLOWS
NEW SMOUHA PUMP STATION

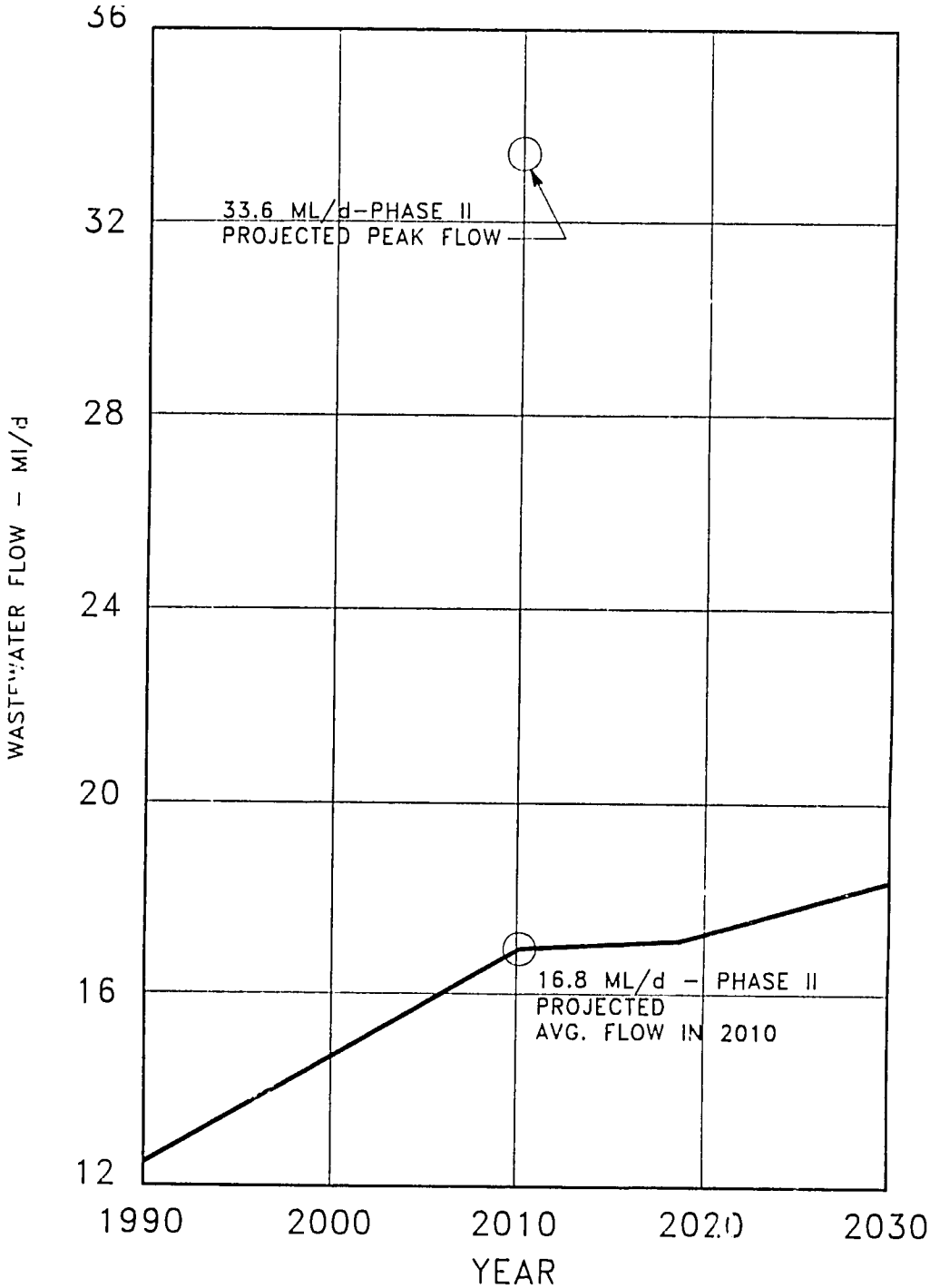
MASTER L/5



1992 WASTEWATER MASTER PLAN UPDATE
ALEXANDRIA WASTEWATER PROGRAM

FIGURE 4-9
PROJECTED AVERAGE WASTEWATER FLOWS
EAST TREATMENT PLANT

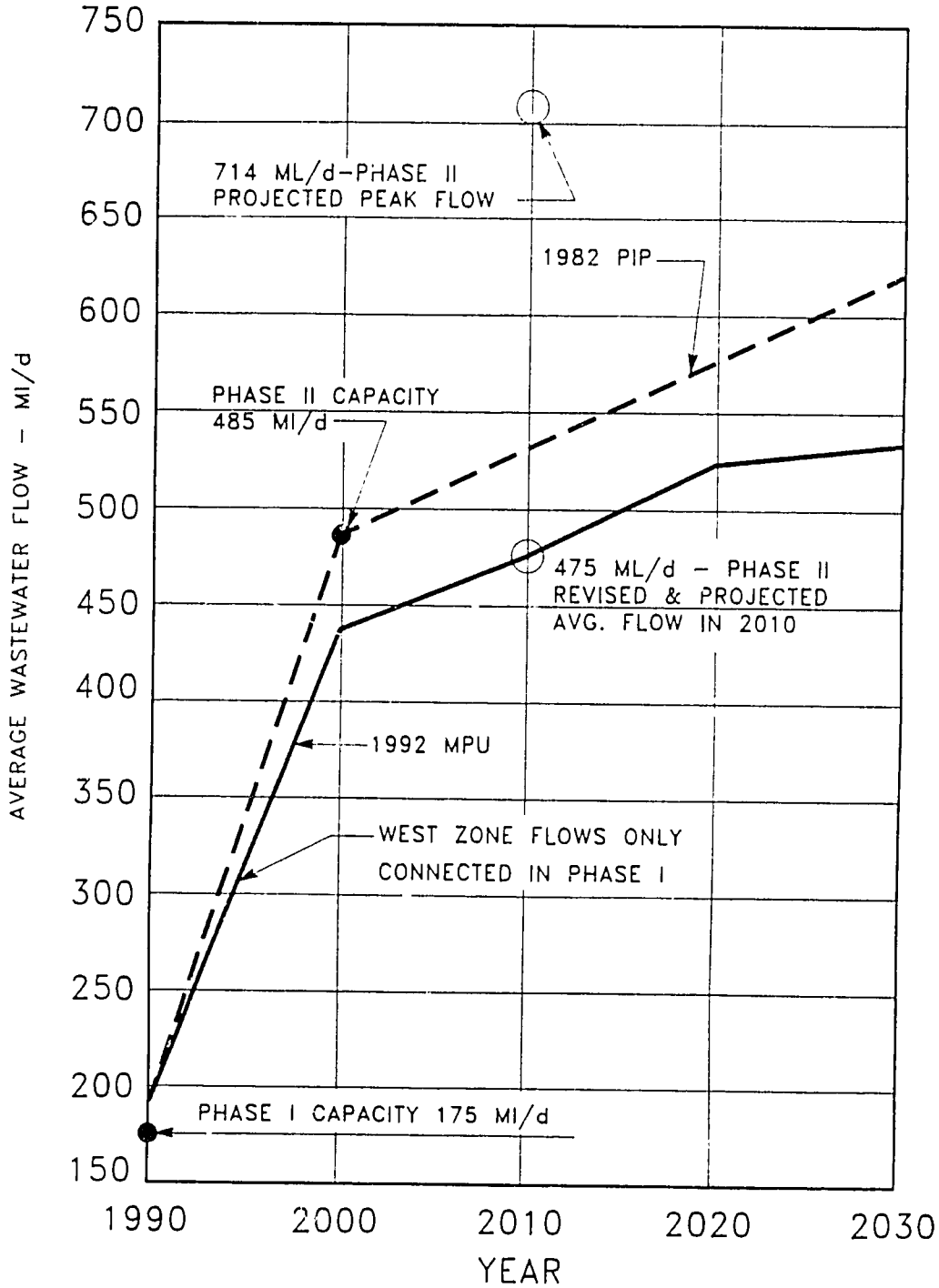
MASTER L/6



1992 WASTEWATER MASTER PLAN UPDATE
ALEXANDRIA WASTEWATER PROGRAM

FIGURE 4-10
PROJECTED AVERAGE WASTEWATER FLOWS
SPORTING PUMP STATION

MASTER L/7



1992 WASTEWATER MASTER PLAN UPDATE
ALEXANDRIA WASTEWATER PROGRAM

FIGURE 4-11
PROJECTED AVERAGE WASTEWATER FLOWS
WEST TREATMENT PLANT

CHAPTER 5

FUTURE CONSTRUCTION ALTERNATIVES EVALUATION

CHAPTER 5

FUTURE CONSTRUCTION ALTERNATIVES EVALUATION

The Alexandria Wastewater Program components described in Chapter 5 will be completed by December 1994. These pollution control improvements, grouped under the heading "Phase I", represent prioritized and indispensable elements of the overall program that are needed immediately. They do not, however, achieve the full objectives of the program nor were they intended to do so in themselves.

Completion of the Alexandria Wastewater Program to the point where USAID's environmental objectives are achieved in full, as originally envisioned, requires the continuation of design and construction activities. The projects in this category represent those that could not be implemented effectively until the necessary initial "Phase I" projects had been undertaken. For convenience, these projects are grouped under the heading "Phase II".

This chapter presents WWCG's evaluation of the various Phase II wastewater collection, treatment, disposal and sludge management alternatives that are available to achieve the program's environmental objectives fully. As discussed in Chapter 4, the Design Year 2010 is applicable to most Phase II components. Major conveyance systems such as the Outfall and Central Zone Tunnel systems are exceptions to this general rule; these would be designed and constructed to meet Design Year 2030 peak flow projections.

Options for Phase II works are discussed under the following section titles in this chapter:

- Effluent Disposal
- Treatment Plant Expansions
- Sludge Handling and Disposal
- Collection System Improvements
- Pump Station Improvements

It should be noted that the discussion in this chapter focuses on the potential "physical" components that are needed to meet the objectives of the Alexandria Wastewater Program in the next increment of planned construction. However, this discussion is not in any way intended to minimize the importance or need for the infrastructure support, institutional support and planning considerations that are addressed in Chapter 6.

WWCG's specific recommendations concerning the various Phase II alternatives addressed in Chapters 5 and 6 are presented in Chapter 8, following the cost considerations contained in Chapter 7.

EFFLUENT DISPOSAL

This section addresses the alternatives available to AGOSD for the disposal of treated wastewater. Interim and final effluent disposal options are discussed separately. Since Lake Maryout is integral to interim disposal options, a general discussion of the lake and its current environment is warranted prior to addressing the disposal alternatives themselves.

DESCRIPTION OF LAKE MARYOUT

Introduction

Lake Maryout is a large, fresh-water lake situated immediately south of western Alexandria. It is a shallow body of water, having an average depth of about one meter. Most of the lake is within the Alexandria Governorate. Lake Maryout comprises four major basins that are divided by the Alexandria-Cairo Desert Road, the Omoum Agricultural Drain and the Noubaria Water Canal. The basins are hydraulically interconnected by many large openings in the dikes of the Omoum Drain and Noubaria Canal. The basins are illustrated in Figure 5-1 and are identified in Table 5-1.

Essentially all wastewaters discharged to the lake enter the Main Basin, which is the water body most visible to the public. Wastewater from the Western Zone of Alexandria enters the Main Basin primarily via three north shore outfalls: Qabbari; Gheit El Enab; and Industries. These outfalls will be discontinued as soon as the West Treatment Plant is commissioned. Wastewater from Alexandria's Eastern Zone enters the southeastern quadrant of the Main Basin, with agricultural drainage and stormwater, via the Kalaa Drain. The Northwest, Southwest and Fisheries Basins are not directly influenced by municipal sewage but the water quality of these basins has been severely degraded by agricultural runoff and by water interchange with the Main Basin over the years.

Other than untreated domestic and industrial sewage, the principal sources of inflow to Lake Maryout are nutrient-rich agricultural drainage flows. Order-of-magnitude average flow estimates for all sources of flow entering Lake Maryout are summarized in Table 5-2. Approximately 50-60 percent of the total Kalaa Pump Station flow cited in the table consists of Eastern Zone wastewater of domestic and industrial origin that enters the Kalaa Drain from the Smouha and Hydrodrome Drains, upstream of the Kalaa Pump Station.

The Noubaria Water Canal is another but very minor source of both salt and fresh water inflow to the Lake. Water levels in the Noubaria Canal are adjusted by locks to permit small boat traffic to move back and forth from the lower reaches of the canal to the Mediterranean Sea. The El Mex Pump Station, which discharges lake water to the sea outside Alexandria's Western Harbor, is used to control lake water surface elevations between (-2.0) and (-2.8) meters below sea level.

The travelling public is subjected to strong odors from the lake along the Desert Road, particularly near the southeast corner of the Main Basin. These odors have been the subject of public complaint and criticism for many years. The exact source and breakdown of these odors have not been identified. Certainly at least part of the odors comes from the large garbage dumping and landfill operations in the area. Another part is probably generated by the decomposition of organic sediments and floating material (grease and oils, in some cases 30 cm thick) resulting from the sewage discharges to the Main Basin. The odors are carried to the southeast corner of the Main Basin by the generally northwest-to-southeast prevailing winds.

Lake Maryout has few uses at the present time. Some fishing activities take place in the lake but these are no longer significant because of increasing concerns and awareness of lake contamination. The high evaporation rate (about 5 mm/day) compared to fresh water inflow also renders the lake too saline for direct agricultural reuse. At this rate, fresh water evaporation losses from the Main Basin alone amounts to approximately 94,250 cubic meters/day.

Lake Maryout Water Quality Monitoring Study - 1983

WWCG conducted a limited study of Lake Maryout in early 1983 to establish baseline water quality conditions at that time. Monthly water samples were taken at approximately 56 locations throughout the four basins of the lake, the Kalaa and Omoum Drains, and the Noubaria Canal. They were analyzed for a broad spectrum of wastewater parameters, heavy metals and algae.

A partial summary of results from this 1983 Lake Maryout Water Quality Baseline Study is presented in Tables 5-3 and 5-3A. The data shown represent averages at 26 sampling points in the Main Basin of Lake Maryout only. Grab samples were taken once per month in February, March and April 1983. The selected data is summarized in this report to indicate the general quality of the Main Basin in 1983. Where appropriate, these data are compared below to more recent sampling results to assess lake quality changes over the past nine years. Complete data results of the 1983 baseline study are available in WWCG's files.

Key conclusions of the 1983 lake study are highlighted as follows:

- Water quality throughout Lake Maryout is very poor and reflects substantial pollution.
- The limited data indicates that a significant reduction in organics (e.g. BOD, COD) and bacteria takes place in the influent drains and in the lake prior to the discharge of lake water to the sea at the El Mex Pump Station.
- There is a degree of interaction between the waters of the four lake basins.

- Very little flushing of the shoreline waters of the Main Basin, where the most septic and odorous conditions are found, to more central waters takes place.

Lake Maryout Water Quality Monitoring Study - 1992

Lake Maryout is critical for interim effluent disposal in both the current upgrading (Phase I) and the initial expansion (Phase II) of Alexandria's wastewater collection and treatment system. No other practical, timely effluent disposal options other than using the lake can be implemented before a permanent means of disposal such as an outfall or land treatment/disposal is placed in operation.

Consequently, USAID authorized WWCG to conduct an "environmental assessment of continued wastewater discharge into Lake Maryout". This work commenced in March 1992; it will be completed in the first quarter of 1993. The purpose of the work is to assess the Lake's present condition and to predict the impact of continued wastewater discharges to it over the short term.

The following discussion presents WWCG's preliminary assessment of lake conditions based on our 1992 sampling program to date. WWCG's further evaluation of impacts with respect to the interim disposal options discussed below must also be considered preliminary because the current lake assessment work is still ongoing.

The 1992 Lake Maryout sampling program involves the collection of water, algal and bacterial samples from nine land-based drains discharging untreated industrial and domestic wastewater to the lake and the collection of water, sediment, algal and bacterial samples from ten receiving water locations in the lake. The sampling program is scheduled to be conducted from March 1992 through March 1993 and, when completed, should provide comprehensive baseline information which can be used to characterize existing conditions of the lake and the discharges. Results of this sampling program are available only for data collected during the first three to five months of the program, depending upon the type of analyses performed.

The following discussion presents a preliminary assessment of conditions in Lake Maryout, based on the limited data collected to date. To provide a better representation of the past and present conditions of the lake, available 1992 water quality data is compared here to the sampling data collected in 1983.

Water Quality. Ten receiving water stations, located in the lake's Main and Northwest Basins, and nine land-based drains were selected for sampling so that the effects of the current discharges could be characterized and the effects of the proposed East and West Treatment Plant discharges could be predicted. Water samples collected from the lake and drains were analyzed for the following parameters:

- Temperature
- Conductivity
- Total Solids
- Volatile and Fixed Solids
- Heavy Metals
- Alkalinity
- Chlorides
- Total Hardness
- Calcium Hardness

Initial water quality data, collected from March through July 1992, indicate that the lake continues to be severely degraded in the Main and Northwest Basins (see tables 5-3 and 5-3A). In general, dissolved oxygen concentrations in these basins have decreased and biochemical oxygen demand and chemical oxygen demand concentrations have doubled since the 1983 sampling survey. Receiving water pollutant concentrations often exceed levels of concentrations associated with "strong" untreated wastewater (Metcalf & Eddy, 1991)

Large portions of Lake Maryout are anoxic, as evidenced by the extremely low dissolved oxygen concentrations measured in the Main Basin. Between March and July 1992, 80 percent of the dissolved oxygen concentrations measured in samples from the Main Basin were equal to zero mg/l and all concentrations were equal to or less than 2.5 mg/l. Although higher concentrations of dissolved oxygen are typically associated with cooler waters, dissolved oxygen concentrations were consistently low during both spring and summer sampling periods. In the United States, a minimum dissolved oxygen concentration of 5 mg/l is typically required for warm waters designated, at a minimum, for secondary contact recreation and as suitable habitats for wildlife and fish. The average measured dissolved oxygen concentration of 0.4 mg/l observed in the Main Basin is over one order of magnitude lower than this limit. Under the anoxic conditions of the Main Basin, the promotion of a healthy aquatic population is inhibited and only pollution tolerant species are able to survive.

The U.S. Environmental Protection Agency (EPA) has established guidelines for the protection against acute (short-term) and chronic (long-term) effects on sensitive aquatic species and for the protection against human health effects from eating fish. These criteria are used in establishing standards and regulatory requirements, however they are guidelines and do not serve as regulatory standards themselves. Comparison of concentrations of copper, lead and mercury from both the 1983 and 1992 sampling programs to U.S. EPA aquatic life water quality criteria indicates that elevated concentrations of metals exist in the lake. Average concentrations of copper for the two sampling programs were approximately equal to the U.S. EPA acute aquatic life criterion and exceeded the chronic criterion by a factor of up to six. Average lead concentrations exceeded the U.S. EPA acute criterion by a factor of 2 to 16. The average mercury concentration of 120 ug/l in the Main Basin, measured during the 1983 sampling program, was 50 times higher than the U.S. EPA acute water quality criterion of 2.4 ug/l, and 10,000

times higher than the chronic water quality criterion of 0.012 ug/l. In addition, this concentration was 800 times higher than the U.S. EPA human health fish consumption water quality criterion of 0.15 ug/l for mercury.

No recent data are available for the Fishery and Southwest Basins. However, given the sampling results for the Main and Northwest Basins, it is likely that pollutant concentrations in these areas are either similar to or worse than those observed during the 1983 sampling program. During the 1983 sampling surveys, concentrations of total solids, total suspended solids, volatile suspended solids and sulfates in samples collected from the Fishery and Southwest Basins exceeded concentrations typically found in strong untreated wastewater. Concentrations of BOD, COD and oil and grease were similar to those concentrations associated with "weak" untreated wastewater.

Algal Populations. Algae were sampled and identified from March through May, 1992 in Lake Maryout, Egypt. The dominant genera identified include chlorophyta (green algae) and Bacillariophycaea (diatoms). The abundance and diversity of genera changed through the sampling period. In March 1992, algae were identified broadly as chlorophyta, Diatoms, and Euglenophyta. In April 1992, dominant algae included: Euglena, Chlorella, Cyclotella, Ulothrix, Zygnema, and protozoa sp. The composition of algae in Lake Maryout changed when sampling was performed in May 1992. In addition to Euglena, Chlorella, and Cyclotella identified in the April samples, Melosira, Spirulina, Tabelaria, Agmenellum, Phytoconies, and diatom sp. appeared in the water column. In June 1992, most of these genera remained in the water column. Three genera present in the May sample, Chlorella, Agmenellum, and Phytoconies disappeared in June and were replaced by Pediastrum, Actinastrum, and Stephanodescus.

Several generalizations may be formed regarding the genera of algae identified in Lake Maryout and may be used to understand the water quality of Lake Maryout. Several genera identified have been associated with different water conditions. For example, Chlorella, Euglena, and Agmenellum are algae usually found in polluted water [16]. Euglena are usually found in waters contaminated by animal pollution or decaying organic matter. This information suggests that Lake Maryout is poor water quality since it is dominated by algae that are able to survive in polluted conditions.

Another indication that Lake Maryout consists of low water quality is the low density of algal cells present throughout the sampling period. The total number of algae identified ranged from 6.5 to 1092 cells/l. Although periodic oscillations in abundance of algal species is expected, density for each species typically ranges from 0–4000 cells/ml within a growing season [17]. Thus, total densities are significantly lower than those found in normal lakes, indicating a severely stressed system.

Bacterial Levels. Bacterial levels in samples collected from the land-based drains and receiving water stations during March through May 1992 indicate that the untreated wastewater discharged by the drains consistently exceeded the limit of 5000 MPN/100 ml for coliform by a factor of 1,000,000. In addition, receiving water samples collected from

the Main and Southwest Basins often exceeded this limit by a factor ranging from 1,000 to 1,000,000. Bacterial counts from samples collected in the Northwest Basin ranged from 96 to 1200 MPN/100 ml, reflecting the die-off and dilution of bacteria which are discharged in to the Main Basin and flow into the Northwest Basin.

Conclusions. Current conditions in Lake Maryout have deteriorated even more since 1983 indicating a severely stressed aquatic system. The excessive concentrations of solids, BOD, COD and metals (in particular mercury), and the low concentrations of dissolved oxygen in the lake have resulted from years of discharging untreated wastewater to the lake. The lake's anoxic environment prevents the establishment of healthy, diverse aquatic population. In addition, metals concentrations threaten aquatic life and human health from fish consumption.

INTERIM EFFLUENT DISPOSAL

This section addresses options for disposal of primary effluent during the "interim" period between startup of the East and West Treatment Plants (Phase I) and startup of permanent effluent disposal facilities such as a sea outfall or a land treatment and disposal system. The advantages and disadvantages as well as WWCG's preliminary evaluation of the environmental impact of the interim options are presented.

Since the earliest days of the current Alexandria Wastewater Program, the land and sea were the only ultimate discharge points considered feasible, cost-effective and environmentally acceptable for the ultimate disposal of Alexandria's wastewater.

With the exception of the Central Zone's raw wastewater discharges to Alexandria's coastline, domestic and industrial wastewater in Alexandria is discharged, untreated, to Lake Maryout. Over the decades, this practice has transformed a body of water that was once considered a national resource into a heavily polluted and perhaps toxic sink for the City's liquid wastes.

Sewerage facilities now being implemented under Phase I of the Alexandria Wastewater Program will provide primary treatment for East and West Zone wastewaters before these flows are discharged to the Lake. The Program also calls for providing primary treatment to Central Zone wastewaters before discharge to Lake Maryout in the next stage of planned development. Diverting Central Zone sewage to treatment will have a further positive impact on the beaches, especially during the summer tourist and swimming season. In the short-term at least, Lake Maryout is the only discharge point available if basic treatment is to be provided for Alexandria's wastewaters.

Before a permanent means of effluent disposal can be implemented, the impact of using Lake Maryout for interim primary effluent disposal must be considered. Two discharge options warrant examination:

- Direct disposal of primary effluent to Lake Maryout.

- Bypass Lake Maryout by rerouting primary effluent directly to the sea via the Omoum Drain and El Mex Pump Station.

Direct Disposal of Primary Effluent to Lake Maryout

This interim scenario will continue the use of Lake Maryout for wastewater disposal, much the same as the lake is used now. In this case, however, the discharges will be primary effluent rather than untreated sewage.

At startup of the current Phase I improvements (Summer 1993), approximately 213 Ml/day (excluding Nouzha and Central Zone areas) of treated wastewater from Alexandria's West Zone will be discharged from the West Treatment Plant to the north shore of Lake Maryout's Main Basin through a single outfall. Raw sewage discharges from the West Zone's three major lake outfalls (Qabbari, Gheit El Enab and Industries) will be discontinued once these are connected to the new West Zone Collector, which will convey these flows to the West Plant for primary treatment.

Start up of Phase I facilities in 1993 at the East Plant will result in the rerouting of approximately 395 Ml/day of wastewater from Alexandria's East Zone to the East Plant prior to discharge to Lake Maryout. East Plant effluent will be discharged to the southeast quadrant of Lake Maryout's Main Basin by the same route untreated sewage is now transported: via the Hydrodrome Drain, the Kalaa Pump Station, and the Kalaa Drain. The effluent will combine with agricultural and stormwater drainage en route.

When the East and West Treatment Plants are expanded to accommodate the Phase II design flows, treated effluent would continue to be discharged in the interim to Lake Maryout as described above until the permanent effluent disposal facilities planned for Phase II are operational. To accommodate anticipated average flow conditions in Design Year 2010, the future program would consist of expanding the West Treatment Plant from 175 to 475 Ml/day, primarily for treatment of wastewater from the Central Zone. The capacity of the East Plant would be expanded from 410 Ml/day to 544 Ml/day to incorporate population increases and AGOSD's hookups of various sewerage areas.

The impact of organic and suspended solids wastewater loads to Lake Maryout under this development scenario is illustrated in Table 5-4. Under pre-Phase I startup (1993) conditions (i.e. without primary treatment), average BOD and suspended solids loadings to Lake Maryout are estimated to be about 316,160 and 322,240 kg/day, respectively. Using this condition as a benchmark for comparing future loads, the following conclusions can be made from the loading estimates presented in Table 5-4:

- When Phase I facilities are placed in operation, organic (BOD) and solids loads to Lake Maryout will initially decrease to about 75- and 50-percent of pre-Phase I loadings, respectively.

- As the proposed Phase II facilities are completed and Central Zone flows are diverted to the expanded West Plant, organic loads to Lake Maryout will gradually increase through Design Year 2010 to about 126-percent of current loads but suspended solids loads, although significantly higher than those in Phase I, will peak at about 84-percent of current loads.

- When Central Zone flows are diverted to the West Plant in Phase II, direct wastewater discharges to the beaches of Alexandria will be eliminated.

- When all Phase II facilities are fully completed, including the permanent effluent disposal system, wastewater pollutant loads to Lake Maryout and to the beaches of Alexandria will be eliminated.

Continuing wastewater effluent discharges to Lake Maryout through Phase II as described above has the advantage of avoiding expenditures that might be better spent on permanent facilities.

The principal disadvantage of this option is that it makes no positive attempt, other than providing much needed initial wastewater treatment, to mitigate further potential short-term degradation of the lake. Although the total organic load to Lake Maryout will decrease initially when the Phase I works are placed on line, this load will ultimately climb above current levels through Phase II as population increases and area sewerage connections to the system are made. Note, that the suspended solids load, however, will continue to be below pre-Phase I levels. Given the current heavily polluted conditions of the lake, the real water quality and health impacts of the changes in organic loads described above are very difficult to predict with confidence. However, public perception will probably be that little has been done. One of the more recognizable pollution conditions in the lake, odors along the southeast shore of the Main Basin, are likely to continue at roughly the present levels

Computer Model. A simple computer model of Lake Maryout was created to simulate existing and Phase I hydraulic conditions and concentrations of BOD and dissolved oxygen. Using the model, the lake was split into small subareas so that the movement or exchange of flows and pollutant concentrations between the areas could be simulated.

The model used a water budget approach in which the flows into the lake (and subareas) were balanced with the flows out of the lake (and other subareas). Sources of inflow included wastewater outfalls, drains, and groundwater recharge, while types of outflow included evaporation and the El Mex Pump Station. Where water from one subarea was expected to flow into multiple subareas, certain assumptions were made to reflect the exchange of water. These assumptions were based on factors such as the direction of currents and the presence of physical barriers. Both evaporation and groundwater flows were calculated based on the total wet area of the subarea.

The most recent data available were used to create the model of Lake Maryout. Model inputs included: flows estimated in 1983 for the drains which discharge to the northern shore of the Main Basin, flows estimated in 1990 for the Omoum and Kalaa Drains, and BOD and dissolved oxygen data from the 1992 sampling program. No information is available for the two Industries Drains. It was assumed, therefore, that the flow in each of these drains was relatively small, 10,000 m^3 day, and the pollutant concentrations in the drains were equal to those concentrations measured at the receiving water station, located in the Northwest Basin.

Model Results. Current and Phase I concentrations of BOD in the lake were simulated using the model; refer to Table 5-3B. It should be noted that because only limited water quality data were available and the validity of using 1983 flow data is suspect, the model should only be used to provide order of magnitude predictions of water quality parameters.

Comparison of measured BOD concentrations with simulated concentrations for existing conditions indicates that the concentrations are in close agreement in the southeast portion of the Main Basin. The model appears to under-predict BOD concentrations in the north and west portions of the Main Basin, however, examination of the 1992 data indicates that the data may not fully reflect the conditions in the lake. In many cases, the average 1992 BOD concentrations are higher in the receiving waters of the Main Basin than in the wastewater discharging to these waters. Because of BOD decay, receiving water concentrations of BOD are expected to be lower, not higher, than wastewater concentrations. The trend of BOD concentrations indicates that some of the information used to examine the system is either incomplete or inaccurate.

Possible explanations for these trends are: there may be pollution sources to the lake which are unknown and therefore, unmeasured; or the estimated flows of the outfalls and drains to the lake may not reflect present conditions in the lake; or laboratory error may have influenced the measured concentrations. Collection of water quality samples is scheduled to continue through the spring of 1993. The additional information collected may provide some insight concerning the concentrations of BOD in the lake and its discharges.

Keeping the model limitations in mind, predictions can be made related to the future condition of the lake, following implementation of Phase I. Once the East and West plants are operating, a small improvement in BOD concentrations in the southern portion and the northeast corner of the Main Basin can be expected. Concentrations of BOD could decrease in these areas by approximately 5 to 50 percent, depending on the location within these basins. The improvements in the south and northeast portions of the Main Basin will likely be offset by the further degradation of the northwest corner of the Main Basin and the eastern portion of the Northwest Basin from discharge of primary effluent from the West plant. Based on the model predictions, BOD concentrations in these areas could increase by 10 to 30 percent. Wastewater flows will be discharged to Main Basin and are expected to move from the Main Basin through the Noubaria Canal

and the eastern portion of the Northwest Basin to the Cmoum Drain and the El Mex Pump Station. Therefore, water quality is not predicted to be improved in the remaining portion of the Northwest Drain or in the Fishery or Southwest Basins.

The elimination of raw wastewater discharges and replacement of these with the two larger Phase I discharges of primary effluent may cause a shift in water quality within the lake so that conditions within the south and northeast portions of the Main Basin will improve while conditions in the remaining portion of the Main Basin and in part of the Northwest Basin may be further degraded. During Phase II, when the wastewater from the Central Zone will be treated by the West Treatment Plant and discharged to the lake, water quality conditions between the west outfall and El Mex pump station are expected to degrade even more.

Because of the limited water quality and flow data available at this time, and because some of the BOD concentrations in the system are suspect, dissolved oxygen concentrations cannot be accurately predicted using the model. Given the current dissolved oxygen concentrations and the predicted Phase I BOD concentrations in the Main Basin, the anoxic conditions present in the Lake's Main Basin are expected to continue after implementation of Phases I and II. There may be small areas within the Main Basin which show some improvement in dissolved oxygen concentrations, however this improvement is expected to be minimal.

Conclusions. The Phase I program could result in some localized improvements along the north shore of the lake. By eliminating the raw wastewater discharges, there could be some improvement in dissolved oxygen (DO) in shallow areas where reoxygenation per unit volume is relatively great. This could potentially result in the reintroduction of some tolerant fish species in localized areas. However, it is likely that anoxic conditions would return periodically during periods of high temperature, low wind, and reduced flow from agricultural drains. The anoxic conditions would result in fish kills if populations became established in localized areas.

The reduced discharges along the north shore could also improve sediment conditions. With at least periodic aerobic conditions and the significantly reduced solids discharge, the build-up of anaerobic sediments would be halted and the existing deposits might start to decrease due to animal and bacterial metabolism.

The algal conditions in the lake are currently severely degraded and this condition is not expected to change as a result of the Phase I program. The extremely low densities and domination by pollution tolerant species is likely caused by a combination of factors. The extreme turbidity limits light which effects algae, and the generally anoxic conditions inhibit the normal cycling and processing of nutrients, so even though the lake is extremely nutrient rich, the form and availability of nutrients may significantly affect the algae in the lake. Also, the hydrogen sulfide prevalent throughout the lake is toxic to many species and constitutes a significant stress on the algae and other organisms attempting to survive in the lake. Finally, the heavy metals and other industrial chemicals present in

the water column and sediments are certainly a stress on all forms of lake biota. On a lake-wide basis, none of these conditions are expected to change significantly as a result of Phase I improvements. Consequently, since the algal assemblage is largely integrated over the entire lake, the algal community within the lake is not expected to change. Since the algae form the base of the food chain and other in-lake biological processes, lack of improvement in the algae will be reflected by lack of improved conditions in the overall biological characteristics of the lake. This would mean there would continue to be only rare and isolated occurrence of fish, only extremely pollution tolerant species present, and generally lake-wide anoxic conditions.

Bacterial conditions in the lake could show some improvement as a result of diverting and treating north shore raw discharges. The concentrations would significantly decrease in localized areas and, due to solids removal, overall lake concentrations should show some improvement. Probably the most important improvement would be that the concentrations, and thus the potential health risk, would decrease in the nearshore areas which represent greatest potential for possible human exposure.

Phase II improvements would most likely represent a continuation of lake changes described above for the Phase I program. Localized conditions in some north shore areas would show signs of biological integrity as normal lake processes proceed uninhibited and the anoxic sediment deposits decrease. However, the overall lake conditions as represented by the algal community would be very similar to existing conditions. The increased BOD and suspended solids loading to the main portion of the lake as a result of the Phase II program would probably produce even worse biological and water quality conditions than presently exist.

The greatest Lake Maryout concerns are odors (caused by anoxia), bacterial contamination, and a severely degraded biological community (caused by anoxia and toxic compounds). As a result of Phase I, all of these conditions will be marginally improved in isolated areas along the north shore. However, with the possible exception of bacteria, all of these conditions will be degraded in the lake as a whole. Except during certain weather conditions, the anoxia, hydrogen sulfide and thus, odor conditions would generally be similar to or worse than present conditions in most areas of the lake. Following Phase II improvements the trend of marginal improvement to some areas of the north shore and overall lake degradation will continue.

The water quality and biological characteristics of a lake generally falls into one of three categories. A clean lake has a health biological assemblage and an orderly, well buffered, oscillation of conditions based on seasonal, water balance, or internal (e.g. nutrient cycling) processes. A lake subject to significant stress generally supports excessive, but out of balance, biological conditions alternating with wide and abrupt abiotic (demise of the biological community) conditions. The massive oscillations in such systems produce fish kills, growth of excessive algal populations, and then the demise and decay of the algal. The fish kills and dying algal assemblages produce anoxia, odors, and a strong general impression of a very polluted system. The third category of lake

conditions is basically abiotic the entire year. In such cases, the pollution and other sources of stress are so severe the biological processes can never get started. Consequently, the system always appears bad but there is no punctuation of obvious periods of degradations as opposed to the second category of lake where periodic periods of die-off are highly visible.

Lake Maryout is currently in the third of the above categories of lakes: continually abiotic. With the full implementation of Phase I, it is possible that some small, but highly visible, areas of the north shore could move toward conditions reflective of the second category of lake: excessive growth alternating with abiotic conditions. The remainder of the lake might show a BOD degradation but since it is already largely abiotic little change in the water quality and biological conditions would be noted. Changes in the lake due to Phase II improvements would be similar in type but greater in magnitude to Phase I conditions. The over all perception could well be no improvement in most of the lake and severe degradation in the north shore area because of fish kills and the presence and then die off of massive algal populations. This is some what ironic because just the opposite would be true: marginal improvement in the north shore and worse conditions in the overall lake.

Lake Maryout Bypass Options

Possible opportunities do exist for mitigating the potential adverse impacts of primary effluent discharges on Lake Maryout before such discharges can be eliminated entirely by permanent effluent disposal facilities.

As noted previously, both organic and solids wastewater loads to the lake will decrease significantly as soon as the Phase I facilities are placed in operation. Solids loads to the lake will remain lower than current levels through Phase II. Organic loads will continue below current levels until total primary effluent flows to the lake exceed about 810 Ml/day, which is well into Phase II operations. Beyond this point, however, organic loads to the lake will be higher than current levels.

The Phase II Implementation Schedule presented in Figure 9-1 indicates that the treatment plants can be ready to accept increased flows from the Central Zone and other areas of the City about 3.5 years before permanent effluent disposal facilities are on-line. Diverting these flows to treatment as soon as possible will benefit the City. However, discharging the added loads to Lake Maryout will continue to deteriorate the Lake.

A possible solution to this problem is to upgrade and use existing drains and pumping stations, or construct new facilities, to divert plant effluent flows around the Lake until permanent effluent disposal systems are ready to assume the load. Potential effluent diversion systems for the East and West Treatment Plants are illustrated in Figure 5-2.

Diversion of East Plant Effluent. Three options have been reviewed for diverting East Plant effluent from its current discharge point near the southeast corner of Lake Maryout's

Main Basin. The first two options involve separate diversions of the East and West Plant's effluents while the third option incorporates combined effluent diversions from both East and West Plants.

In the first two cases, plant effluent would continue to flow from the East Plant to the Kalaa Pump Station via the Hydrodrome and Kalaa Drains, as it does now. At the Kalaa Pump Station, flow can be directed either to the Maryout Agricultural Drain leading to the Dishoudy Pump Station or to the Abis Agricultural Drain leading to the Abis Pump Station. In either of these cases, the capacity of the pump station (Dishoudy or Abis) and associated influent drain would have to be upgraded substantially to handle the additional peak flow of the Kalaa Drain, which is currently estimated to be about 770,000 cubic meters per day.

The advantages of these first two options are:

- Direct wastewater discharges to Lake Maryout's Main Basin from the East Treatment Plant would be eliminated before permanent effluent disposal facilities could be placed in operation.

- Diverting East Plant discharges in this manner may help reduce (but certainly will not eliminate) wastewater-generated odor problems in the southeast portion of the Main Basin.

- By diverting flows directly to the Omoum Drain, the East Plant effluent will be immediately diluted with agricultural drainage before the effluent partially re-enters the lake through the many dike openings in the Omoum Drain.

The disadvantages of these two options are:

- Upgrading either the Dishoudy or Abis Pump Station to handle a flow increase on the order of 770,000 cubic meters per day is a very significant and costly undertaking, particularly for an interim project that will not be needed when permanent effluent disposal facilities are constructed.

- Either of these alternatives requires re-pumping substantial wastewater and agricultural drainage flows, which consumes additional energy resources for a short-term benefit.

- Although diluted, the primary effluent and agricultural drainage flows will still re-enter the lake through multiple existing dike openings in the Omoum Drain.

- The pumping station and drain construction work falls under the Ministry of Irrigation's responsibility and therefore would be out of the Alexandria Wastewater Program's control with respect to priorities and schedule.

- In bypassing the lake, any wastewater treatment benefits provided by the Main Basin prior to sea discharge at the El Mex Pump Station are lost; however, dilution with agricultural water from Omoum Drain would occur.

- In light of the fact that primary effluent rather than raw sewage will be discharged to the Main Basin in the future, the potential odor reduction benefit claimed for the bypass alternatives may not be significant compared to the option of continued short-term discharge to the lake. Odors from the garbage dumping and landfill operations noted earlier in this chapter would continue.

A third possibility for bypassing effluent around the lake exists. This alternative could be employed to serve both the East and West Treatment Plants. It would entail designing and constructing part of the permanent effluent disposal conveyance facilities (gravity tunnels from the East and West Plants and an Effluent Pump Station that would ultimately serve either land or sea disposal facilities).

To bypass the lake, interim forcemains (3 - 1800 mm pipes) would be constructed from the new Effluent Pump Station to the Omoum Drain as illustrated in Figure 5-2. If the land disposal option were ultimately implemented in the future, most of the length of the "interim" forcemains would become an integral part of the land disposal system. If the sea disposal option were implemented in the future, the interim forcemains from the Effluent Pump Station to the Omoum Drain would no longer be needed.

The advantages of this option are similar to the two "agricultural drain" alternatives discussed above. The option is also suitable for both treatment plants rather than just the East Plant alone. In addition, a portion of facilities constructed for this interim bypass alternative would become part of the permanent effluent disposal system (land or sea) with proper planning. Since most of the forcemains used in the interim could be incorporated into a land disposal system in the future, this bypass alternative is more attractive economically if the land system is selected for permanent effluent disposal.

The disadvantages of this "piped" bypass alternative are:

- The hydraulic capacity of the Omoum Drain to accommodate the additional flows from the interim pipes discharge point to the El Mex Pump Station must be very carefully checked during the BODR stage of design if this option is to be pursued. It is possible that the upstream capacity of the Omoum Drain will have to be augmented to handle the flows safely. Augmentation of the drain falls under the Ministry of Irrigation's responsibility and therefore would be out of the Alexandria Wastewater Program's control with respect to priorities and schedule.

- If permanent effluent disposal to land is selected, the length (and therefore cost) of temporary piping to the Omoum Drain can be minimized with proper

selection of forcemain routing to the land disposal point. However, if the sea option is selected for ultimate effluent disposal, the substantial costs for temporary forcemains (approximately 10 Km each for 3 - 1800 mm pipes) reduces the economic viability of this bypass alternative significantly.

- Although diluted, the primary effluent and agricultural drainage flows will still re-enter the lake through multiple existing dike openings in the Omoum Drain.

- In bypassing the lake, any wastewater treatment benefits provided by the Main Basin prior to sea discharge at the El Mex Pump Station are lost.

- In light of the fact that primary effluent rather than raw sewage will be discharged to the Main Basin in the future, the potential odor reduction benefit claimed for the bypass alternatives may not be significant compared to the option of continued short-term discharge to the lake. Odors from the garbage dumping and landfill operations noted earlier in this chapter would continue.

Diversion of West Plant Effluent. West Treatment Plant effluent could be diverted directly to the Omoum Drain by constructing a new primary effluent pump station on the West Plant site and a new forcemain from this station to the Omoum Drain. The pump station would have to be designed to handle a peak flow of about 620 Ml/day (Design Year 2010). The single new forcemain would be about 2250 mm diameter and 3.8 Km long. It would also be necessary to incorporate a special siphon structure for the forcemain to cross the Noubaria Water Canal.

This bypass option is depicted in Figure 5-2. It could be employed in conjunction with either of the East Plant effluent bypass options that incorporate expansion of the Maryout or Abis Agricultural Drains and associated pumping stations.

The advantages and disadvantages of diverting West Plant effluent are essentially the same as those presented for diverting East Plant flow.

FINAL EFFLUENT DISPOSAL

This section addresses the options available to the City of Alexandria for the permanent disposal of treated wastewater. The long-term disposal of primary effluent to Lake Maryout is not acceptable for both environmental and health reasons. Although much of the Lake is heavily polluted now, it remains a potential wildlife and fisheries resource for the Country.

There are three options for permanent, long-term disposal of wastewater effluent: to inland waters including Lake Maryout; to the land; and, to the Mediterranean Sea. These are evaluated below.

SECONDARY TREATMENT AND DISPOSAL TO LAKE MARYOUT

Egyptian Law No. 48 (1982) establishes maximum effluent quality limits for wastewater effluent discharged to "fresh and unfresh" water bodies. These water bodies specifically include Lake Maryout as well as "pools", canals and drains. Selected limitations for wastewater effluent specified in Egyptian Law No. 48 are presented in Table 5-5.

In effect, Egyptian Law No. 48 mandates secondary treatment, chlorination, and post-aeration as minimum requirements for treating Alexandria's liquid wastes if these are to be discharged to Lake Maryout. Without a specific written waiver by the Government of Egypt to the contrary, any planned permanent wastewater effluent discharges to Lake Maryout under the Alexandria Wastewater Program must meet these legal standards in full.

WWCG has examined the possibility of providing secondary treatment at the East and West Plants as an alternative to land or sea disposal systems. We have come to the following conclusions based on this work:

- If secondary treatment is employed, the system should be of the biological filter rather than the activated sludge type. Biofilters are less prone to upset, have superior secondary sludge settling characteristics, are less costly, and are less expensive to operate than activated sludge systems. They are, however, more subject to odors and are less efficient (5-10%) than well-operated activated sludge systems.

- Average raw wastewater characteristics for Biochemical Oxygen Demand (BOD) and Total Suspended Solids (TSS) in Alexandria are estimated to be 520 and 530 mg/l, respectively. To achieve the maximum effluent limits established by Egyptian Law No. 48, secondary treatment efficiencies must be at least 88-90 percent. These requirements probably cannot be met consistently without the use of chemical coagulation and/or effluent filtration in addition to secondary treatment.

- The current site at the East Plant is barely adequate to accommodate basic secondary treatment facilities (i.e. excluding effluent filtration, post-aeration and sludge management systems) for an average design flow of 544 Ml/day (Phase II). The basic secondary treatment facilities considered (biological filters and pumping station, secondary clarifiers, chlorination facilities) would not be adequate to meet the requirements of Egyptian Law No. 48. Also, the future need for capacity above 544 Ml/day (Design Year 2010) could not be accommodated at the East Plant without the acquisition of additional land, which is in short supply in the immediate area.

- The current site at the West Plant is barely adequate to accommodate the basic secondary treatment facilities cited above for an average West Plant flow of 475 Ml/day (Phase II). The same disclaimer applies for meeting the requirements of Egyptian Law No. 48. Any future expansion of the West Plant would have to be accomplished in the Lake Maryout wetlands south of the plant.

- There is serious concern that industrial chemical constituents in Alexandria's waste streams would be sufficiently toxic to kill or severely inhibit the biological treatment process. Even if a strict industrial waste discharge program were successfully implemented and enforced, as is mandated by the Egyptian authorities, accidental and periodically recurring toxic discharges of industrial waste could result in the loss of secondary treatment. The efficiency of secondary treatment can only be demonstrated by a successful, long-term, pilot testing program.

LAND TREATMENT AND DISPOSAL

WWCG's 1981 "Review and Update of the 1978 Alexandria Wastewater Master Plan" addressed two ultimate wastewater disposal alternatives for the City of Alexandria in detail. These alternatives were the land treatment and disposal of raw wastewater and sea disposal via outfall following primary treatment. The potential land treatment and disposal option is updated and summarized in this section.

Two viable land treatment and disposal alternatives were developed by WWCG as part of its 1981 Master Plan Review. These were designated Alternatives IIIA and IIIB; they differed basically in the level of pretreatment provided for the raw wastewater. The level of treatment, in turn, influenced the type and value of crops that could be produced (i.e. high versus low return value) and the land areas needed for cultivation. Present worth costs of the two alternatives were estimated to be essentially the same.

This current update of the land treatment and disposal system is modelled after Alternative IIIA in the 1981 Master Plan Review. In this update, however, we have

assumed disposal of primary effluent rather than raw wastewater because the Phase I wastewater treatment plants and sludge disposal systems have already been constructed.

Basis of Land Treatment/Disposal System Design

The fundamental design criteria employed in the 1981 Master Plan Review for developing the land treatment and disposal system alternatives are reflected in the updated design data for this system shown in Table 5-6. The initial (Phase II) land area requirements and conceptual design for the updated land disposal system is based on the Design Year 2010 flows shown in Table 5-6; these are close to equivalent figures employed in the 1981 Master Plan Review for Design Year 2000. An appropriate expansion of the system would be required to meet anticipated Design Year 2030 conditions. The land treatment and disposal alternative was cost estimated based on Design Year 2030 flows so that it could be more fairly contrasted with the sea outfall alternative.

The flows shown in Table 5-6 originate from the West, Central and East Zones of Alexandria. The projections exclude Mex-Dekheila and Amria.

Site Selection

Seven large areas were studied in 1981 to identify potential locations suitable for land application of wastewater. The only site within 100 Km of Alexandria that appeared to have characteristics suitable for the land application of the entire wastewater flow being considered was located approximately 80 Km south of Alexandria in an area between the El Nasser and Noubaria Canals, along the Desert Road.

For the purposes of this Master Plan Update, we have assumed that the same site, or a suitable site(s) of equivalent size and distance from Alexandria, can be identified for land treatment and disposal of Alexandria's primary effluent.

Wastewater Conveyance Systems

The major updated facilities that would be used to convey wastewater to the land application site are shown conceptually in Figure 5-3. Major system components are:

- Gravity primary effluent conveyance tunnels from the East (4.25 Km, 2750 mm) and West (5.85 Km, 2500 mm) Treatment Plants to the Effluent Pump Station

- New Effluent P.S.
  (1478 Ml/day Peak Hour Capacity - Design Year 2010)

- Forcemains from Effluent P.S. to Desert P.S.
  (3-1800 mm for Design Year 2010, 4-1800 mm for Year 2030; 36 Km route)

- New Desert P.S. with on-site flow equalization tanks (1324 Ml/day Peak Day Capacity - Design Year 2010)

- Forcemains from the Desert P.S. to the Land Application Site (3-1800 mm for Design Year 2010, 4-1800 mm for Year 2030; 44 Km route)

Land Application Alternative

The updated Land Application Alternative would consist of pretreatment by anaerobic lagoons, followed by rapid infiltration basins for additional high-level treatment and ground water storage. The stored water would then be recovered by wells for use during the peak irrigation season. Except for dissolved minerals, the recovered ground water would be of high quality and could be used for irrigation of most crops, including high value crops that could result in significant economic returns. Based on a conceptual design for the Year 2010 wastewater flows shown in Table 5-6, major features of the land application system include:

- 210 hectares of anaerobic lagoons

- 1540 hectares of rapid infiltration basins

- 223 ground water recovery wells

- 444 center-pivot irrigation machines

- 23,000 hectares of cultivated land, irrigated at an average rate of 1.5 m/year

- Total land area requirement of 31,000 hectares, which is about 6.2 times the current size of Lake Maryout

Land Application System Conclusions

Based on the discussion above, we can draw the following conclusions regarding the land treatment and disposal alternative for Alexandria:

- The areas close to Alexandria are unsuitable for large-scale land application systems because of conflicts with existing land use or because of poor or marginal site conditions.

- In 1981, the most feasible location for large-scale land application of Alexandria's wastewater was located approximately 80 Km south of Alexandria in an area between the El Nasser and Noubaria Canals, along the Desert Road.

- If properly executed, the land application alternative should be acceptable from social, economic, public health and environmental standpoints.

- The only significant environmental effect of land application would be on the ground water. Ground water flows would be increased and ground water quality would be affected by the high salt concentration of percolate from the irrigation systems. A detailed hydrogeological investigation would be required to determine the overall effects on future down-gradient uses.

- The land application alternative would have a high degree of reliability and should be able to handle most difficulties arising from the failure of mechanical equipment or treatment mechanisms and from brief electrical power disruptions.

- The most critical factor affecting the implementability of land application is the availability of the required land area. A field survey conducted by WWCG in October 1992 for this study indicated that at least part of the area identified in 1981 as most suitable for land irrigation is already under irrigation and is therefore apparently no longer available for wastewater disposal purposes as described herein. Consequently, additional site selection surveys must be conducted to identify another site for land application if this alternative is to be pursued further. It is likely that any site identified now will be farther from Alexandria than the site identified in 1981. Both capital and O&M costs for implementation of land application now will therefore be higher in relative terms than they were in 1981. To handle ultimate Year 2030 wastewater flows for Alexandria, a suitable site area on the order of 41,100 hectares must be located and acquired. This land area requirement is about 8.2 times the current total size of Lake Maryout.

In light of these conclusions, land application should continue to be considered as a wastewater disposal alternative for Alexandria. To pursue this option further, initiation of more detailed site investigations is required. These investigations would include production of an accurate base map, a detailed soil survey, and a hydrogeological study. It will also be necessary to verify the agricultural crop types, methods of irrigation and the economics of the potential alternative in more depth. However, based upon current information obtained from the Ministry of Agriculture, all land reclamation sites available within 100 km of Alexandria already nave the necessary project water resources. Therefore, the overall prospect of finding an available effluent disposal site within a reasonable economic distance of Alexandria is not good.

SEA OUTFALL

The 1978 Alexandria Wastewater Master Plan Study considered construction of two sea outfalls for the disposal of the City's wastewater. WWCG's 1982 Phased Implementation

Plan proposed construction of a single 8-10 Km outfall at Kait Bey to serve the West and Central Zones of Alexandria followed by possible construction of a second outfall after the Year 2000 to serve the Eastern Zone. WWCG's 1983 Predesign Report for Alexandria Sea Outfall revised previous concepts by proposing that the outfall at Kait Bey be sized to accommodate all projected total wastewater flows from the City of Alexandria through the Year 2030. The discussion below addresses the potential use of a single Mediterranean Sea outfall for disposing all of Alexandria's treated wastewater.

Basis of Outfall Design

Table 5-7 presents an updated summary of key factors for sizing a sea outfall to serve the City of Alexandria as well as basic outfall data that result from this sizing. The outfall system itself, including land-based outfall conveyance systems, is illustrated in Figure 5-4.

The sizing criteria shown (e.g. populations, flows, wastewater characteristics) are based on the 1992 updates presented in this report, which are similar to those employed previously. The feasibility outfall design data shown (e.g. outfall diameter and length) were developed by WWCG for its 1983 Outfall Predesign Report. These design data, however, were based almost solely on available oceanographic, geophysical, geotechnical and biological information obtained during investigations for the 1978 Alexandria Wastewater Master Plan Study.

WWCG's preliminary outfall design is based on an estimated total population of 5.26 million (including seasonal population) in the City of Alexandria for the Design Year 2030, as indicated. This figure does not include "outlying" areas such as Amria or Mex-Dekheila. The average and peak design primary effluent flows for the outfall are 1253 and 1817 Ml/day, respectively, including flow allocations for seasonal populations.

Sea Outfall Conclusions.

In its 1983 feasibility design work for the outfall, WWCG made the following conclusions, some of which are still relevant today:

- All of Alexandria's primary wastewater effluent flows through Design Year 2030 can be discharged through a single outfall off Kait Bey without violating USEPA standards; EPA standards are more stringent than any standards yet adopted for the Mediterranean Sea. Such discharges would meet coliform bacteria requirements for bathing waters adopted for the Mediterranean Sea and would have no significant impact on the fisheries off Alexandria as a result of excessive toxics concentrations or depression of dissolved oxygen.

- Outfall computer modelling conducted by WWCG indicates that the predominantly along-shore currents would keep the wastewater effluent

plume offshore more than 80 percent of the time. When current reversals occur, the plume will move toward shore. About half of this time (i.e. 10 percent of total time), the plume will remain submerged and will not reach shore. The plume will reach shore, however, for the remaining 10 percent of time.

- The periods when the plume reaches Alexandria's shoreline are the most critical with respect to water quality conditions at the beaches. Based on its computer modelling using limited 10-meter depth current data, WWCG estimated that bacterial standards at the beaches would be met with an outfall length of 8 Km but may not be met with a length of 6 Km.

  Near surface (2-3 meter depth) currents are the most significant factor in determining shoreline bacterial concentrations. If near-surface currents are significantly different from those measured at 10-meter depths, an outfall longer than 8 Km may be indicated. Therefore, it is most important that near-surface current data be obtained prior to final design of this outfall.

- At a distance of about 9 Km from Kait Bey, the sea bottom slopes steeply from approximately 45 meters to 60 meters in depth. Extending the outfall into the deeper water would increase construction costs. It is therefore very important that any such decision be based on a performance analysis in which there is a high degree of confidence.

- Although the construction of the outfall by tunnelling offers several advantages, a preliminary analysis of the results of a single, deep onshore boring at Kait Bey indicates that rock tunnel construction may not be feasible but soft ground tunnelling may be feasible and should be evaluated further. Overall, additional marine studies are required which will evaluate not only tunnelling, but also cut-and-cover construction as a basis of design for the outfall.

- Additional oceanographic, geophysical and geotechnical field data, analyses and evaluations are essential for final design of any sea outfall. The exact location and configuration of both outfall and diffuser are critically dependent on data that is not presently available.

Since preparation of the 1983 Outfall Feasibility Design Report, some of the outfall design issues have to be revised. The 1983 Report was based on the 1976 USEPA Water Quality Criteria. Since then, the list of priority pollutants and their criteria have been modified. The discharge requirements into the Mediterranean Sea may have also been modified. The effect of these modifications need to be assessed.

The impacts of bacteria on the bathing beaches and fisheries was based on an uncalibrated modeling effort. A calibrated model is needed to verify the 1983 results.

The concern for extending the outfall into deeper water is not as critical now as it was in 1983. Outfall construction costs are less dependent on depth than construction method and the type of equipment that has to be mobilized to support the chosen construction method. Remote methods of pipe laying have been developed over the last ten years that ameliorates the concern about depth limits on outfall construction.

Additional Marine Studies Needed

The available oceanographic, geophysical and geological data employed in WWCG's 1983 analyses were nearly all obtained during investigations for the 1978 Alexandria Wastewater Master Plan Study. These data were used primarily to evaluate the feasibility of the outfall and in many cases are not adequate for final design. Confirmation and upgrading of data by additional field measurements and analyses is mandatory prior to final design and construction.

Subsurface information employed in 1983 was limited to reflection survey data, very shallow drop tube samples of sediment and preliminary information from a single on-shore borehole at Anfushi, near Kait Bey. A reliable, economical and safe outfall design requires more information on the nature of material on and below the sea floor. Marine investigations must be conducted over the four seasons of a year to obtain the detailed information needed for final design. The marine studies recommended by WWCG as well as the rationale for them are summarized in Table 5-8.

The Marine Studies are organized to collect just the data that is required to design and verify operation of the Alexandria Sea Outfall. The location and design of the diffused section of the outfall is the most critical element of the outfall project. It is the component of the outfall that protects the environment through initial dilution, far-field dilution, and plume travel. Thus, it is the component that will determine the success or failure of the project. Diffuser design will focus on diffuser performance by optimizing the location and configuration of the diffuser within the limits of constructability, cost, and pipe reliability. Diffuser related environmental studies include the wastewater characterization, the physical oceanographic monitoring (CTD, current meter arrays, drogues), biological oceanographic monitoring (flora and fauna sampling and analysis, bacteria die-off studies), and chemical oceanographic monitoring (water sampling and testing, sediment sampling and testing).

The design of the total outfall system deals with the more traditional civil, geotechnical, marine, and structural engineering issues of the design. These issues include structural integrity, seafloor stability, hydraulic performance, pipe materials, construction methods, cost estimates, and construction scheduling. The supporting marine engineering studies include the geophysical survey (fathometer, side scan, seismic reflection, and seismic refraction), the geotechnical testing (borings and cone penetrometer), the sediment transport study (analysis and test trench), and the wave analysis.

Land-based Outfall Conveyance System

The specific and most effective means of conveying primary effluent from the East and West Treatment Plants across the City to the sea outfall described above has not yet been determined in detail. One reason for this is that it is necessary to conduct the marine studies addressed above to determine the exact location of the outfall itself. Nonetheless, there are a number of wastewater effluent conveyance options that involve gravity conveyance systems, pumping stations and forcemains, as shown in Figure 5–4. The final selection of the best overall transport system combination must be determined by an engineering predesign evaluation followed by a BODR for the selected system.

For the purposes of this Master Plan Update, however, a land–based outfall conveyance system has been assumed. Major components of this system would be the same as those discussed above for the Land Application and Disposal Alternative. The assumed land–based outfall conveyance system, which is illustrated in Figure 5–4, consists of the following major components:

- Gravity primary effluent conveyance tunnels from the East (4.25 Km, 2750 mm) and West (5.85 Km, 2500 mm) Treatment Plants to the Effluent Pump Station

- New Effluent P.S.
  (1817 Mℓ/day Peak Hour Capacity – Design Year 2030)

- Forcemain from Effluent P.S. to Outfall Point of Departure at Alexandria Shoreline
  (1–3600 mm for Year 2030; 3.4 Km route across City)

TREATMENT PLANT EXPANSIONS

Work carried out at the existing treatment plants in Phase I, in general terms, comprised providing new facilities to provide preliminary and primary treatment of wastewater flows tributary to the two plants. Facilities were also provided for the removal of primary sludge from the two plants and for conveyance of the sludge to mechanical dewatering facilities at the West Treatment Plant prior to ultimate disposal of dewatered sludge at Site 9N.

Details of the sludge dewatering and disposal facilities are contained in the "Sludge Handling and Disposal" section of this chapter.

Details of wastewater treatment facilities provided in Phase I and required for the expansion of both treatment plants in Phase II are contained in the following subsections.

EAST TREATMENT PLANT

Phase I Facilities (ETP)

At the completion of Phase I of the Alexandria Wastewater Program in 1993, facilities at the East Treatment Plant will comprise the following major treatment components:

- A new Headworks containing mechanical screens, flow measuring flumes, aerated grit chambers and an overflow structure to convey screened wastewater in excess of 470 Ml/d directly to the Hydrodrome Drain.

- Eight new primary clarifiers and piping for discharge of primary effluent to the Hydrodrome Drain. The eight primary clarifiers are to operate as a "high rate" facility rated at 410 Mℓ/d.

- Primary Sludge Pump Stations and Sludge Transfer Pump Building where primary sludge will be diluted with effluent and conveyed to the West Treatment Plant for re-settling with wastewater tributary to the West Plant. The combined sludges from the two plants will be dewatered on Belt Filter Presses in the mechanical sludge dewatering facility at the West Plant.

- Seventy-two rehabilitated sludge drying beds that will provide dewatering capacity for approximately 9 percent of sludge generated or emergency storage of sludge for 7 to 8 days in the event of temporary problems in the operation of mechanical dewatering facilities at the West Plant.

Phase II Facilities (ETP)

Primary treatment facilities at the East Plant would be expanded to provide a total average Phase II capacity of 544 Ml/d, which represents an increase of 134 Ml/d over the

current "high rate" East Plant primary treatment capacity of 410 Ml/d. The additional facilities for Phase II would comprise the following major treatment components:

- Four primary clarifiers with effluent discharge to the Hydrodrome Drain.
- One Primary Sludge Pump Station.

The design of Phase II facilities for the East Treatment Plant was completed in August 1985, as a part of the Phase I program. Update of this design is necessary, however, to assimilate various site and technology changes since design completion.

WEST TREATMENT PLANT

Phase I Facilities (WTP)

At the completion of Phase I of the Alexandria Wastewater Program in 1993, facilities at the West Treatment Plant will comprise the following major treatment components:

- Mechanical screens and an Influent Pump Station to lift wastewater flows from the West Zone Collector to the treatment plant. Screening and influent pumping facilities provided in Phase I are sufficient to handle flows projected for Phase II.
- A new Headworks containing aerated grit chambers, scum removal facilities, and flow measurement flumes. Although the structure housing these treatment facilities was based on estimated Phase II requirements, mechanical equipment has been installed to handle Phase I design flows only.
- Eight new primary sedimentation tanks with sludge and scum removal mechanisms and pumping facilities.

Phase II Facilities (WTP)

Primary treatment facilities at the West Plant would be expanded to provided a total average Phase II treatment capacity of 475 Ml/d, which represents an increase of 300 Ml/d over the current West Plant capacity of 175 Ml/d. The additional facilities for Phase II would comprise the following major treatment elements:

- The installation of mechanical equipment in the existing headworks to duplicate the flow measurement, grit and scum removal capacities provided in Phase I.

- Upgrading of eight existing primary sedimentation tanks with sludge and scum removal mechanisms and pumping facilities

- Eight new primary sedimentation tanks with sludge and scum removal mechanisms and associated pumping facilities

The design of the Phase II facilities was completed in October 1985, as part of the Phase I program. Update of this design is necessary, however, to assimilate various site and technology changes since design completion.

In addition to the construction of physical facilities for wastewater treatment, the following additional rolling stock would be provided to convey grit, screenings and scum from both treatment plants to Site 9N for burial:

- 5 – 8 m^3 grit/screening trucks
- 7 – 11 m^3 vacuum scum trucks
- 2 – Front end loaders

The total number of trucks indicated for both treatment plants is based on operating one 8–hour shift each day.

SLUDGE HANDLING AND DISPOSAL

This section presents the background of events leading to the selection of sludge handling and disposal methods and the identification of an acceptable sludge disposal site. The section also contains descriptions of facilities provided in Phase I for the dewatering, transportation and disposal of primary sludges and discussions of alternative sludge handling and disposal options for Phase II.

BACKGROUND

Since the inception of the Alexandria Wastewater Program, many sludge management alternatives as well as sludge treatment and disposal sites have been evaluated in an effort to determine the most feasible means of sludge disposal for the East and West Treatment Plants.

Sludge treatment and dewatering alternatives included:

- Dewatering on sand drying beds
- Mechanical dewatering by coil filters, centrifuges and belt filter presses
- Lagooning
- Stabilization by anaerobic digestion
- Composting
- Incineration

Sludge disposal alternatives included:

- Landfilling of dewatered sludge
- Commercial use of stabilized sludge compost
- Dedicated land disposal of dewatered sludge
- Ocean disposal of liquid sludge
- Land application for reclamation or agricultural use

Sludge transport alternatives to treatment and disposal sites included:

- Pumping of liquid sludge
- Truck hauling of both liquid and dewatered sludge
- Rail hauling
- Barge hauling

A general review of events leading to the selection of belt filter presses for mechanical sludge dewatering and the procurement of Site 9N for sludge disposal is contained in Chapter 2.

Throughout the course of the program, the selection of an acceptable sludge management plan has been frustrated by the difficulties encountered in securing a suitable disposal site. In August 1989, AGOSD succeeded in gaining approval to dispose of dewatered sludge at Site 9N and permission was given to proceed with the final design of the sludge disposal facilities.

In response to a request by USAID in late 1990, WWCG evaluated transporting sludge from the West Treatment Plant to Site 9N by train and trucks. A report of this comparative evaluation titled "Study of Sludge Hauling Alternatives from West Treatment Plant to Site 9N: Train versus Truck" was prepared in May 1991. Economic and non-economic considerations identified in that report favored trucking as the most feasible and acceptable method of transporting dewatered sludge. The report recommended that the use of trucks, adopted for the Phase I facilities, be continued in Phase II. This recommendation is re-evaluated in the "Sludge Transporation" section of this Chapter.

SLUDGE DEWATERING

Phase I Facilities

In general, Phase I sludge dewatering facilities comprise 12 belt filter presses and associated equipment to dewater primary sludge from the East and West Treatment Plants. These facilities are located at the West Plant. The details of the installation are contained in the Basis of Design Report for the Mechanical Sludge Dewatering System, May 1989 [10].

The selection of mechanical sludge dewatering, rather than alternative processes such as sand drying beds, was made as a result of the insistence of the GOE that processes other than mechanical dewatering were unacceptable. Although ranking sand drying bed dewatering more highly, WWCG acknowledged that mechanical dewatering appeared to be the only implementable solution to the dilemma. WWCG recommended the use of belt filter presses following an evaluation of the two most suitable dewatering machines: centrifuges and belt filter presses [15]. Raw wastewater flows and total influent suspended solids concentrations used in the development of Phase I sludge quantities are shown in Table 5-9. The primary sludge quantities that formed the basis of design of the Phase I sludge dewatering facilities are summarized in Table 5-10. A total of twelve belt filter presses are contained within the Phase I dewatering building, of which eight will be under operation on an average day and nine on days of maximum sludge production. Basic design criteria that formed the basis of selection of the number of belt presses are summarized in Table 5-11.

Phase II Facilities

Mechanical dewatering of sludge was adopted in Phase I in order that the Alexandria Wastewater Program could continue with a minimum of delay despite the fact that other,

less complex, dewatering systems were deemed more appropriate by WWCG. Concerns have been expressed recently regarding the complexity of the dewatering facilities included in Phase I, especially since sludge handling and disposal is a key element upon which the success of the Alexandria Wastewater Program depends. Before proceeding with Phase II, therefore, it is desirable that the other less mechanically-intensive alternatives be re-examined.

Some concern has also been expressed over potential problems that may occur in the transfer of sludge from the East to the West Treatment Plant. To address these concerns, WWCG has considered the feasibility of providing separate sludge dewatering systems at each treatment plant.

The updated sludge dewatering alternatives considered for Phase II in this report and discussed below are as follows:

- Alternative 1: Continuation of all sludge dewatering at the West plant using Belt Filter Presses.
- Alternative 2: Separate Belt Filter Press dewatering at the East and West Treatment Plants.
- Alternative 3: Belt Filter Press dewatering at the West Plant and Sand Drying Bed dewatering at the East Treatment Plant.
- Alternative 4: Belt Filter Press dewatering at the West Plant and Sand Drying Bed dewatering at a Remote Site.
- Alternative 5: Sand Drying Bed dewatering at a remote site for total combined sludges from the East and West Treatment Plant.

The raw wastewater flows and total influent suspended solids concentration used in the development of Phase II sludge quantities are shown in Table 5-12. These updated figures were determined as a result of the re-analyses presented in Chapter 4.

Primary sludge quantities derived from the updated figures presented in Table 5-12, that formed the basis of design of alternative sludge Phase II dewatering facilities are shown in Table 5-13.

Alternative 1: Continuation of all sludge dewatering at the West Treatment Plant using Belt Filter Presses. Basic design criteria that formed the basis of selection of the total number of belt filter presses required in this alternative are shown in Table 5-14.

Alternative 1 involves the duplication of the Sludge Dewatering Building (with its 12 Belt Filter Presses), and all associated ancillary equipment provided in Phase I.

The advantages of continuing all sludge dewatering at the West Treatment Plant are:

- All sludge dewatering operations would be standardized, centralized and controlled at a single location.

- The added standby capacity of all equipment combined increases dependability

- Experienced Phase I operating staff would be available to assist operating staff on the expanded Phase II facilities

- The selection of the same equipment manufacturers in Phase II as those in Phase I would minimize spare parts inventory requirements

- The expansion of Phase I dewatering facilities to handle sludge flows in Phase II was considered, and necessary means for expansion included, during the detailed design of Phase I facilities

- Land is available at the West Treatment Plant for expansion of Phase I facilities under this approach

The disadvantages of this approach are:

- Sludge dewatering is a key element of the wastewater treatment and disposal program. Mechanical dewatering of sludge is a complex process requiring a high level of expertise on the part of equipment operators. Although extensive training of operations staff will be provided, the potential for failure of mechanical sludge dewatering facilities is higher than that of less mechanically intensive dewatering processes such as sand drying beds. Existing facilities within the West Treatment Plant are available, however, and could be adapted for raw sludge storage to minimize the adverse impact of a temporary breakdown in the sludge dewatering facilities.

- Mechanical sludge dewatering also requires a continuous supply of conditioning polymer which, at the present time, must be imported. Interruption of this supply can severely restrict dewatering operations.

- The need for a continuous supply of imported polymer requires expenditures of hard currency.

- The current means of diluting and transferring sludge from the East to the West Treatment Plant is included as a disadvantage because of AGOSD's concerns regarding the long term viability of this transfer system. A cost has been included in the economic evaluation of the alternatives for a

dedicated sludge force main which could, if adopted, replace the transfer system provided in Phase I.

Alternative 2: Separate Belt Filter Press dewatering at the East and West Treatment Plants. This alternative would provide separate mechanical dewatering facilities at the East and West Plants to serve wastewater flows tributary to those plants.

Estimated Phase II primary sludge loads for the West Treatment Plant are presented in Table 5-13. Average and maximum day solids loads shown are 151,050 and 229,000 Kg/day, respectively. To provide approximately the same unit loadings and level of redundancy incorporated in the original Phase I design, and for general process symmetry, 4 additional Belt Filter Presses and associated equipment will be installed at the West Plant in Phase II.

Estimated Phase II primary sludge loads for the East Treatment Plant are also presented in Table 5-13. Average and maximum day solids shown are 144,200 and 205,400 Kg/day, respectively. Under the same loading conditions described above, a separate Phase II mechanical dewatering facility at the East Plant would be sized to house 14 Belt Filter Presses and associated equipment.

The use of mechanical dewatering processes other than Belt Filter Presses was not considered for this Phase II alternative because:

- All mechanical dewatering processes have similar levels of complexity. The adoption of two different type of system would necessitate the recruitment and training of a second team of specialized operators.

- Benefits of scale in standby equipment, spare parts and chemicals inventory would be lost with the adoption of a second dewatering system.

The advantages of two dedicated Belt Filter Press installations, one at the West Treatment Plant and one at the East Treatment Plant, are:

- The need for facilities to dilute and transfer primary sludge from the East Treatment Plant to the West Treatment Plant would be eliminated.

- The elimination of sludge transfer and resettlement of East Plant sludges at the West Plant would increase overall solids capture efficiency to some degree.

The disadvantages of two separate Belt Filter Press installations are:

- Two installations de-centralizes management and control of sludge dewatering operations, which would result in O&M inefficiencies.

- Two installations limits any potential considerations of using the railroad system for hauling dewatered sludge in the future due to higher initial costs and operating management complexities.

- The total number of installed Belt Filter Presses would increase from twenty-four, as originally envisaged, to thirty.

- Total costs of this alternative would be appreciably higher than that of a single dewatering facility at the West Plant.

- The need for hard currency, identified in the previous alternative, for the supply of polymer would continue at a higher level.

Alternative 3: Belt Filter Press Dewatering at the West Treatment Plant and Sand Drying Bed Dewatering at the East Treatment Plant. Similar to Alternative 2, this option would also provide separate dewatering operations at the East and West Plants. The West Plant would continue with mechanical dewatering on Belt Filter Presses, expanded as needed to suit Phase II flows that are tributary to the West Plant.

The intent of Alternative 3, however, is to examine the possibility of employing the existing sand drying beds at the East Plant for dewatering sludge generated at the East Plant. These drying beds are currently being re-furbished by AGOSD for emergency use. Unfortunately, the current beds will only have sufficient capacity to accommodate approximately 6-percent of anticipated Phase II sludge loads and there is insufficient area at the site for construction of additional drying beds. Therefore, this particular alternative is not considered further.

Alternative 4: Belt Filter Press Dewatering at the West Plant and Sand Drying Bed Dewatering at a Remote Site. This alternative is similar to Alternative 3 but would require locating and acquiring a suitable "remote" site for construction of sand drying beds to accommodate East Plant sludge loads in Phase II. Liquid primary sludge would be pumped to this "remote" site from the East Plant. Mechanical dewatering would continue at the West Plant.

The advantages of this approach are:

- Use of sand drying beds for East Plant sludge would provide some "backup" capability with respect to overall sludge dewatering operations.

- The need for facilities to dilute and transfer primary sludge from the East to the West Treatment Plant would be eliminated.

- Hard currency requirements would be less than that for total mechanical dewatering alternatives.

The disadvantages of remote sand drying bed dewatering of East Plant sludge are:

- Two separate sludge dewatering methodologies and locations unnecessarily complicates and de-centralizes management and control of dewatering operations, which would result in O&M inefficiencies.

- The difficulties and delays in securing Site 9N for the disposal of dewatered sludge is documented elsewhere in this report. There is insufficient area at Site 9N to consider this a potential site for both sand drying bed and sludge disposal operations. It is unlikely that procurement of a second separate remote site for East Plant sludge sand drying beds would be any less difficult or time consuming.

Alternative 5: Sand Drying Bed Dewatering at a remote site for total combined sludges from the East and West Plants. The mechanical dewatering facilities installed at the West Treatment Plant provide capacity to dewater combined sludges generated at the East and West Treatment Plants in Phase I.

The purpose of re-considering this sand drying bed alternative for all primary sludge generated at the East and West Plants in Phase II is to provide a basis of comparison with other available dewatering options in the event of future policy changes concerning sand drying beds. These policy changes may result from the burden of the continuing need for hard currency for polymer purchase; the desirability of a less complex and more reliable dewatering method; or for other reasons. If such a future change is contemplated, the costs already expended for of the initial mechanical dewatering facility must be considered in determining the relative economic merits of the alternative.

With this in mind, the advantages of this alternative are:

- Future requirements for hard currency would be eliminated.

- Operation and maintenance would be simplified and O&M costs would be reduced.

- Environmental problems such as odors and vectors would be less objectionable at a remote site.

The disadvantages of this dewatering alternative are:

- Considerable monies have already been expended in constructing mechanical dewatering facilities at the West Plant and in securing and developing Site 9N for dewatered sludge disposal. These expenditures would be wasted if the remote sand drying bed option to handle all of Alexandria's sludge were re-initiated.

- The difficulties and delays in securing Site 9N for the disposal of dewatered sludge is documented elsewhere in this report. It is unlikely that procurement of a second remote sand drying bed site for East and West Plant sludges would be any less difficult or time consuming.

SLUDGE TRANSPORTATION

Phase I Sludge Transportation Facilities

Transportation facilities provided in Phase I are based on the use of 27 m^3 capacity trucks conveying dewatered sludge from the West Treatment Plant to the Site 9N. The trucks will operate continuously 24 hours per day, 7 days per week. A total of fifteen trucks are provided in Phase I, of which ten are operating and five standby. Full design details are contained in the Bases of Design Report for the Mechanical Sludge Dewatering System, May 1989 [10].

Since the completion of design of the Phase I facilities, concern has been expressed by USAID about the long-term viability of sludge hauling by truck. WWCG's study and report completed in May 1991 [13] addressed these concerns by comparing costs and non-economic factors concerned with rail haul and truck haul of sludge cake generated at the West Treatment Plant in Phase I.

Before proceeding with a discussion of the means of transportation to be adopted in Phase II, it is appropriate to re-examine the two basic sludge-haul alternatives based on the increased volume of sludge cake expected in Phase II.

Re-examination of Sludge Haul Alternatives

The projected design quantities of sludge cake to be produced at the West Treatment Plant in Phases I and II, based on 95-percent solids capture on the Belt Filter Presses, are shown in Table 5-15. Computations of truck and train car requirements to handle these cake quantities are summarized in Table 5-16.

A summary of the comparative costs of these two sludge haul methods for Phase II sludge loads is presented in Table 5-17. These costs are based on the assumptions and considerations presented in the May 1991 Report [13] with costs updated to the first quarter 1993. However, in this analysis, the useful life of sludge trucks and front-end loaders at the West Plant and Site 9N has been reduced to 5 years. A minimum annual railroad charge of $500,000 for hauling the sludge from the West Treatment Plant to Site 9N has been assumed. Despite these changes, the total costs still overwhelmingly favor the continued use of sludge trucks.

The May 1991 Report [13] also contained a comparative analysis of the major impacts of both transportation methods. A summary of the conclusions of this analysis is presented

in Table 5-18. It should also be noted that severe site limitations at the West Plant and the planned configuration of dewatering facilities in Phase II would make the handling and operation of two trains, each with thirty sludge cars extremely difficult if not impossible.

Because rail haul appears to offer no non-economic advantages over truck haul and because rail haul is significantly more costly than truck haul, rail haul is not considered further in this report. To address the concerns regarding the viability of truck haul of sludge cake, however, consideration could be given the feasibility of sub-contracting all truck transportation activities after some experience with the operation of this system is gained in the near future. During the early period of Phase II, operational experience regarding the use of trucks will be available from which to determine if the present concerns are justified.

Phase II Sludge Transportation Facilities

This section addresses the Phase II sludge transportation facilities that are associated with the updated Sludge Dewatering alternatives presented above. Although these facilities are discussed separately here, they must be considered in conjunction with the sludge dewatering and disposal options with which they are associated.

Alternative 1: Continuation of all sludge dewatering at the West Plant using Belt Filter Presses. With the elimination of the rail-hauling of sludge cake to Site 9N as discussed above, the only sludge transport option available under Alternative 1 is that of continuing the transport of dewatered sludge to Site 9N by truck. To accommodate estimated Phase II primary sludge loads, 11 additional 27-m^3 trucks (for a total of 26 sludge trucks) will need to be purchased for hauling sludge from the West Plant to Site 9N.

The principal advantage of continuing sludge trucking in Phase II is that it will be a familiar operation. By the time the Phase II facilities are on-line and operating, the system of transporting sludge by truck should be well established, with no more than normal operational problems. Expansion of the system by adding more trucks should be achievable with only moderate disruption.

The principal disadvantage of this approach is associated with the problems of maintaining the fleet of 26 large trucks. However, vehicle maintenance facilities are being provided as part of the Phase I facilities to minimize this problem.

Alternative 2: Separate Belt Filter Press Dewatering at East and West Treatment Plants. This alternative will require hauling of dewatering sludge cake by truck from both the East and West Treatment Plants to Site 9N. There appear to be no significant advantages to transporting sludge from both plants as opposed to one plant. However, there are several disadvantages to this approach:

- A total of 34 sludge trucks would be required to accommodate Phase II loads under this "two plant" option, compared to a total of 26 trucks if all dewatering operations were carried out at the West Plant as originally planned. Additional trucks are required to provide appropriate redundancy and standby capacity at each plant.

- The cost of providing adequate maintenance facilities and personnel at both plants would be more costly than continuing with a centralized facility at the West Plant.

- With dewatering at both plants, improved coordination would be needed to avoid disrupting disposal operations at Site 9N.

Alternative 3: Belt Filter Press Dewatering at the West Plant and Sand Drying Bed Dewatering at the East Plant. This alternative has been eliminated as infeasible at the East Plant from a process perspective.

Alternative 4: Belt Filter Press Dewatering at the West Plant and Sand Drying Bed Dewatering at a Remote Site. This alternative comprises two separate sludge transport operations: pumping of liquid sludge from the East Plant to a remote site, at a location which is yet to be determined; and, the continued truck hauling of sludge cake from the West Plant to Site 9N.

Since primary sludges from the East and West Treatment Plants would be handled separately under this option, only 3 additional sludge trucks would be required for anticipated Phase II sludge loads at the West Plant. However, a new high-pressure liquid sludge pump station would have to be constructed at the East Plant as well as a new sludge force main from the East Plant to the remote sand drying bed site.

The advantages of this sludge transport alternative are:

- Concerns associated with transporting sludge to the West Plant via the West Zone Collector will be eliminated.

- Problems associated with operation and maintenance of a large fleet of sludge trucks are reduced because fewer trucks are required under this option.

The disadvantages of this alternative are:

- With two sludge transport operations, the overall complexity associated with transporting sludge will increase.

- Delays in identifying and acquiring land for the sludge forcemain will delay implementation of Phase II facilities at the East Treatment Plant.

Alternative 5: Sand Drying Bed Dewatering at a Remote Site for Total Combined Sludges from the East and West Plants. This sludge transport option involves pumping of liquid sludge from the East and West Treatment Plants to a remote site for dewatering on sand drying beds. Since a suitable site for sand drying beds cannot been identified at this time, Site 9N has been assumed for comparison purposes only.

Under this transport option, sludge could either be conveyed directly to the disposal site from the East and West Plants in separate force mains or East Plant sludge could first be pumped to the West Plant and combined sludges then pumped from the West Plant to the dewatering site.

The advantages of this alternative are:

- Potential hazards and congestion from sludge traffic truck would be eliminated.
- Potential environmental problems from sludge spills would be reduced
- Potential odors from sludge trucks along the transportation route would be eliminated.
- O&M costs for pumping are lower than for truck haul.

Disadvantages of sludge pumping are:

- The process of identifying and acquiring suitable pipeline routes could be lengthy and delay implementation of needed Phase II work.
- Sludge pumping is not as flexible as truck transportation.

SLUDGE DISPOSAL

Chapter 2 describes the difficulties encountered between 1982 and 1989 in obtaining a suitable site for sludge disposal. Up to twenty-four different sites were identified and many comparative evaluations of alternative treatment and disposal options were conducted in an effort to hasten the procurement of an acceptable site. The delay in securing the sludge disposal site until 1989 delayed the completion of Phase I of the Alexandria Wastewater Program.

In order to avoid similar delays in execution of Phase II of the Program, it has been assumed that sludge disposal will be confined to Site 9N.

Phase I Facilities

Facilities at Site 9N provide for the disposal of grit, scum and screenings collected at both the East and the West Treatment Plants, and dewatered sludge cake from the mechanical sludge dewatering installation at the West Treatment Plant.

Grit, scum and screenings will be transported to the disposal site during daylight hours only Dewatered sludge cake will be transported by truck continuously 24 hours per day. Screening and scum will be disposed of in shallow, lined trenches. Grit will be disposed with dewatered sludge cake in a dedicated sludge disposal area.

To measure the feasibility of converting dewatered sludge to compost suitable for agricultural reuse, a pilot composting plant will be established at Site 9N using 10 percent of the dewatered sludge cake. Details of these facilities are contained in the Basis of Design Report for Solids Disposal Facilities at Site 9N, March 1990.

The total area of Site 9N is 150 Hectares. Of this, 64 Hectares have been allocated for disposal of grit and sludge cake in a dedicated land disposal area. The remaining area provides space for disposal of screenings and scum, filtrate evaporation ponds, composting pilot plant and associated facilities, unloading areas, maintenance and administration buildings.

In Phase I, approximately 540 m^3/day of sludge cake and 119 m^3/day of grit will be disposed at the site. This will necessitate the use of 31 hectares of the total 64 hectares allocated for sludge and grit disposal.

Phase II Facilities

During Phase II, disposal of screening and scum from both treatment plants will continue. The disposal of sludge cake, however, will be governed by the means adopted for dewatering and transportation of sludge discussed earlier. With the elimination of Alternative 3 (Belt Filter Press Dewatering at the West Plant and Sand Drying Bed Dewatering at the East Plant), four remaining alternatives are considered as follows:

- Alternative 1: Continuation of all sludge dewatering at the West Plant using Belt Filter Presses
- Alternative 2: Separate Belt Filter Press dewatering at the East and West Treatment Plants
- Alternative 4: Belt Filter Press dewatering at the West Plant and Sand Drying Bed dewatering at a remote site
- Alternative 5: Drying Bed dewatering at a remote site for total combined sludges from the East and West Treatment Plants

Alternative 1: This is the original concept on which the design of disposal facilities at Site 9N was based. Continuation of all sludge dewatering at the WTP in Phase II would necessitate merely an expansion of disposal activities (equipment and personnel) within the boundaries of Site 9N. No significant site changes would be needed.

Alternative 2: Although a small increase in the quantity of sludge cake generated at the East Treatment Plant would result from a separation of the dewatering facilities between the two treatment plants, this increased quantity would not adversely affect the continuation of disposal operations at Site 9N. Other than the planned increase in disposal activities (equipment and personnel) at Site 9N, no other impacts are anticipated.

Alternative 4: Whichever method of dewatering is adopted in Phase II, whether by mechanical means or by sand drying beds, it will have little impact on the quantity of sludge cake produced and hence disposal operations at Site 9N as originally planned will not be affected. However, the total 150-ha area at Site 9N is already being developed for the disposal of Phase I dewatered sludge cake, scum, screenings and grit.

The total sand drying bed area that would be required to dewater sludge generated at the East Treatment Plant in Phase II is 60 Hectares. This represents 40 percent of the total Site 9N area and makes the location of Sand Drying Beds at Site 9N completely infeasible.

The adoption of the alternative in Phase II to dewater East Treatment Plant sludge separately from sludge from the West Treatment Plant using Sand Drying Beds would, therefore, necessitate the identification and procurement of a second remote site of approximately 80–100 Hectares. It would also necessitate procurement of approximately 16 sludge trucks to convey the sludge cake from this new dewatering site to Site 9N.

Alternative 5: The total area of Site 9N is required for the disposal of scum, screenings and grit from the two treatment plants in addition to dewatered sludge cake.

The adoption of remote sand drying beds now for dewatering total combined and West Plant Sludge would necessitate the identification and procurement of a second remote site of approximately 150–200 Hectares. It would also necessitate a continuation of truck haul of dewatered sludge from this new dewatering site to Site 9N.

Conclusions

Conclusions derived from the comparisons of alternative methods for the dewatering, transportation and disposal of primary sludges generated at the East Plant and West Treatment Plants are summarized below. These conclusions are based on the continued use of belt filter presses at the West Treatment Plant and sludge disposal at Site 9N.

- The adoption of the Belt Filter Press installation constructed at the West Plant in Phase I, as a dedicated facility for West Plant sludge only in Phase II, would necessitate the provision of four additional presses and associated equipment.

- The provision of dedicated mechanical dewatering facilities at each of the two treatment plants would result in higher capital, operation and maintenance costs, while offering no significant commensurate advantages over a single Belt Filter Press facility at the West Treatment Plant. As a result, Alt. 3 is not recommended.

- The use of sand drying beds would result in less complex operational procedures for dewatering primary sludge than a Belt Filter Press installation. Their use would also result in lower operation and maintenance.

- Sufficient land area is not available at the East Treatment Plant for construction of sand drying beds for dewatering sludge generated at the East Treatment Plant.

- Dedicated use of Belt Filter Presses for dewatering West Plant sludges and use of new sand drying beds at another location for dewatering East Plant sludges would reduce dependency on the mechanical dewatering system and would reduce total hard currency requirements for polymer and spare parts.

- Separation of dewatering operations for sludges generated at the two treatment plants would result in a need for additional trucks to transport sludge cake to Site 9N.

- Sufficient land area is not available at Site 9N for construction of sand drying beds to dewater sludges generated at the East Treatment Plant.

- A detailed comparative analysis of hauling dewatered sludge by rail and truck indicated little non-economic advantage of either transportation method. It did, however, show a significant cost advantage in favor of truck hauling.

- The likelihood of finding a remote site for sand drying bed dewatering for both ETP and WTP sludges is small. This concept would also void all Phase I expenditures for WTP Mechanical Dewatering. Therefore, Alt. 5 for remote site dewatering of combined East and West Plant sludges is not recommended.

COLLECTION SYSTEM IMPROVEMENTS

Untreated wastewater from the Central Zone is presently discharged through multiple short outfalls and overflows along the coastline near Kait Bey. The intent of the Alexandria Wastewater Program has always been to convey this wastewater to an expanded West Treatment Plant for treatment. To achieve this end, it will be necessary to

- construct the proposed new Central Zone Tunnel to the existing West Zone Collector and to
- construct the Central Zone Connections to intercept flows in the existing Central Zone sewerage system.

In addition to the Central Zone Tunnel and Connections projects, the El-Mafrouzah and El Wardeyane Districts contain a network of lateral sewers and collectors in the West Zone collection system. Wet weather flooding in these districts and the current discharge of raw wastewater from the El Wardeyane District to the Western Harbor necessitate the construction of the proposed "Qabbari Relief Sewers" to convey wastewater from these two districts to the West Treatment Plant.

Details of these projects are addressed below. Details of two other collection system improvements, the proposed Smouha and Hydrodrome Drain Improvements have been discussed in Chapter 3.

CENTRAL ZONE TUNNEL

Final design of the Central Zone Tunnel was completed in 1985 as part of the Phase I Alexandria Wastewater Program. However, a design review and update will be required prior to tender to account for any site changes and advances in tunneling technology since design completion.

The Central Zone Tunnel will be a deep 2250 mm diameter gravity collector, approximately 3.5 kilometers in length, traversing the Central Zone. The route of the tunnel is shown in Figure 5-7.

CENTRAL ZONE CONNECTIONS

This project comprises direct and indirect connection of a number of existing collectors to the Central Zone Tunnel and includes associated bulkheads and storm water overflow structures. In addition, a new trunk sewer will be provided to convey sanitary flows from the West Harbor area to the Central Zone Tunnel. These connections are also indicated in Figure 5-7.

This project was investigated during the design of the Central Zone Tunnel in sufficient detail to define its scope and hydraulics. Although no detailed design has been carried out, preliminary work indicates the need for constructing approximately 1.5 km approximately of 900 mm pipe and 1.5 km of 600 mm diameter pipe with associated connections.

QABBARI RELIEF SEWERS

A Basis of Design Report for the proposed Qabbari Relief Sewers was completed in March 1989. Brief details of recommendations are contained in the following paragraphs. Before proceeding with construction of these two collectors, it will be necessary to carry out the final design and prepare contract documents.

El Mafrouzah District

Most of the El Mafrouzah District drains through existing gravity sewers to a main collector in El Qabbari Street that, in turn, discharges south to Lake Maryout. The three main collectors in this district are the El Emam, Ebn El Sayar and El Qabbari Collectors.

Insufficient capacity in the El Qabbari Collector results in frequent flooding in areas adjacent to the Alexandria-Matrouh railway and the Qabbari Rapid Road. Two alternatives to relieve these flooding problems were considered in the 1989 Basis of Design Report:

- Rehabilitation and cleaning of existing sewers
- Construction of a relief sewer along Malik Shah Street by either open cut or tunneling methods

The rehabilitation/cleaning alternative was eliminated because neither the Ebn El Sayar Collector nor the El Qabbari Collector have sufficient capacity to accommodate peak design flows. Since open-cut construction would involve problems of congestion, difficult excavation and foundation conditions, and adverse groundwater conditions, WWCG recommended that a relief sewer along Malik Shah Street be constructed by tunneling.

The Malik Shah Collector will be approximately 1110 meters in length with a diameter of 1200 mm and will discharge to the existing West Zone Collector, which discharges to the Influent Pump Station at the West Treatment Plant.

The route of the proposed Malik Shah Relief Collector is shown in Figure 5-7.

El Wardeyane District

During early design stages in Phase I, it was WWCG's understanding that a force main would be built between Pump Station 2W, in the northern part of the district, to Pump

Station 3W adjacent to the West Treatment Plant. However, this force main was never fully constructed. As a result, flow from Pump Station 2W is currently discharged to the Western Harbor. In addition, wet weather flow surcharges gravity sewer lines in the northern part of the district. These sewers also discharge raw wastewater to the Western Harbor and contribute to localized flooding in the El Wardeyane District.

Two alternatives were considered in the 1989 BODR to eliminate dry weather wastewater discharges from Pump Station 2W to the Western Harbor and to relieve flooding problems in the El Wardeyane District:

- Construction of a new force main from Pump Station 2W to the Wardeyane Collector which discharges to the Influent Pump Station at the West Treatment Plant

- Construction of a new relief sewer, by either open cut or tunneling methods, along El Kaffal Street

As in the case of the Malik Shah Collector, construction of a force main or gravity sewer by open cut methods would be extremely difficult because of adverse foundation conditions necessitating the use of piles, and groundwater conditions that would require extensive dewatering with possible resulting settlement of adjacent building foundations. It was recommended, therefore, that the tunneling alternative be adopted for construction of the El Kaffal Street Collector.

The El Kaffal Street Collector would be approximately 1140 meters in length with a diameter of 1200 mm and would discharge to the West Treatment Plant.

The route of the El Kaftal Street Collector is shown in Figure 5-7.

PUMP STATION IMPROVEMENTS

Seven new major pump stations were constructed in Phase I of the Alexandria Wastewater Program, as follows:

- Abu Qir Pump Station
- Maamoura Pump Station
- Sporting Pump Station
- Ras El Soda Pump Station
- Sidi Bishr Pump Station
- East Zone Pump Station
- New Smouha Pump Station

This section identifies expansions and improvements to these pump stations that will be necessary to handle projected wastewater flows in Phase II. Prior to implementing the Phase II expansions and improvements at the seven pump stations a comprehensive flow monitoring program is recommended to validate projected wastewater flows.

PHASE I DESIGN CRITERIA

In the design of wastewater collection, treatment and disposal facilities, mechanical and electrical equipment components are typically based on a life expectancy of 10 to 15 years. The design of structural elements such as pipelines and pump station structures is normally based on an extended service life of 40 to 50 years. This concept was adopted by WWCG in the design of the new pump stations in Phase I. As a result, expansions and improvements of these pump stations to handle projected wastewater flows in Phase II are, to a large extent, confined to additional or replacement pumps and other items of mechanical equipment, associated electrical equipment and instrumentation.

Needed rehabilitation of existing AGOSD pump stations, including repair or replacement of equipment, is addressed in Chapter 6 of this report

PHASE II EXPANSIONS AND IMPROVEMENTS

Table 5-19 summarizes selected design data for each of the seven new pumping stations provided under Phase I of the Alexandria Wastewater Program. The table also indicates the original plan for expanding these stations as well as the planned expanded pump station capacities. Table 5-20 contains a summary of screens and bar-racks installed at these pump stations in Phase I as well as the total planned requirements for this equipment in Phase II.

As a result of the update of projected wastewater flows presented in Chapter 4, design flow rates from these pumping stations has been revised in some cases. Phase II requirements resulting from these revisions are discussed below.

Abu Qir Pump Station

The original plan to change impellers of the two pumps installed in Phase I at the Abu Qir Pump Station will increase the station's average capacity to 11.4 Ml/d. This change should meet updated flow demands through the Year 2013. No additional work will be required as part of the Phase II expansion. However, consideration should be given during the Phase II program to means of increasing capacity of the pump station and force main to handle additional flows projected beyond the Year 2013.

Maamoura Pump Station

The original plan to change the motors of the two pumping units installed in Phase I will increase the average station capacity to 43.7 Ml/d and meet the flow demands of the station through the Year 2010. No additional work will be required as part of the Phase II expansion. However, consideration should be given during the Phase II program to means of increasing capacity of the pump station and force main to handle additional flows projected beyond the Year 2010.

Ras El Soda Pump Station

The average pumping capacity of the Ras El Soda Pump Station is 117 Ml/d. This capacity is sufficient only for projected current flows. Because the pump station was designed and built by others, the original plans for expansion of this pump station are not available. During the early stages of the Phase II program flow measurements should be carried out to determine flows influent to the pump station from which to assess the need for additional pumping capacity. For purposes of determining budget costs to be included in this Master Plan Update, it has been assumed that all six pumps and motors will have to be replaced.

Sporting Pump Station

The average pumping capacity of the Sporting Pump Station is 22 Ml/d.

The projected wastewater flow tributary to the pump station in the Year 2010 is 16.8 Ml/d. Because of the projected stabilization of population in this area, the tributary population is not expected to increase beyond Year 2010. Based upon projected increases in per capita wastewater contribution only, the anticipated flow tributary to the pump station in the Year 2030 is 18.9 Ml/d. No increase in pumping capacity, therefore, is required in the Phase II expansion.

The only means of screening provided in the pump station are two manually-cleaned bar racks. On a regular routine basis, these bar racks present a difficult operational procedure with a high risk to the health of the operators. To alleviate these problems, a cost has been included for the study, design and construction of suitable mechanically-operated screens. If possible, the existing bar-racks might be retained for emergency use only.

Sidi Bishr Pump Station

The installed average capacity of pumps at the Sidi Bishr Pump Station is 59 Ml/d, with a peak capacity of 98 Ml/d. This compares with an estimated Phase II required capacity in the Year 2010 of 61.9 Ml/d. The original plan to change impellers would increase the average station capacity to 107 Ml/d, with a minimum to peak range of 75 to 164 Ml/d.

Although it appears that upgrading the capacity of the Sidi Bishr Pump Station may not be needed immediately, we have assumed that replacement of the impellers would proceed in Phase II. If actual flows to the station are as anticipated, impeller replacement can be delayed.

East Zone Pump Station

The installed average capacity of the East Zone Pump Station is 400 Ml/d, with a minimum to peak range of 280 to 580 Ml/d. This compares with a projected Phase II required capacity in the Year 2010 of 369.2 Ml/d. The original plan to add a sixth pump would increase the average station capacity to 610 Ml/d.

Although it appears that upgrading the capacity of the East Zone Pump Station may not be needed immediately, we have assumed that the sixth pump would be added in Phase II. If actual flows to the station develop as anticipated, the pump addition can be delayed.

The East Zone Pump Station also contains three mechanically-raked bar screens with structural provisions for a fourth screen. Costs have been included for the provision of this additional screen with associated electrical equipment and instrumentation in Phase II.

New Smouha Pump Station

The installed average capacity of the New Smouha Pump Station is 190 Ml/d with a minimum to peak range of 123 to 275 Ml/d. The projected Phase II required pump station capacity is 174.5 Ml/d with an ultimate Year 2030 capacity of 188 Ml/d. On the basis of the updated flow projections contained in Chapter 4, no expansion of facilities at this pump station will be required in Phase II.

TABLE 5-1
LAKE MARYOUT BASINS

BASIN NAME	AREA (Hectares)	PERCENT OF TOTAL AREA
MAIN BASIN	2193	43.8
NORTHWEST BASIN	723	14.5
SOUTHWEST BASIN	1603	32.0
FISHERIES BASIN	485	9.7
TOTALS	5004	100.0

TABLE 5-2
CURRENT INFLOW SOURCES TO LAKE MARYOUT

INFLOW SOURCE	APPROXIMATE AVERAGE FLOW (Ml/day)
LOWER OMOUM DRAIN	4376
DISHOUDY PUMP STATION	785
HARIS PUMP STATION	1360
KALAA PUMP STATION	610
ABIS PUMP STATION	100
NOUBARIA WATER CANAL	0
WEST ZONE WASTE OUTFALLS:	
• QABBARI	20
• GHEIT EL ENAB	26
• INDUSTRIES	35
TOTALS	7312

TABLE 5-3
SELECTED WATER QUALITY RESULTS FOR LAKE MARYOUT MAIN BASIN

PARAMETER	FEBRUARY - APRIL 1983		MARCH - JULY 1992		TYPICAL COMPOSITION OF STRONG UNTREATED WASTEWATER (mg/l)[b]
	AVERAGE (mgl)	RANGE (mgl)	AVERAGE (mg/l)	RANGE (mg/l)	
Dissolved Oxygen	–	0–20.8	0.4	0–2.5	–
Total Solids	3604	1916–11,787	3042	1231–5644	1200
Total Suspended Solids	543	10–1743	(a)	(a)	350
Volatile Suspended Solids	185	2–1123	(a)	(a)	275
BOD	237	60–715	560	140–1220	400
COD	507	135–1400	1112	240–2672	1000
NH_3–N	20.7	2–130	2.2	0–10	50
PO_4–P	2.2	0.15–20.0	4.87	0–30	10
Chlorides	1462	550–2749	780	290–1200	100
Sulfates	332	68–768	229	64–800	50
Oil & Grease	51	7–224	18	1–65	150
Mercury	0.12	0.03–0.20	(a)	(a)	–
Copper	0.33	0.02–0.80	0.091	ND–0.850	–
Lead	0.38	0.06–0.92	0.158	0.025–0.900	–

TABLE 5-3A
SELECTED WATER QUALITY RESULTS FOR LAKE MARYOUT NORTHWEST BASIN

PARAMETER	FEBRUARY - APRIL, 1983		MARCH - JULY, 1992		TYPICAL COMPOSITION OF STRONG UNTREATED WASTEWATER (mg/l)[b]
	AVERAGE (mg/l)	RANGE (mg/l)	AVERAGE (mg/l)	RANGE (mg/l)	
Dissolved Oxygen	8.5	0–15	5.1	1.6–8.8	–
Total Solids	6594	4582–8686	6629	3194–9266	1200
Total Suspended Solids	1004	288–2075	(a)	(a)	350
Volatile Suspended Solids	389	960–1123	(a)	(a)	275
BOD	205	60–480	736	220–1582	400
COD	563	288–860	1264	380–2620	1000
NH_3–N	6	0.30–26	1.1	0.4–2.8	50
PO_4–P	0.94	0.25–2.30	3.18	0–10	10
Chlorides	2473	1700–3050	2005	1200–2670	100
Sulfates	688	375–800	536	375–750	50
Oil & Grease	66	17–148	14.5	1–40	150
Mercury	0.13	0.05–0.20	(a)	(a)	–
Copper	0.27	0.06–0.80	0.05	ND–0.010	–
Lead	0.26	0.12–0.62	0.116	0.037–0.210	–

(a) Not measured
(b) Source: Metcalf & Eddy, 1991

TABLE 5-3B
PREDICTED AND MEASURED CONCENTRATIONS OF BIOCHEMICAL OXYGEN DEMAND IN LAKE MARYOUT

BASIN	NAME	EXISTING CONDITIONS			PHASE I CONDITIONS	
		Inflow Conc (mg/l)	Ave. Measured Basin Conc (mg/l)	Predicted Basin Conc (mg/l)	Inflow Conc (mg/l)	Predicted Basin Conc (mg/l)
A	Kalaa Drain	678	739	629	582	554
B			707	554		490
C			678	330		316
D				218		284
E	Industries Drain	1077		80	1077	85
F				67		67
G	Industries Drain	1077		1124	1077	1124
H				682		681
I				874		873
J	El Omoum Drain Inflow Dishoudy Pump Station Haris Pump Station Abis Pump Station	1318 909 909 909	909	1159	1318 909 909 909	1156
K	Industries Outfall Gheit El Enab Outfall	1278 531	1014	449	0 0	240
L			620	304		330
M	Fron El Geraya (Kabbari) Outfall Elmetras Outfall	508 310	881	235	0 0	304
N			1727	1085		1067
O	Kalaa Drain	678		119	582	120

TABLE 5-4
POLLUTANT LOADS TO LAKE MARYOUT

	PRE-PHASE I CONDITIONS (Summer, 1993)	PHASE I FACILITIES OPERATIONAL (Summer, 1993)	PHASE II FACILITIES OPERATIONAL (Design Year 2010 Loads)	
			INTERIM	ULTIMATE
NOTES	• EAST ZONE 395 Ml/d • WEST ZONE 213 Ml/d	• ETP - 395 Ml/d • WTP - 213 Ml/d	• ETP - 544 Ml/d • WTP - 475 Ml/d • CENTRAL ZONE COLLECTORS	• SEA OUTFALL
POLLUTANT LOADS: - AS AVERAGE KG/DAY - (AS % OF PRE-PHASE I LOADS)				
LOADS TO LAKE MARYOUT				
• ORGANIC (BOD)	316,160 (100%)	237,120 (75%)	397,410 (126%)	0 (0%)
• SUSPENDED SOLIDS (TSS)	322,240 (100%)	161,120 (50%)	270,035 (84%)	0 (0%)

NH:sm/me/sa/hh

TABLE 5-5
SELECTED EFFLUENT DISCHARGE LIMITS FOR UNFRESH WATERS
EGYPTIAN LAW NO. 48 (1982)

PARAMETER	MAXIMUM EFFLUENT CONCENTRATION
BOD	60 mg/l
COD	80 mg/l
DISSOLVED OXYGEN	NOT LESS THAN 4 mg/l
LIPIDS AND OILS	10 mg/l
DISSOLVED SOLIDS	2000 mg/l
SUSPENDED SOLIDS	50 mg/l
SULFIDES	1 mg/l
NITRATES	50 mg/l
TOTAL HEAVY METALS	1 mg/l
PROBABLE COLIFORM COUNT	5000 / 100 ml
CHLORINE RESIDUAL	NOT LESS THAN 0.50 mg/l

TABLE 5-6
BASIC UPDATED DESIGN DATA FOR LAND TREATMENT SYSTEM

PARAMETER	DESIGN YEAR	
	2010	2030
POPULATION (1000s):		
• WEST ZONE	828	905
• CENTRAL ZONE	1006	1010
• EAST ZONE	2784	3348
	4618	5263
DESIGN FLOWS (Ml/d):		
• LAND APPLICATION SYSTEM		
– Average Annual	1019	1253
• EAST TREATMENT PLANT		
– Average Dry Weather	544	718
– Peak Hour	789	1041
• WEST TREATMENT PLANT		
– Average Dry Weather	475	535
– Peak Hour	689	776
• EFFLUENT PUMPING STATION		
– Average Dry Weather	1019	1253
– Peak Hour	1478	1817
• DESERT PUMPING STATION		
– Average Dry Weather	1019	1253
– Maximum Day + Storage	1324	1629

NOTES:

1. POPULATIONS AND FLOWS DO NOT INCLUDE AMRIA OR MEX-DEKHEILA

TABLE 5-7
BASIC UPDATED DESIGN DATA FOR SEA OUTFALL

PARAMETER	DESIGN DATA
DESIGN YEAR:	2030
OUTFALL POINT OF ORIGIN:	KAIT BEY AREA
POPULATIONS (1000s):	
• YEAR 2010	4618
• YEAR 2030	5263
DESIGN FLOWS (Ml/d):	
• 2010 AVERAGE/PEAK	1019/1478
• 2030 AVERAGE/PEAK	1253/1817
PRIMARY EFFLUENT CHARACTERISTICS:	
• BOD	390 mg/l
• TSS	265 mg/l
• AMMONIA NITROGEN	29 mg/l
• PHOSPHATE PHOSPHORUS	10 mg/l
• pH	6.1 – 9.4
• FECAL COLIFORM	0.75×10^{11}/100 ml
PRELIMINARY OUTFALL DATA:	
• OUTFALL PIPE DIAMETER	3600 mm
• TOTAL OUTFALL LENGTH	8 km
• TOTAL DIFFUSER LENGTH	1173 m
• PIPE MATERIAL	Reinforced or prestressed concrete.
• DIFFUSER DISCHARGE DEPTH	40 – 45 m

NOTES:

1. POPULATIONS AND FLOWS DO NOT INCLUDE AMRIA OR MEX DEKHEILA.

TABLE 5-8
MARINE STUDIES NEEDED FOR OUTFALL DESIGN

TYPE OF STUDY	WHY INFORMATION IS NEEDED	STUDY TASKS
Wastewater Characterization	Obtain pollutants and concentration in the wastewater stream. Screen pollutants to determine initial dilution needed to meet water quality standards.	Collect wastewater samples from each treatment plant. Laboratory testing and analysis of wastewater samples. Analysis to determine initial dilution.
Physical Ocean Monitoring	Calibrate ocean model used to predict initial and far-field dilutions and bacterial concentrations at the beaches. Verify and refine wastewater plume trajectories, including amount of time plume surfaces.	Conductivity, temperature, depth (CTD) casts for seawater density profiles. Deployment of current meter arrays and drogues.
Biological Ocean Monitoring	Predict bacteria types and concentrations at the beaches. Predict impact of proposed discharge on existing biological communities. Provide baseline flora and fauna data against which future data after outfall startup can be compared.	Conduct bacterial die-off tests. Collect flora and fauna samples from the water column near the proposed diffuser site and at a control station. Will include trawls, seining, and water column casts. Collect bentic infauna samples from near the proposed diffuser site and at a control station. Analyze and catalog all biological data.

TABLE 5-8 (Cont'd)
MARINE STUDIES NEEDED FOR OUTFALL DESIGN

TYPE OF STUDY	WHY INFORMATION IS NEEDED	STUDY TASKS
Chemical Ocean Monitoring	Obtain background pollutant concentrations in seawater and sediments near the proposed diffuser site and at a control station. Provide baseline pollutant data against which future water and sediment data can be compared.	Collect water samples in Mediterranean Sea off Alexandria. Collect sediment samples near the proposed diffuser site. Laboratory testing and analysis of water samples and sediments.
Geophysical Survey	Obtain seafloor topographic information for outfall design. Determine presence and nature of seafloor obstructions to outfall construction. Compare foundation and construction conditions along different outfall alignments to optimize design.	Fathometer survey producing a bathymetric map of the outfall area. Side scan sonar survey producing an obstructions map. Seismic reflection survey producing continuous subbottom profiles of sediment facies. Seismic refraction survey producing continuous profiles on sediment thicknesses and densities.

TABLE 5-9
RAW WASTEWATER FLOWS
PHASE I

TREATMENT PLANT	WESTWATER FLOW (Mℓ/d)		INFLUENT TOTAL SUSPENDED SOLIDS (mg/ℓ)
	Average	Maximum Day	
East Plant	410	470	530
West Plant	175	271	530

TABLE 5-10
PRIMARY SLUDGE SOLIDS
PHASE I

Parameter	Primary Sludge Solids-Kg/d (Phase I)	
	Average	Maximum day
ETP Solids Removed	108,650	124,550
ETP Dilution Water Solids	2,000	2,300
Total Solids: ETP to WTP	110,650	126,850
ETP Solids Removed in WTP Sedimentation Tanks	110,650	101,480
WTP Solids Removed	55,650	86,180
Total Combined Sludge Solids	166,300	187,660
Filterate Recycle Solids Removed	8,750	9,880
Total Solids to Dewatering	175,050	197,540
Sludge Concentration to Dewatering (%)	4	4
Sludge Flow to Dewatering (Ml/d)	4.38	4.94

Assumptions:

1. TSS removal at ETP – 50 percent
2. TSS removal at WTP – 60 percent
3. Recovery of ETP solids in WTP Sedimentation Tanks at average flow – 100 percent
4. Recovery of ETP solids in WTP Sedimentation Tanks at maximum day flow – 80 percent
5. Solids capture in mechanical dewatering facilities – 90 percent
6. Removal of filtrate recycle solids in WTP Sedimentation Tanks – 50 percent
7. Solids concentration of primary sludge – 4%. (In the development of certain units in the sludge dewatering train, a solids concentration range of 3% – 6% has been used).

TABLE 5-11
BASIC DESIGN CRITERIA FOR BELT FILTER PRESSES
(PHASE I)

Parameter	Phase I
Total Solids Loading Kg/d	
Average	175,050
Maximum Day	197,540
Solids Concentration (%)	4
Sludge Flows (Ml/d)	
Average	4.38
Maximum Day	4.94
Number of Presses	
Average	8
Maximum Day	9
Installed	12
Unit Solids Loading (Kg/m/hr)	
Average	456
Maximum Day	457
Unit Hydraulic Loading (m^3/m/hr)	
Average	11.4
Maximum Day	11.4

TABLE 5-12
RAW WASTEWATER FLOWS
PHASE II

TREATMENT PLANT	WASTEWATER FLOW (Mℓ/d)	INFLUENT TOTAL SUSPENDED SOLIDS (mg/ℓ)
	Average	
East Plant	544	530
West Plant	475	530

TABLE 5-13
PRIMARY SLUDGE SOLIDS
(PHASE II)

	Primary Sludge Solids-Kg/d (Phase II)	
	Average	**Maximum Day**
ETP Solids Removed	144,200	205,400
ETP Dilution Water Solids	2,670	3,800
Total Solids: ETP to WTP	146,870	209,200
ETP Solids Removed in WTP Sedimentation	146,870	167,400
WTP Solids Removed	151,050	229,000
Total Combined Sludge Solids	297,900	396,400
Filtrate Recycle Solids Removed	15,700	20,860
Total Solids to Dewatering	313,600	417,260
Sludge Concentration to Dewatering (%)	4	4
Sludge Flow to Dewatering (Mℓ/d)	7.84	10.41

Assumptions:

1. TSS removal at ETP -50 percent
2. TSS removal at WTP - 60 percent
3. Recovery of ETP solids in WTP Sedimentation Tanks at average flow - 100 percent
4. Recovery of ETP solids in WTP Sedimentation Tanks at maximum day flow - 80 percent
5. Solids capture in mechanical dewatering facilities - 90 percent
6. Removal of filtrate recycle solids in WTP Tanks - 50 percent
7. Solids concentration of primary sludge - 4%. (In the development of certain units in the sludge dewatering train, a solids concentration range of 3% - 6% has been used).

TABLE 5-14
BASIC DESIGN CRITERIA FOR BELT FILTER PRESSES
(PHASE II)

Parameter	Phase II
Total Solids Loading (Kg/d)	
Average	313,600
Maximum Day	417,260
Solids Concentration (%)	4
Sludge Flows (Ml/d)	
Average	7.84
Maximum Day	10.43
Number of Presses	
Average	14
Maximum Day	19
Installed	24
Unit Solids Loading (Kg/m/d)	
Average	464
Maximum Day	456
Unit Hydraulic Loading (m^3/m/hr)	
Average	11.6
Maximum Day	11.4

TABLE 5-15
DESIGN SLUDGE CAKE QUANTITIES
(West Treatment Plant)

Belt Filter Press Performance	Sludge Cake Quantities (m^3/d)	
	Phase I	Phase II
Average Solids:		
• 20% sludge cake solids	764	1369
• 25% sludge cake solids	600	1075
Maximum Day Solids:		
• 20% sludge cake solids	862	1822
• 25% sludge cake solids	677	1431

TABLE 5-16
TRUCK AND TRAIN-CAR REQUIREMENTS
(West Treatment Plant)

Parameter	Phase I	Phase II
Sludge cake quantity – (m^3/d)	764	1369
Truck capacity (m^3)	27	
No. of truck-trips per day	29	51
Round-trip travel time (hrs)	8	
Duty trucks	10	17
Standby trucks	5	9
TOTAL TRUCKS REQUIRED	15	26
Train-car capacity – m^3	46	
Duty train-cars[a]	17	30
Standby train-cars[b]	17	30
Spare	12	20
TOTAL TRAIN-CARS REQUIRED	46	80

(a) Numbers of train cars required to hold one day's production of sludge cake.
(b) Duplicate train cars for continuous loading of cake during transportation of first train car and for emergency standby.

TABLE 5-17
COMPARATIVE COST ESTIMATES OF TRAIN AND TRUCK HAUL
(Phase II)

Item	Train–haul	Truck–haul
Capital costs	25,903,000	6,932,000
Annual O&M costs	2,829,000	1,920,000
Replacement costs	4,515,000[a]	19,969,000[b]
Present Worth costs	$51,594,000	$30,378,000

(a) Replacement costs for front–end loaders at the WTP only after 5, 10 and 15 years.

(b) Replacement costs for front–end loaders at WTP plus sludge hauling trucks after 5,10 and 15 years.

TABLE 5-18
COMPARTATIVE IMPACTS OF SLUDGE HAULING METHODS
(Truck vs. Train)

Major Impact	Favored Transportation Method
Ecological Resources	Truck
Sludge Spillage	None
Traffic	Train
Land Acquisition	Truck
Operation & Coordination with Outside Authorities	Truck
Maintenance and Repair	None
Noise	None
Air Quality/Odors	None
Health Effects	None
Flexibility/Adaptability	Truck

Source: "Study of Sludge Hauling Alternative from West Treatment Plant to Site 9N: Train Versus Track", WWCG, May 1991

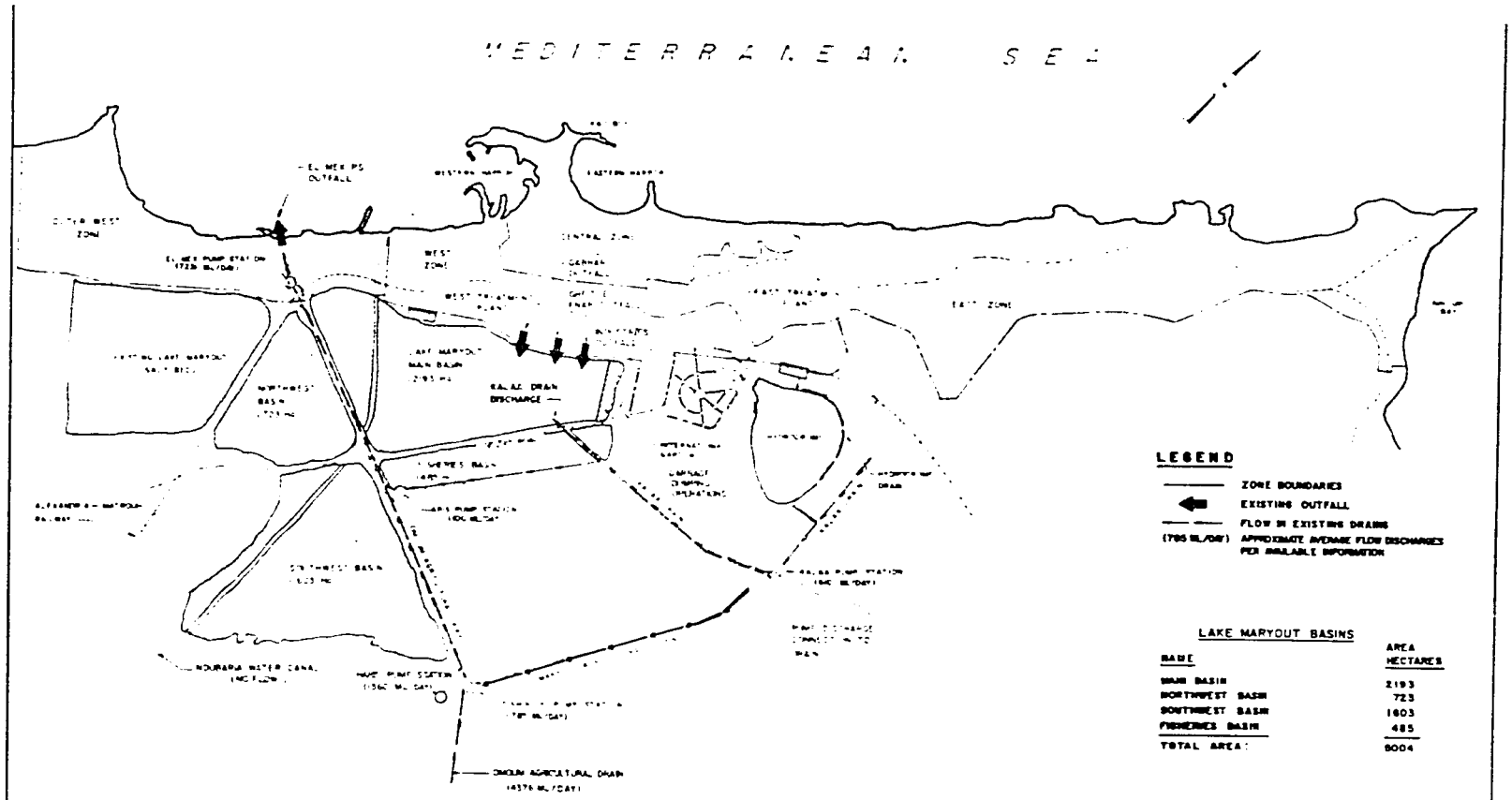
TABLE 5-19
CURRENT USAID-FUNDED PUMPING STATION DESIGN DATA

Parameter	Abu Qir[a]	Maamoura[b]	Ras El Soda[c]	Sidi Bishr[d]	East Zone[e]	New Smouha[f]	Sporting[g]
CURRENT STATION DESIGN (1992)							
Capacity (Mℓ/d):							
• Minimum	2.7	12	NA[i]	41	280	123	12
• Average	9.4	35	117	59	400	190	22
• Maximum	17.5	62	211	98	580	275	44
Pump Station Type	Submersible	Dry Well	Dry Well	Dry Well	Dry Well	Dry Well	Dry Well
Number of Pumps Installed:							
• Operating	2	2	4	3	3	2	2
• Standby	2	2	2	2	2	2	2
Pump Speeds Available	1	3	1	2	6	3	2
PLAN FOR UPGRADING CAPACITY PER ORIGINAL DESIGN[h]							
Upgrading Method	Change Impellers	Change Motors	NA	Change Impellers	Add One Pump	Add One Pump	NA
Planned New Capacity (Mℓ/day)							
• Minimum	3.3	15.3	NA	75	427	155	NA
• Average	11.4	43.7	NA	107	610	283	NA
• Maximum	23	76	NA	164	850	342	NA

(a) Data taken from WWCG's BODR. Final design of Abu Qir P.S. was by AGOSD.
(b) One 450 mm forcemain constructed, which limits discharge to approximately 36 Mℓ/day. A second 600 mm forcemain was planned for next capacity upgrade
(c) Ras El Soda P.S. was designed by CDM. Data shown taken from O&M manual. Any four pumps reported capable of handling maximum current station capacity
(d) Data taken from WWCG's BODR. Any three pumps are capable of handling 164 Mℓ/day.
(e) Data taken from WWCG's BODR. East Zone P.S. sized to handle future "Sadat City" area; it now appears that this currently undeveloped area will not be developed in the foreseeable future
(f) Data taken from WWCG's BODR. Space for fifth pump is available
(g) Sporting P.S. was designed by CDM. Data shown taken from O&M Manual. Any two pumps reported capable of handling maximum current station capacity
(h) Information shown is based on projections assumed in original design. These assumptions are not necessarily relevant now
(i) NA - Not available

TABLE 5-20
PUMP STATION SCREEN AND BAR RACK SUMMARY

Pump Station	Phase I		Phase II	
	Number of Screens	Number of Bar Racks	Number of Screens	Number of Bar Racks
Abu Qir	–	2	–	2
Maamoura	2	1	2	1
Ras El Soda	4	–	4	–
Sporting	–	2	–	2
Sidi Bishr	2	1	2	1
East Zone	3	1	4	1
New Smouha	3	0	4	0



LAKE MARYOUT BASINS

BASIN	AREA HECTARES
MAIN BASIN	2193
NORTHWEST BASIN	723
SOUTHWEST BASIN	1603
FISHERIES BASIN	485
TOTAL AREA:	5004

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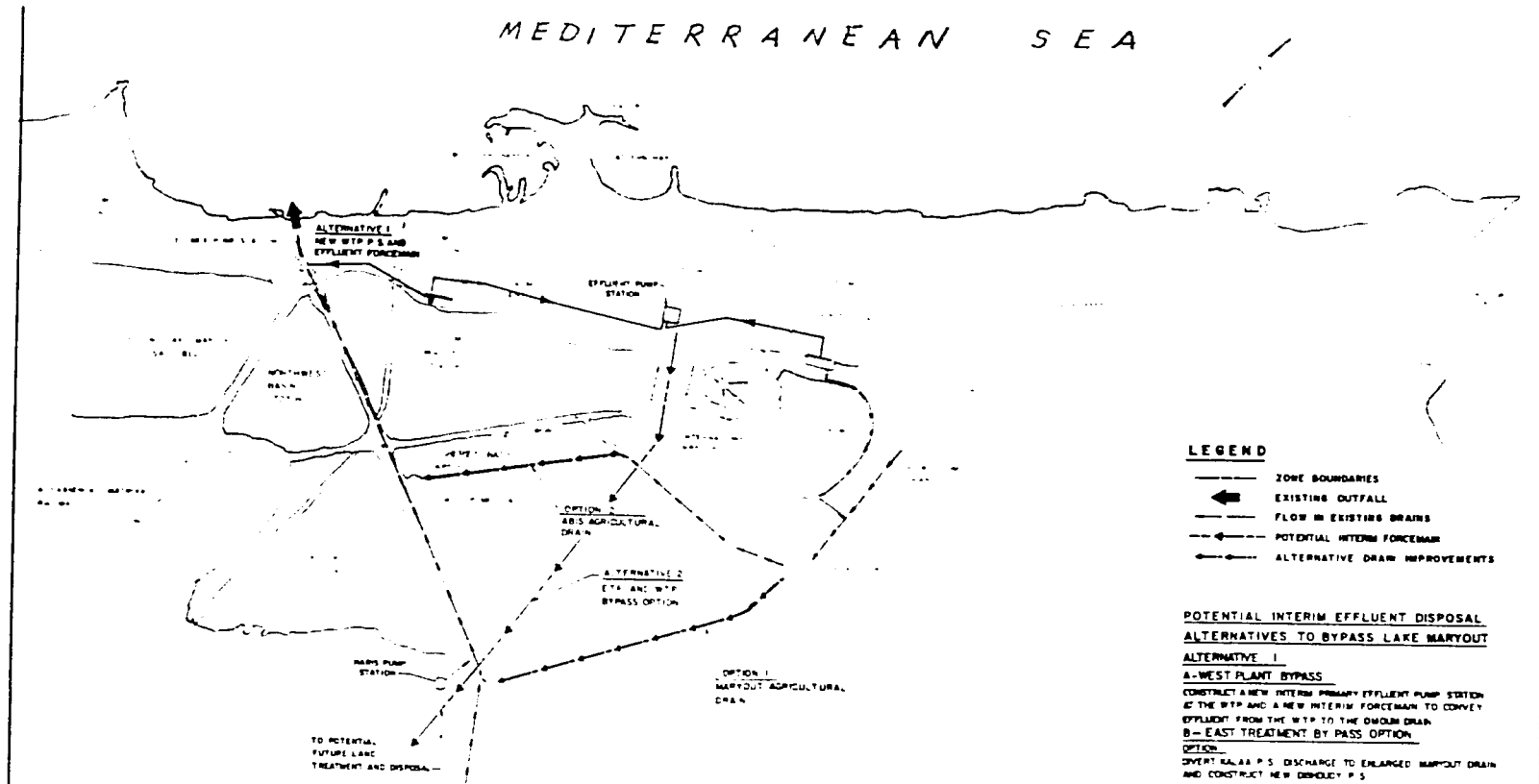
FIGURE 5 - 1
CURRENT LAKE MARYOUT CONDITIONS



POTENTIAL INTERIM EFFLUENT DISPOSAL
ALTERNATIVES TO BYPASS LAKE MARYOUT

ALTERNATIVE 1

A-WEST PLANT BYPASS

CONSTRUCT A NEW INTERIM PRIMARY EFFLUENT PUMP STATION AT THE WTP AND A NEW INTERIM FORCEMAIN TO CONVEY EFFLUENT FROM THE WTP TO THE OMOUM DRAIN

B-EAST TREATMENT BY PASS OPTION

OPTION

DIVERT RAJAA P S DISCHARGE TO ENLARGED MARYOUT DRAIN AND CONSTRUCT NEW DEMOLIOY P S

OPTION 2

DIVERT RAJAA PS DISCHARGE TO ENLARGED ABIS DRAIN AND CONSTRUCT NEW ABIS P S

ALTERNATIVE 2

A-EAST AND WEST PLANT BY PASS OPTION

CONSTRUCT PERMANENT EFFLUENT QUALITY CONVEYANCE SYSTEMS AND EFFLUENT P S

CONSTRUCT TEMPORARY FORCEMAINS FROM THE EFFLUENT P S TO THE OMOUM DRAIN

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FIGURE 5 – 2

POTENTIAL INTERIM EFFLUENT DISPOSAL ALTERNATIVES
EAST AND WEST TREATMENT PLANTS

BEST AVAILABLE DOCUMENT

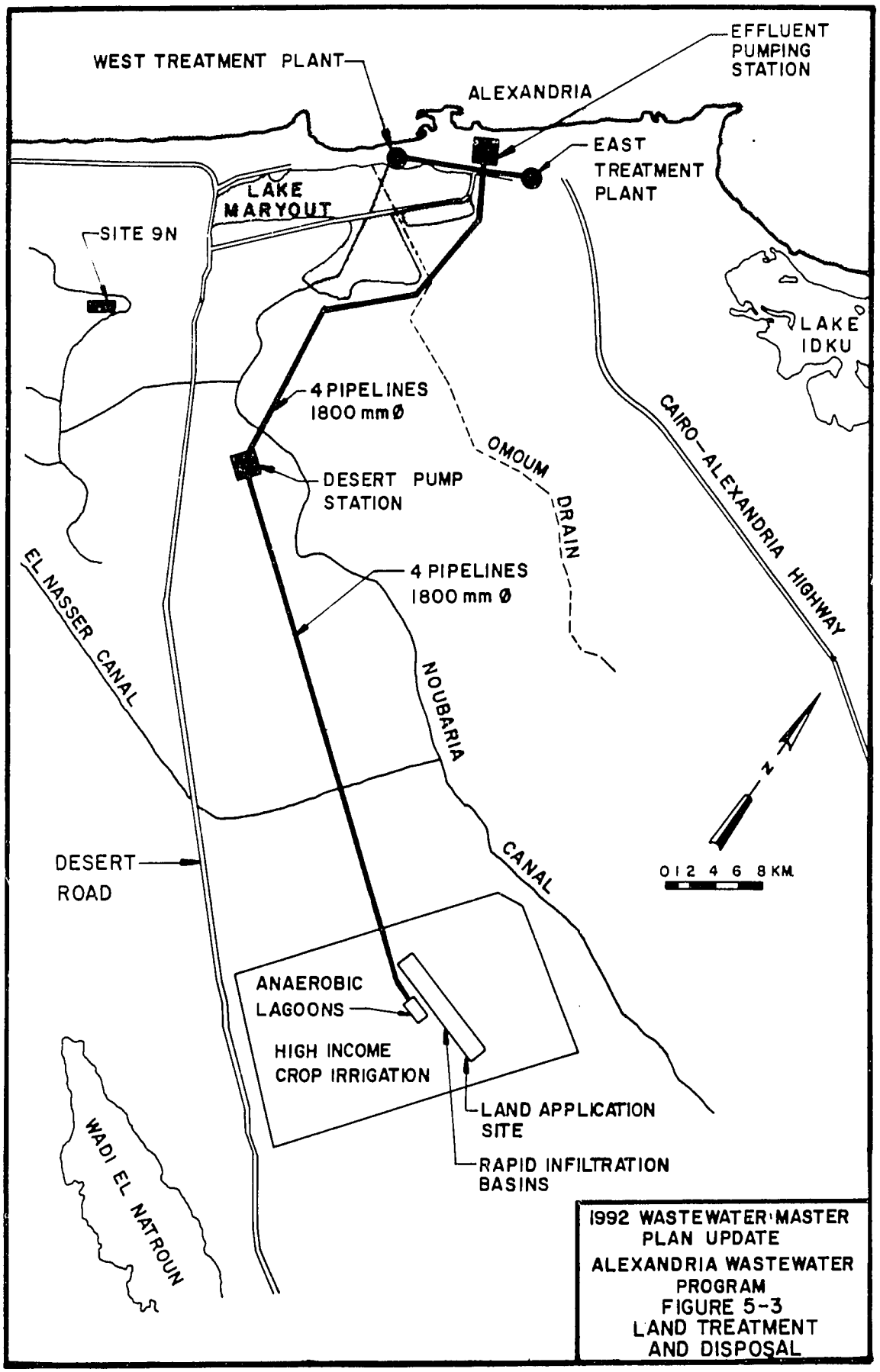

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FIGURE 5-3
LAND TREATMENT AND DISPOSAL

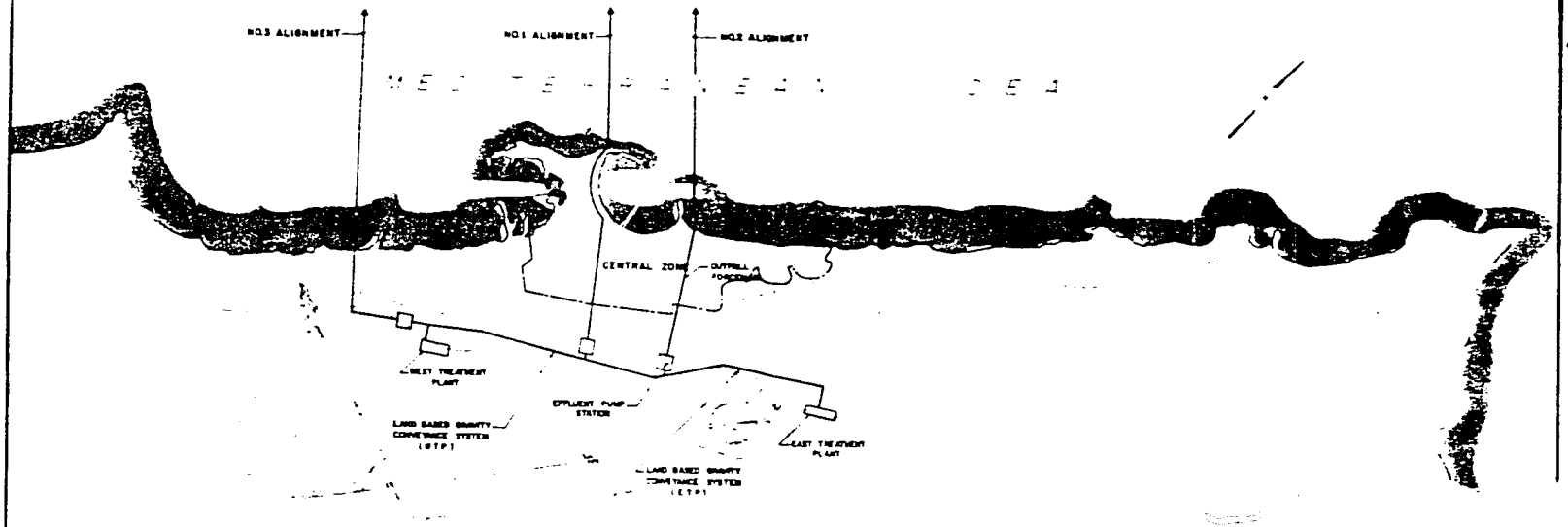

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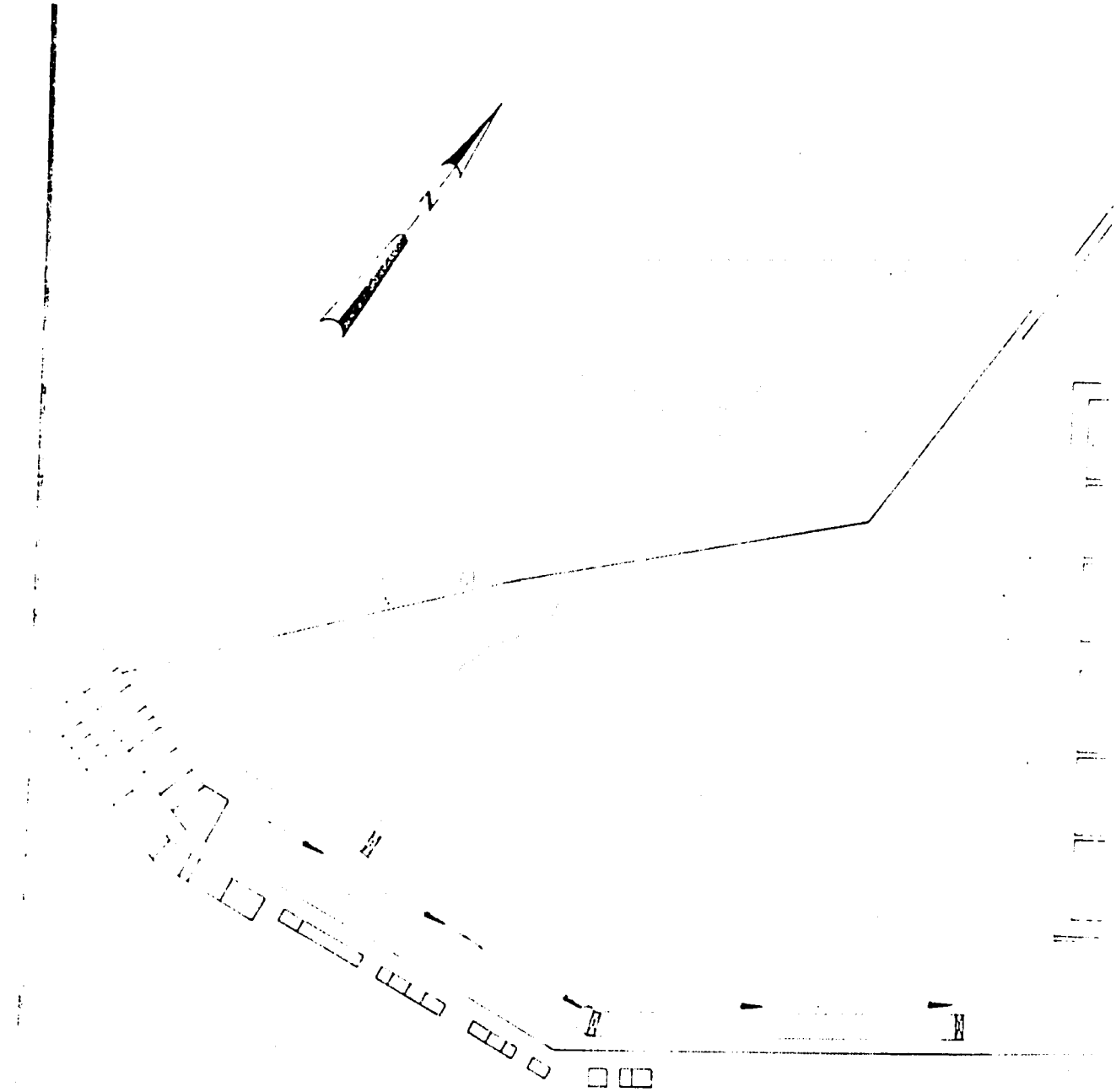
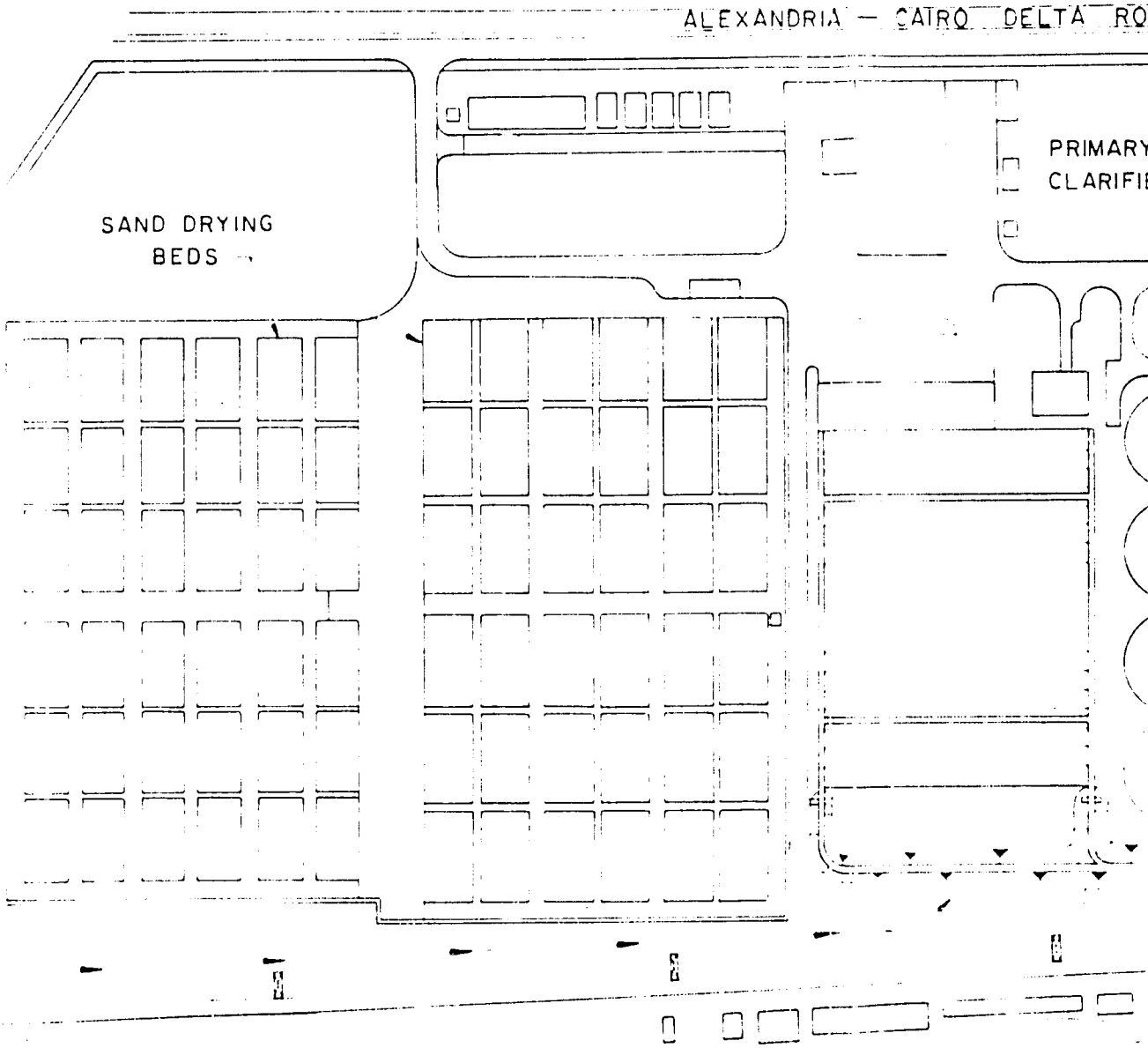
FIGURE 5 — 4

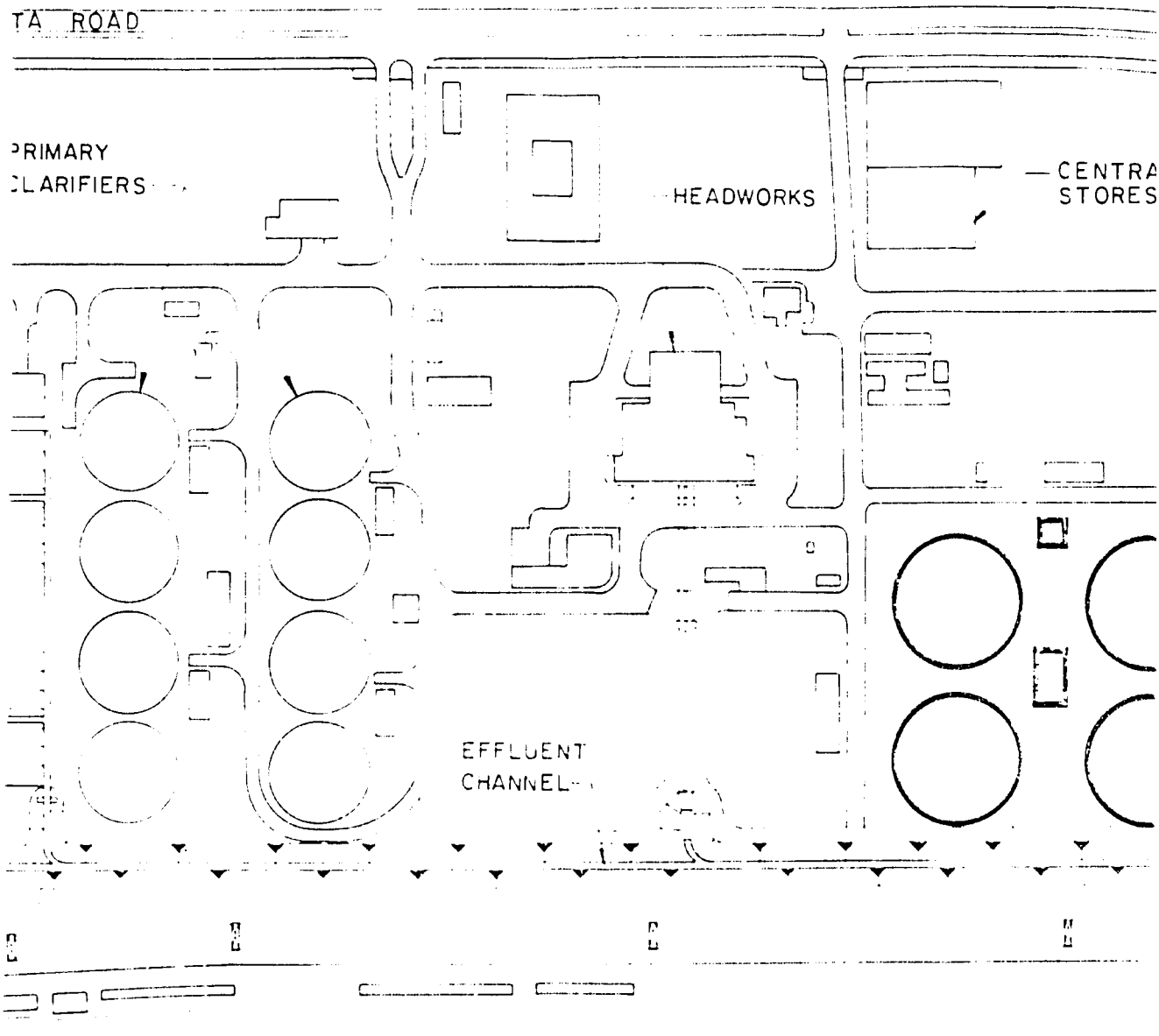


LEGEND

EXISTING FACILITIES

RECOMMENDED FACILITIES


ALEXANDRIA — CAIRO DELTA RO
SAND DRYING
BEDS
PRIMARY
CLARIFIE


TA ROAD
PRIMARY
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HEADWORKS
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STORES
EFFLUENT
CHANNEL

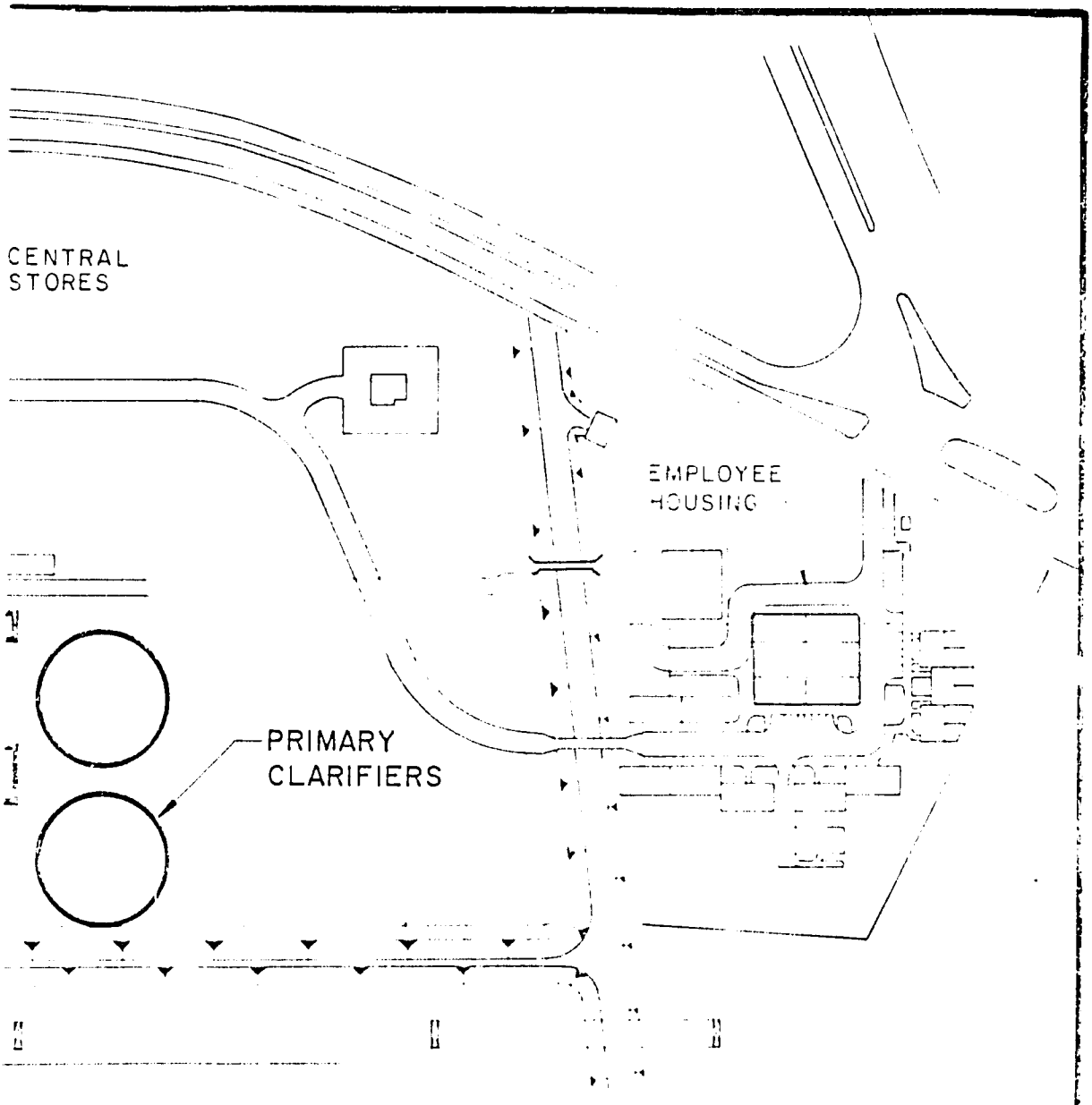

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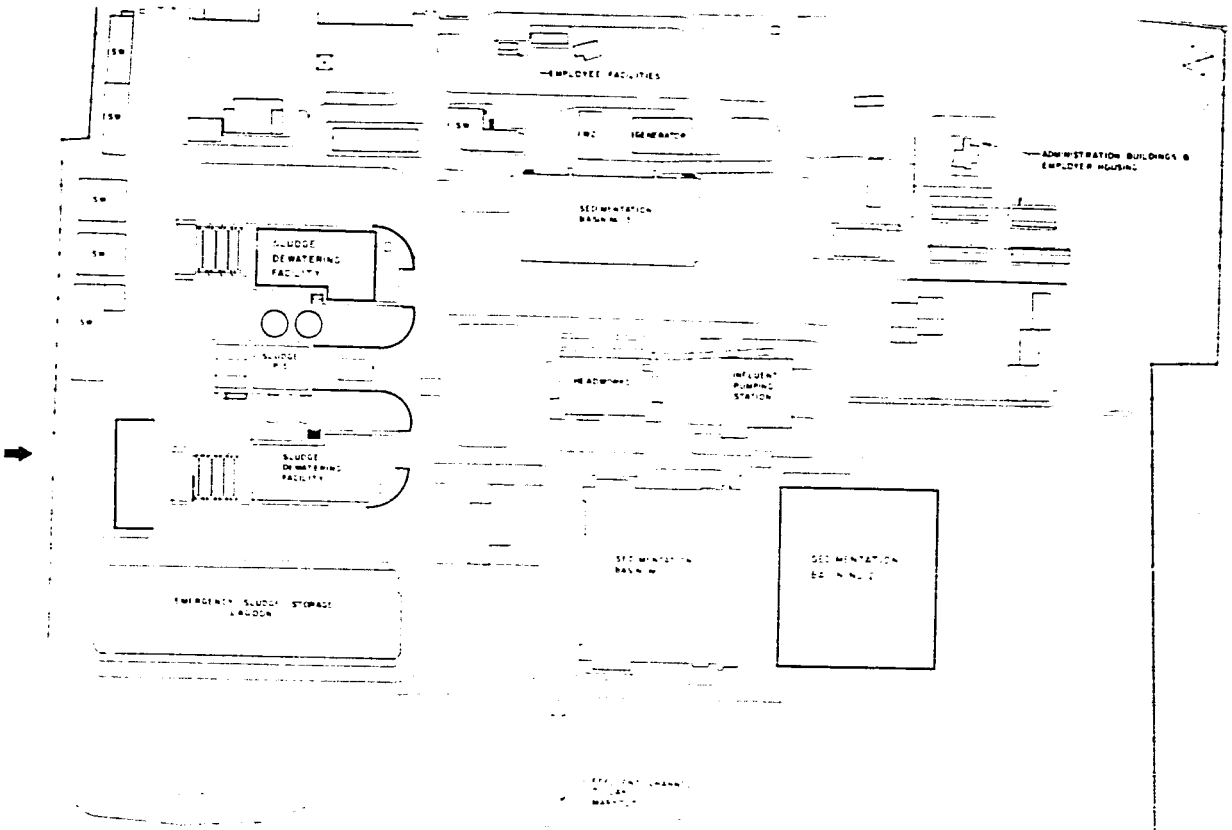
FIGURE 5 — 5

EAST TREATMENT PLANT

GENERAL LAYOUT

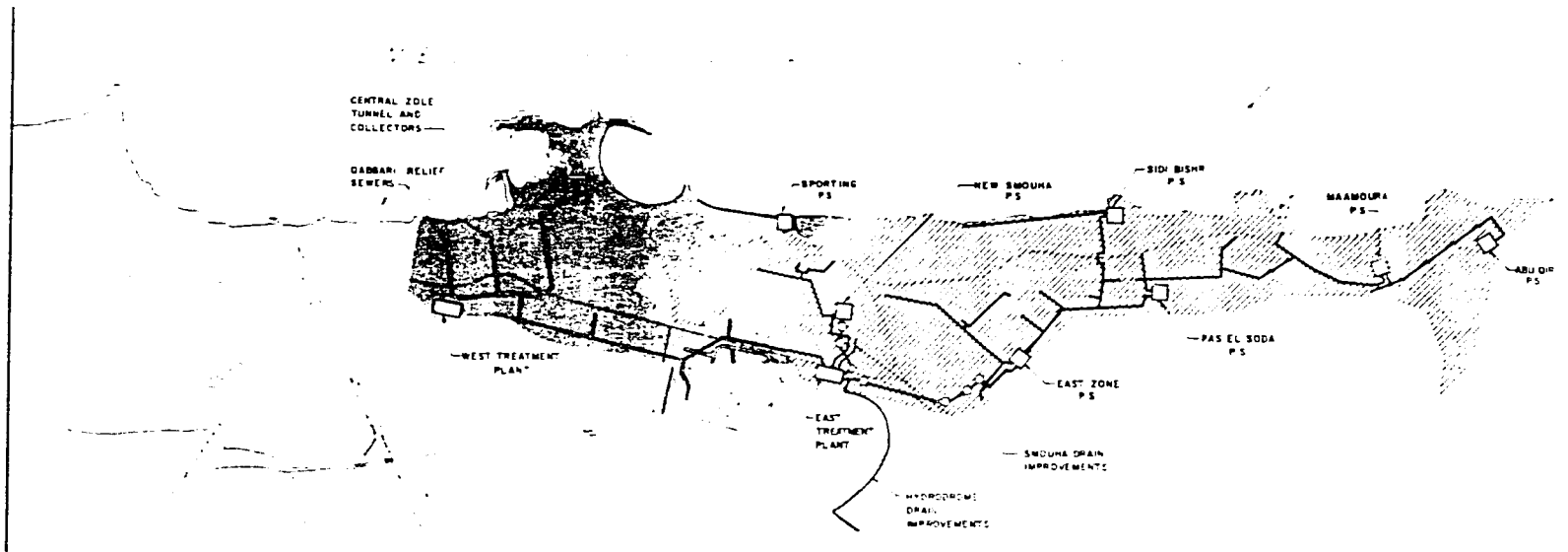
165C



LEGEND

EXISTING FACILITIES
RECOMMENDED FACILITIES
OTHER OR MISCELLANEOUS

FIGURE
WASTE TREATMENT PLANT
GENERAL LAYOUT



LEGEND

- PUMP STATION
- UNDER CROSSING
- COLLECTORS & FORCEMAINS
- EAST ZONE DRAINAGE AREA
- WEST ZONE DRAINAGE AREA

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FIGURE 5 — 7
COLLECTION AND PUMPING STATION IMPROVEMENTS

CHAPTER 6

ADDITIONAL PROGRAM NEEDS

CHAPTER 6

ADDITIONAL PROGRAM NEEDS

The evaluations of feasible alternatives in Chapter 5 were directed towards:

- Expansion of the service area to include all of the Alexandria Wastewater Program Area
- Upgrading of facilities provided in Phase I to handle projected flows in Phase II
- Provision of an environmentally acceptable means of effluent disposal

These evaluations provided the basis of Recommendations in Chapter 8 for additional physical program elements.

This Chapter 6 addresses additional non-physical needs which will ensure the continued satisfactory operation of the total system beyond the completion of the Alexandria Wastewater Program. The following items are included as Additional Program Needs, and are described in the later sections of this chapter:

- Infrastructure Support
- Institutional Support
- Alternative means of Project Delivery and Funding
- Outer West Zone Wastewater Program

INFRASTRUCTURE SUPPORT

The first phase of the Alexandria Wastewater Program will, when completed in 1994, contribute significantly to the upgrading of wastewater collection and treatment, and sludge handling and disposal facilities within the Program area. The further expansion of these facilities in Phase II, as proposed in this Master Plan Update, will provide a complete wastewater system for the entire Program area through the Year 2010.

To ensure that the level of service, established under the Phase I program is maintained, it is imperative that the infrastructure support initiated in Phase I be continued and expanded to cover the additional facilities proposed under Phase II.

The work described in this section represents the minimum level of effort that is required to ensure the continued, successful operation of the Alexandria Wastewater Program facilities. The work is presented under five categories:

- Rehabilitation of some non-USAID funded Pump Stations
- Decommissioning of some non-USAID funded Pump Stations
- Rehabilitation of existing Collection System
- Provision of Stores and Workshop areas
- Operation and Maintenance Technical Assistance

REHABILITATION OF AGOSD PUMP STATIONS

The "Consolidated Pump Station Condition Report", January 1992 [14] prepared by WWCG reported on the condition of 17 AGOSD pump stations in Alexandria. The report concluded that the overall condition in the majority of the older AGOSD pump stations evaluated ranged from poor to fair.

Based on the findings of this report, an order of magnitude cost estimate for the rehabilitation of AGOSD pump stations was developed and is presented in Table 7-1. The cost estimate was based on the pump stations listed in Table 6-1. This table lists nineteen AGOSD pump stations that will remain in full service beyond 1994.

From the data presented in the Consolidated Pump Station Report, it was assumed for cost estimating purposes that all nineteen pump stations, that will remain in full service beyond 1994, would require a complete mechanical and electrical rehabilitation. No cost allowance was made for any structural or hydraulic deficiencies. Structural deficiencies occur less frequently and would need to be evaluated on a case-by-case basis.

DECOMMISSIONING OF AGOSD PUMP STATIONS

Table 6–2 lists twenty–six pump stations that will be either formally decommissioned or be maintained for emergency standby purposes. A cost estimate for the decommissioning of facilities has not been prepared.

REHABILITATION OF EXISTING COLLECTION SYSTEM

Based on the assumptions presented in Table 6–3, an order of magnitude cost estimate is presented in Table 7–1 for the rehabilitation of the existing collection system. It is recommended that the first stage of a rehabilitation program include a comprehensive Collector and Force Main Infrastructure Needs Study to identify and prioritize areas of the existing collection system in need of rehabilitation.

PROVISION OF STORES AND WORKSHOP AREAS

Six categories of stores and workshop areas were identified as being necessary to support O&M activities on completion of the Phase II expansion as follows:

- Administration and Laboratory Facilities
- Spare Parts Storage
- Large Vehicle Overhaul Facility
- Central Garage
- Shaded Vehicle Storage/Parking and Bulk Storage Areas
- Specialty Workshops

Administration and Laboratory Facilities

Administration and Laboratory facilities were provided in the first phase of development at the East and West Treatment Plants, at the Sludge Dewatering Building and at the Sludge Disposal Site 9N.

Additional facilities will be provided in the expansion of the Sludge Dewatering Building in Phase II.

These total facilities are sufficient to handle all administration and laboratory needs in Phase II. However, an allowance has been included to cover the cost of additional vehicles and equipment to support an expanded industrial monitoring capability.

Spare Parts Storage

The Central Stores rehabilitated in Phase II will provide sufficient central storage space in Phase II from which stores will be dispersed to local spare parts stores throughout the system.

Additional storage space is already planned for the Phase II expansion of the Sludge Dewatering Building. Additional storage space should also be included in expansion plans of the East and West Treatment Plants.

Large Vehicle Overhaul Facility

A major overhaul facility will be provided at the East Treatment Plant in Phase I for all scum, screenings, grit and sludge trucks. The number of these trucks will almost double in Phase II. Therefore an expanded or second major overhaul facility will be required. The expanded facility should duplicate the overhaul capacity of the original facility, however, duplication of associated administrative functions is not considered necessary.

Central Garage

The existing AGOSD Central Garage is old, poorly equipped, and with inadequate workshop space. It will not be rehabilitated in Phase I. The Central Garage services all of the system cleaning vehicles, in addition to other vehicles. With the expansion of the collection system in Phase II, and the increased emphasis on cleaning and maintenance of the entire system, the Central Garage must be rehabilitated and expanded as part of the Phase II Program.

Shaded Vehicle Storage/Parking and Bulk Storage Areas

Shaded and bulk storage areas will need to be provided in Phase II. These facilities were designed under Phase I but were not constructed due to lack of funding.

Specialty Workshops

There is an urgent need for maintenance/troubleshooting workshops for hands-on training of AGOSD engineers and technicians. This is perhaps the single most important item contributing to the continued successful operation of the wastewater system. Because of funding limitations, these workshops could not be provided in Phase I. It is important, therefore, that the following facilities be provided in Phase II:

- Electrical/Instrumentation Workshop
- Pumps Workshop
- Diesel Engine Workshop
- Laboratory Workshop

These workshops should be furnished with appropriate equipment, spare parts and consumable supplies to provide a hands-on training environment. The workshops would be housed in one facility, preferably at the East Treatment Plant. It should be designed as an industrial or vocational-technical training facility with high ceilings to accommodate overhead cranes. Approximately 1,000 m^2 of floor space will be required.

OPERATIONS & MAINTENANCE TECHNICAL ASSISTANCE

General

The current O&M program is designed to provide mainly start-up services and training to AGOSD personnel assigned to the USAID-funded facilities. The start-up of the facilities and the technical training provided in Phase I will ensure that the facilities are operational, and the O&M staff has the skills and knowledge to operate and maintain them. It will not ensure, however, that AGOSD will function as a mature organization capable of protecting the considerable investment which has been made by the American and Egyptian governments.

When the O&M program began in 1990, it found AGOSD as a design and construction oriented organization with O&M staff limited to the pump stations, and also with limited or non-existent capabilities in training, safety, maintenance management, and laboratory. While much progress has been made so far in establishing the support systems of a wastewater utility, much more is needed before AGOSD can assume full responsibility in operating and maintaining the facilities in an efficient and cost-effective manner. The purpose of the Operations and Maintenance Technical Assistance, therefore, is to strengthen and institutionalize training, safety, maintenance management, operations and industrial monitoring.

The following scope of work covers recommended O&M Technical Assistance for the period mid-1993 through 1998 and is not included within the existing O&M program.

Scope of Work

Facilities Management Assistance. When the facilities constructed in Phase I are fully operational in 1993, it will be necessary to have experienced managers responsible for their operation and maintenance. The USAID-funded pump stations are staffed and operational. However, it was not until late 1992 that staff were assigned to the two treatment plants, mechanical dewatering facility and site 9N. The assigned managers have no previous technical expertise in wastewater treatment and no management experience in large systems.

It is proposed that WWCG provides on-site, and full-time experienced managers to assist AGOSD managers in carrying out their responsibilities. One WWCG manager will be assigned to each AGOSD facility manager for a period of time proportional to the complexity of the facility. Both managers will work together as a team, with the WWCG manager phasing out in a planned and orderly manner. Initially, the East and

West Treatment Plants will have their respective managers. After the first year of management assistance, only one WWCG treatment plant manager will remain to assist both AGOSD treatment plant managers.

O&M Assistance. A group of four specialist will be available to the AGOSD O&M Department for a period of three to four years to advise and assist AGOSD and ensure that an effective O&M organization is in place. The four specialists and their respective responsibilities are as follows:

- O&M Management Specialist: Responsible for assisting AGOSD to strengthen its O&M management capability, and implement the System Operations Plan. Also responsible for training, safety, and operations and industrial monitoring.

- Maintenance Management Specialist: Responsible for assisting AGOSD to strengthen its maintenance management capability, especially preventive maintenance and inventory control system.

- Operations Specialist: This position will phase in as the Facilities Management Assistance for the treatment plants begins to phase out. Responsible for ensuring that the operational systems in place are functional and adhered to. Provide also subject matter expertise.

- Maintenance Specialist: Similar to the Operations Specialist position.

Schedule

The recommended implementation schedule for the O&M Technical Assistance Program covers the period mid 1993 through 1998. The Facilities Management Assistance component is recommended to be implemented as soon as possible. The O&M Assistance component is recommended to begin during the fourth quarter of 1994. These two components of the overall O&M Technical Assistance Program are recommended for implementation to ensure that the investments made in the Alexandria Wastewater Program since 1978 are transferred to a fully functioning AGOSD.

Figure 6-1 outlines recommended schedule.

INSTITUTIONAL SUPPORT

The wastewater facilities in the Governorate of Alexandria are operated by the Alexandria General Organization for Sanitary Drainage (AGOSD). This includes those facilities constructed under the current portion of the USAID-funded Alexandria Wastewater Program as well as those additional facilities to be funded in a continuing program of assistance. The ability of AGOSD to operate and maintain these facilities properly is directly related to the ability of the organization to function as a modern wastewater utility.

The operation and maintenance activities of a modern wastewater treatment system requires a level of institutional and organizational support not now present within AGOSD. The existing limitations of AGOSD result from both organizational and institutional constraints. Organizational constraints can be defined and measured as elements of the internal dynamics of the organization including the personnel systems, financial systems, and organizational policies, practices and procedures of the management in exercising leadership and control over the organization. Institutional constraints can be defined and measured as those external linkages between the organization and its outside operating environment, including the laws and regulations of the Government of Egypt (GOE) and its relevant agencies, the Governorate of Alexandria, the system users and citizens of Alexandria and donors such as the U.S. Agency for International Development.

The AGOSD is organized pursuant to Presidential Decree No. 363 of 1979 as a "general organization" under Egyptian law. As a general organization, AGOSD lacks the sufficient legal authority and autonomy to operate as an effective utility.

Several specific studies have identified the need for reform of the water/wastewater sector within Egypt. These reports include:

- "Water and Wastewater Sector Study" World Bank Report No. 10350-EGT - April 1992 (Draft)
- "Action Plan for National Policy and Institutional Reforms and Organization of the Independent Water and Wastewater Utilities within the Arab Republic of Egypt"
  USAID Contract No. ANE-0249-1-00-9022-00
- "A Preliminary Institutional Assessment of AGOSD - Milestones for Institutional Reform" WWCG 1992

PROGRAM OBJECTIVES

The objective of an institutional support program is to provide an organization that functions as a modern wastewater utility. The components of a modern wastewater utility can be defined and measured as follows:

Autonomy - Legal/Political

- Ability to decide and act on policies, procedures and personnel (within a charter) without the specific approval of an outside agency or person

- Ability to raise and spend revenues, i.e. budget money without the specific approval by any other outside authority, agency or person. (Expenditures and procedures subject to annual, independent outside audit)

- Ability to regulate, control and enforce technical standards and revenue collection within the jurisdiction served by the agency without relying on any outside authority or agency.

Pricing - Economic

- Rates and tariffs set to charge users of the service in accord with the "marginal cost" of providing the service. (Marginal cost is defined, in very general terms, as the cost of providing the next unit of service to the next customer. Economists consider the cost of providing the next unit of service as reflective of the true value of the commodity)

- An equitable, distribution of costs to the various user classes served such as industry, commerce, and dwellings recognizing that within the developing country economy inter-class subsidy may be required

Financial - Accounting

- An "enterprise fund" financial structure that is designed to:

  - Have independent integrity, that is, be a free-standing fund separate from any and all other units. The fund is structured around a balance sheet and other financial statements utilized by private enterprises

  - Incorporate **all** operation, maintenance and replacement (OM&R) costs of the organization into the enterprise fund

  - Utilize accrual (instead of cash) accounting to value and depreciate assets, services and supplies over time

- A system of accounts and controls that provides for:

  - Internal review, approval and control over all expenditures

- Valuing of physical inventory of stores and supplies and a system of controls over that inventory over time

- Allocation of costs to a chart of accounts (line item descriptions of budgetary expenditures)

o A budgeting system that provides for the development of a detailed annual operating budget. The annual budget process is used to define, review and approve priorities for the entity. Once approved, the annual budget is used by management to empower and hold accountable line managers responsible for expenditures

o A 5 or 10 year capital budget which is reviewed, updated and approved every one or two years. This provides a vehicle for long term financial planning for the entity

o A financial and management information system that generates periodic and timely financial reports for the use of senior management

Structural - Organization

o An organizational structure that differentiates line duties and responsibilities from staff duties and responsibilities

o A middle management corps that can implement policy and actions through a system of "delegation of authority". (This provides for the predictable assumption of responsibility and accountability by individuals within a larger system)

o Personnel policies and procedures that provide senior management with a system of necessary and appropriate incentives and control over all levels of employees

o An on-going program of strengthening and development of management skills for senior, middle and junior managers

Support Systems - Service Delivery

o Ability to deliver services internally and externally of the organization effectively.

- Operations and Maintenance
  - Process Control at plants
  - Preventative maintenance
    - plants
    - pump stations

sewer system
rolling stock and equipment

- Training Programs
- Laboratory Analysis
- Stores, Supplies and Internal Distribution
- Industrial Waste and Hazardous Materials
- Health and Safety of Employees

OBSTACLES TO ACHIEVING PROGRAM OBJECTIVES

To provide AGOSD with the organizational structure for functioning in accordance with modern wastewater utility principles, certain existing constraints must be addressed. These constraints can be categorized as external and internal.

External Institutional Constraints

In general, the current external or sector problems are the result of one or more of the following:

- Centralization of sector policy decisions in the GOE
- Large GOE operational subsidies for operations
- GOE bureaucracy required for budget and personnel decisions

Program for Sector Reform. USAID is finalizing its program for providing technical assistance to NOPWASD to assist the GOE in its program of sector-wide reform. It is the position of USAID that the reforms by the GOE within the sector conform to the basic principles established by USAID in its Water and Wastewater Sector Strategy. Elements of that strategy include: water and wastewater utilities operating as autonomous, municipally-based regulated utilities; recovery revenues for facility O&M from locally generated revenues through a system of tariffs; non-political boards of directors to provide governance of the utility; and merit-based personnel systems independent of the GOE government-wide civil service system.

Internal Institutional Constraints

The long-term success of the Alexandria Wastewater Project depends on the success of the GOE sector reform program for the water wastewater sector, and also on a successful technical assistance program of institutional support for AGOSD to address current internal constraints. This technical assistance program represents the most important element of Additional Program Needs contained in this Master Plan Update The purpose and scope of activities of this technical assistance program are described in the following section.

PROGRAM FOR INSTITUTIONAL SUPPORT AT AGOSD

Institutional support is simply a program to strengthen management practices. This can be done by improving existing skills, teaching new skills, developing new systems for management, improving and documenting procedures and practices.

The purpose of the Institutional Support Project (ISP) for AGOSD is to give AGOSD management appropriate tools and techniques to manage and operate the new facilities which will become their responsibility. These tools and techniques will be consistent with the high standards for wastewater utility management in the United States.

To be successful the ISP requires a continuous long-term commitment of technical assistance for AGOSD and must cover a period of five to eight years. Certain tasks of the program can be completed immediately, from 1992 to 1994. Some of these tasks are to be funded as Modification 11 in WWCG's current contract with USAID. Other tasks will need to be executed between 1995 and 2000.

The program must have sufficient flexibility to be responsive to specialized requirements as they develop. The program activities outlined below are designed to be delivered over an eight-year period from 1993 through 2000.

Program Activities

The Program Activities will be directed towards the strengthening and modernizing of AGOSD day-to-day operations in the areas of:

- Overall Management Systems
- Financial Control Systems
- Management Policies and Procedures
- Personnel Training
- Personnel Management

These Program Activities will culminate in the preparation of a System Management and Operation Plan.

Details of the advice and assistance proposed under each of these Activities are contained in the following sections.

Strengthen AGOSD Management Capability. An intensive management training program for AGOSD's senior managers must be provided and executed. Seminars and workshops must be delivered on topics such as: financial management of utilities, personnel management and procurement procedures and practices.

A corps of middle managers must be developed within AGOSD. Utilizing the approximately 300 graduate engineers and other individuals identified by the AGOSD Chairman as a pool, a consultant must work with AGOSD to select junior-level individuals for a training program in public administration. Selection criteria must be developed which include tools such as personality/aptitude instruments, interviews and supervisor recommendations. Opportunities for graduate study of public administration in the United States and within Egypt will be developed for qualified individuals.

Work is needed to provide "twinning" for senior managers in the USA, to develop opportunities for senior managers to observe and participate with the management team at one or more large wastewater agencies in the United States. Management twinning will be conducted in segments of sufficient duration that the participants are exposed to actual management practices at the large wastewater utility.

Opportunities must be developed for professional advancement of AGOSD managers through a program of participation and observation at professional conferences and trade shows in the United States, Egypt and elsewhere. This would include participation at trade and specialty conferences sponsored by the Water Environment Federation, the International Association for Water Pollution Research and Control (IAWPRC), the Association of Metropolitan Sewerage Agencies, etc.

A long-term program must be developed for strengthening the management capability of AGOSD with specific recommendations to USAID on implementation of a long-term program.

Modernize the AGOSD Management Systems. Personal computers and a local area network (LAN) should be installed at AGOSD headquarters, and AGOSD must be given assistance in the identification of systems, and in the selection of personnel to make appropriate selections of hardware and software for the networked system.

AGOSD personnel must be trained in the use, maintenance and operation of the networked system. A strategic plan for computerization at AGOSD will be prepared. The plan will be developed in conjunction with the current activities in the O&M tasks of the project. Based on the recommendations of the plan developed, specific recommendations will be made to USAID on implementation of a system-wide computerization plan for AGOSD.

Upgrade AGOSD Financial Control Systems. Critical financial management functions at AGOSD which must be computerized will be elements of a total financial management software package. These elements comprise, payroll, purchasing and procurement, cost accounting, personnel administration, inventory management. Such a system will provide AGOSD with a complete procurement, inventory and financial control system for its procurement functions.

AGOSD finance department personnel must be properly trained in use of the selected software and peripheral support systems. A utility chart of accounts for AGOSD must be developed and implemented. The chart of accounts should be developed in

conjunction with Egyptian Standard Accounting System, and AGOSD finance department personnel trained in its use.

Basic and essential equipment for AGOSD finance department, including calculators, typewriters, adding machines, copiers and other equipment must be identified and purchased.

Systems delivered under this task must be coordinated with the maintenance management systems being developed and delivered through the O&M program to insure that the final system is fully integrated. Recommendations for USAID on implementation of a long-term program for developing and strengthening the financial systems at AGOSD must be made.

Develop and Install Systems for Financial Viability at AGOSD. Work must be coordinated closely with the AGOSD Finance Department staff in preparing a zero-based budget and in developing the budget as a method of institutionalizing the procedures and elements of a zero-based budget.

A comprehensive revenue requirements/cost-of-service rate study for AGOSD must be prepared and documented. Revenue requirements of AGOSD as a self-sustaining utility company must be developed.

Work must be coordinated closely with AGOSD staff in developing a five-year financial plan. This will provide a method of institutionalizing AGOSD capability in the preparation of such a plan.

Work must be coordinated closely with the AGOSD staff in developing the capital plan as a method of institutionalizing methods and procedures for preparation of such a plan.

Recommendations must be prepared for USAID regarding a long-term program for institutional strengthening of the AGOSD Finance Department.

AGOSD Organizational Effectiveness will be improved by periodic review of the organizational structure of AGOSD and by providing recommendations to the Chairman for improvements through reorganization of the existing agency. Staff support will be provided to the Chairman in his evaluation of a more effective organizational structure for AGOSD. This will include staff support to the Chairman in discussions with the Minister of Housing, NOPWASD and other offices and agencies of the Government of Egypt.

It will be necessary to conduct an administrative needs assessment and recommend improvements in the physical facilities, office space, communications and transportation needs of AGOSD, and to develop recommendations for USAID on an organizational effectiveness program for AGOSD.

Upgrade AGOSD Management Policies and Procedures. Existing policies and procedures must be reviewed, and a list of critical management policies developed for review and approval by AGOSD Chairman. Once approved, this will include the development of written management policy statements for the Chairman's signature.

Specific, written procedures for implementation of the approved policies should be developed together with means and methods of effective internal communication of policies and procedures within AGOSD.

A written organizational manual must be prepared and updated which catalogs and documents all policies and procedures for printing and distribution to all AGOSD managers.

Prepare a Comprehensive Training Program and Plan for AGOSD. Training needs outside the O&M Department must be reviewed and evaluated and a Comprehensive Training Plan for AGOSD developed which considers the physical facility needs, program support requirements, institutionalization of O&M training, and training program needs for departments other than the O&M department. The Comprehensive Training plan should make specific recommendations for a long-term program of institutional support for a total AGOSD training program.

Development and expansion of the internal training capability of AGOSD must be included.

Improve Personnel Management Practices. Existing personnel administration practices should be reviewed and opportunities for improving systems and practices evaluated, including specific recommendations for making improvements. All personnel management policies and practices which are now administered by agencies of the Government of Egypt must be reviewed and documented. Recommendations to AGOSD and USAID should include the mechanisms for establishment of a system of personnel administration which will support an autonomous wastewater utility.

System Management Plan and System Operation Plan. Based upon the above, a System Management Plan for AGOSD can be prepared. The System Management Plan will be the incorporation of the documentation and recommendations for the long term institutional support program at AGOSD. The Plan will provide detailed recommendations and procedures for conversion of the AGOSD from its current form to an independent, self-sustaining utility.

In conjunction with the O&M program, a System Operation Plan can be prepared which will provide detailed recommendations for the integration of the facility operations into the management structure of a self-sustaining utility company. The principal focus of the System Operation Plan will be the O&M Department.

INDUSTRIAL WASTE MANAGEMENT TECHNICAL ASSISTANCE

General

Alexandria contains 40% of all of the industry in Egypt. Much of the industry is heavy manufacturing and much of it is Government-owned enterprise. A report by WWCG in July 1991, as well as studies prepared by AGOSD, have documented the range and concentrations of the contaminants and topics that are presently discharged into the sewer system.

Some 20% of the industries produce 90% of the industrial waste flows to the system. In the case of the East Treatment Plant it is projected that approximately 20% of the discharge in the drainage areas are industrial waste while in the West Treatment Plant drainage the figure is 33%.

The control of the large volume and high concentrations of contaminants is key to the overall success of the Alexandria Wastewater Project. The key issues of sludge disposal/utilization and the options for ultimate effluent disposal revolve around AGOSD effectively controlling the industrial discharges to the system.

In order for AGOSD to raise the revenues required to support an autonomous utility, it must develop and implement a system to charge fees to the specific industries that discharge high concentrations of BOD and TSS to the system.

Methods and Objectives

The objective of the industrial waste Management Technical Assistance Program will be to assist AGOSD to develop the capacity to effectively manage and control industrial discharges, including pretreatment and source control of topics, through a system of industrial permits and to establish a system of fees and charges that recover the cost of AGOSD treating excessive BOD and TSS. The program will initially focus on the 20% of the industries that discharge the 90% of the volume. Later, the program will establish a priority schedule for addressing the remaining industrial discharges.

Technical Assistance (TA) will be provided to AGOSD in the form of two (2) experienced ex-patriots, one (1) an experienced manager of a wastewater utility industrial waste program (urban), and one (1) engineer (sanitary or chemical) experienced in the development and implementation of an industrial permit/monitoring program. Additional Egyptian professional staff (2 persons) and administrative support will need to be provided.

Overall, Technical Assistance will be provided to the Chairman AGOSD's Industrial Waste Manager, and to AGOSD's Finance Department as part of the Institutional Support Program for AGOSD. Estimated duration of this program is about 2 years, to commence as soon as possible. TA program costs are estimated at $ 1.8 million plus purchase of related equipment.

DESIGN - BUILD CONTRACT PACKAGE

The Alexandria Wastewater Program has, with minor exception been designed and constructed using the "two step" procedure. In the first step, planning and complete design of a particular feature was completed by a Consulting Engineer, who also prepared a construction cost estimate and construction bid documents. As a second step, the designed feature was built by a construction contractor, usually after the construction was competitively bid. During this second step, the construction of the facility, the Consulting Engineer inspected the construction contractor's work to insure that it was constructed in accord with the design, to include final testing where required, and recommended to the client that the facility be accepted.

An alternative procedure, commonly called "Design–Build", places responsibility for producing the final design, and for quality assurance during construction, on the construction contractor. The consulting engineer in the first step prepares a preliminary design and performance specifications and also the "Design–Build" Tender documents. The Consulting Engineer also performs a technical and cost review of the tenders and recommends an award to the client. After the award, the Consulting Engineer reviews and approves the construction contractor's design and determines that the construction contractor's work meets the performance specification's.

The Consulting Engineer in both instances also reviews and approves the construction contractor's pay estimates to insure that he is paid only for work completed in accord with the approved design.

Both methods have advantages. The two–step method allows all of the major design decisions to be made prior to tendering. The marine contractor knows what he is bidding on and is subjected to few surprises into the project. The method can allow the marine contractor a lot of latitude in selecting materials and the construction method. It can also allow the marine contractor to prepare a tighter bid. The two–step method can be used to restrict the choice of materials, equipment, or construction methods. Design–build, on the other hand, allows marine contractors to take advantage of their particular construction equipment, skills, and experience in the preparation of their design. Consequently, design–build is particularly applicable to projects where differences in construction methods and design approaches can significantly affect the cost or schedule of the construction work.

The are disadvantages with either method. The two–step method usually takes longer for project completion. For design–build, not all of the design problems are solved prior to letting the tender, with the resulting design perhaps being somewhat experimental rather than standard. The tender evaluation could also be made difficult by having to compare totally unrelated construction methods and costs.

Of the work identified in this Master Plan Update as remaining to be accomplished, the sea outfall appears suitable for tendering on a "Design-Build" basis. This is because marine construction will require experience and specialized skills on the part of the successful construction contractor. Using "Design-Build" procedures will enable each tenderer to design the Outfall to take advantage of their particular specialized equipment and past experience.

POTENTIAL NON USAID FUNDING SOURCES

General

Competing priorities for available USAID funds provided to Egypt each year may restrict the annual increment and the total amount of USAID funds allocated by USAID to finance remaining program requirements identified in this Update. Consequently the Government of Egypt may find it necessary to obtain financing for a portion of the remaining program from sources other than USAID. There are, however, several important considerations in deciding what portion could be financed by others. In implementing the design and construction of the System to date, care has been taken to insure that each funding increment is for a complete package of useable facilities. The principal of financing complete, useable, stand alone packages should be continued.

Each potential funding source has restrictions regarding source and origin of materials and equipment. New facilities containing electrical and mechanical equipment have to date been financed by USAID, and are consequently of US source and origin. Care has also been taken to insure, as much as possible, that mechanical equipment be of similar make and model to facilitate management of repair parts, and operation and maintenance of the system. This policy is sound and should be continued. Consequently, the financing of future facilities containing mechanical and electrical equipment should be by USAID, if possible. The remaining civil works such as the collection system and the Sea Outfall could be financed by other than USAID with no negative impact on system Operations and Maintenance. The Sea Outfall, because of its specialized nature and large cost should certainly be a candidate for non USAID financing should this be necessary.

The source of non USAID funding, should this be necessary, is a matter for the Government of Egypt to decide. However, this decision should be made as early as possible in coordination with USAID and the U.S. Consultant Program Manager to ensure system integrity.

Parallel Financing

As social infrastructure, the Phase II project conforms to the missions of bilateral aid agencies. Prospective financing may be sought from bilateral funds in the form of grants or, if necessary, from multilateral sources in the form of concessionary loans. The foreign exchange component may be financed under a parallel financing arrangement comprised to the following project packages.

- Consulting services: design, construction supervision.
- Equipment and Materials
- Civil Works
- Interest during Construction
- Physical and Price Contingencies.

Bilateral Financing from CECD Countries

Bilateral financing in the form of grants may be requested from selected governments of countries with large foreign assistance programs, with major interests in Egypt, and with priorities in the environmental sectors.

With the exclusion of USAID, three other industrial countries each commit over $ 100 million a year to Egypt and have proven interest in environmental projects. These include Germany, Japan and France. A portion of German and Japanese aid is untied and would thereby give Egypt added flexibility in procurement.

- GTZ — Eschborn, Germany
  Deutshe Gesellschaft fur Technische Zusammenarbeit
- JICA — Tokyo, Japan
  Japan international Cooperation Agency
- FAC — Paris, France
  Fonds d'Action de Cooperation

Since the outfall project involves the Mediterranean Sea, there is also reason to believe that the European Community and the Government of Italy would have great interest. In 1990, Italy awarded $ 75.8 million in foreign assistance to Egypt; the EEC donated $ 65 million.

- DGAE — Rome, Italy
  Directorate General for Economic Affairs
- EDF — Brussels, Belgium
  European Development Fund

The Nordic countries have much smaller funding programs but also have a greater recent interest in environmental projects. For this reason, it would be useful to approach these governments for early financing, creating an international commitment to the project.

- NORAD — Oslo, Norway
  Norwegian Agency for Development

- o SIDA — Stockholm, Sweden
  Swedish International Development Authority

- o DANIDA — Copenhagen, Denmark
  Danish International Development Agency

Multilateral Development Banks

If the bilateral aid agencies are unable or unwilling to finance the entire project cost, the World Bank and the African Development Bank could offer the Government of Egypt low interest loans, possibly within a joint co-financing arrangement.

- o IDA — The World Bank
  International Development Association

- o ADF — African Development Bank
  African Development Fund

IDA loans carry only a small administration fee, .75% of the undisbursed portion of the loan. The loans have a repayment period of 35–40 years with a 10 year grace period.

Eligibility for concessionary terms at either multilateral bank is determined by three factors: balance of payments, debt, and per capita income of the borrowing country. At this point, the Government of Egypt should be able to negotiate this status, based on its post war population and the intense interest in global environment degradation.

Arab Financing Sources

Bilateral Grants. Aid from Arab sources quadrupled in 1990 to reach 6.3 billion dollars. With major reconstruction efforts and Gulf War debts, it is unlikely that the Arab countries will be able to continue these efforts at this level. According to the OECD, Arab foreign assistance in 1993 will simply depend on Gulf oil prices. The following countries have major assistance programs for Egypt.

- o **Saudi Arabia**
  Awarded grants to Arab countries in the amount of $ 3,054 million in 1990, the largest recipient being Egypt for "non-projects"

- o **Kuwait**
  Kuwaiti aid in 1990 increased its grants 10-fold, totalling $ 1.7 billion.

- o **The United Arab Emirates**
  The UAE, donated $ 900 million to all countries in 1990, mostly for non-project assistance. Egypt was the largest recipient. The Abu Dhabi Fund for Arab Economic Development will donate all future assistance in grant form.

Although it appears that the post-Gulf War surge in Arab aid has peaked, Egypt is, by far, the largest single recipient and may still be able to solicit funds, to a lesser degree, from the countries of Kuwait, Saudi Arabia and the United Arab Emirates.

Bilateral and Multilateral Loans. The following Arab banks and funds should also be explored as they may provide additional soft loans for one or more project packages, if needed:

- Kuwait fund for Arab Economic Development
  Awarded $ 485 million in 1990 for infrastructure projects with loans having a 46% grant element. The largest recipient was Egypt.

- Arab fund for Economic and Social Development (Kuwait).
  Awarded $ 656 million in 1990 in loans and grants to muslim countries.

- Islamic Development Bank (Saudi Arabia)

- Saudi Funds for Development
  $ 274 million was awarded to 41 countries in 1990; the grant element softened to 45%.

Summary of Recommendations

To gain the most favorable financing, the Government of Egypt might approach the bilateral aid agencies of selected European, Japanese and Nordic countries for grants to finance some or all of the projects packages. At the same time, Arab bilateral and multilateral agencies should be investigated. After these financial sources are committed, the GOE might approach both the African Development Bank and the World Bank for additional financing with soft loans, either in a parallel or joint arrangement.

OUTER WEST ZONE - BASIS OF DESIGN REPORT

The area of the Alexandria Wastewater System extends to a western boundary along the Noubaria Canal. The Outer West Zone lies to the west of the Noubaria Canal and encompasses the developments of Mex-Dekheila, Agami and Amria generally within the Mex-Dekheila census tract.

The Outer West Zone has experienced rapid growth in the recent past, and this growth is expected to accelerate in the future with total population in the year 2030 projected to be in excess of 3.5 million.

At the present time, no wastewater services have been provided in the area. Sewage disposal is achieved by the use of septic tanks, cesspools and, in many cases, direct discharge to open drains. High water tables in some areas makes the operation of septic tanks and cesspools ineffective.

Construction of high-rise dwellings in the area has proceeded to keep pace with, and in anticipation of the population explosion. Many of these buildings are completed and lie vacant because of the lack of basic services.

Recognizing the urgent need for a comprehensive wastewater program for the area, a Basis of Design Report (BODR) has been included in the Phase II expansion of the Alexandria Wastewater Program. This BODR, when completed, will provide the City and Governorate of Alexandria with a blue-print for development of wastewater services. It will also provide a basis for early design and construction of high priority sections of the overall program to alleviate the more serious existing problem areas.

A further benefit of early development of the BODR will be the identification of sections of the treatment and disposal facilities that could impact the design and construction of facilities within the Alexandria Wastewater Program to be provided in Phase II.

This section of the Master Plan Update contains a description of the scope of work necessary to complete the BODR, staffing requirements, a schedule for carrying out the work, and a budget cost estimate for preparation of the Report.

PROGRAM OF WORK

The work required to complete the BODR will be carried out under the following general classifications:

- Data collection
- Wastewater flow determinations
- Identification and evaluation of alternatives
- Development of final selected alternative
- Preparation of draft BODR
- Discussions and finalization of BODR

Data Collection.

Work to be performed in this section will include:

- Collection of available data on topography, population and population distribution, water supply, electricity, telephones, existing waste discharges and geotechnical conditions
- Identification of additional data requirements
- Carrying out necessary data collection surveys, topographic surveys and subsurface investigations to supplement available data

Wastewater Flow Determinations.

Use data collected during the first phase of the work to project:

- Population and population distribution for the years 2010, 2020 and 2030
- Per capita wastewater contributions by area based on projected water supply availability and projected per capita water use
- Wasterwater characteristics based on specific local sampling and analyses, and or by comparison with similar development and per capita water use elsewhere

Identification and Evaluation Alternatives.

On the basis of topographical and geotechnical data, and projection of populations and population distributions developed in the first phase of the study, alternative plans will be developed for the phased collection, treatment and disposal of wastewater. These plans will incorporate wastewater flow and characteristic data developed in the previous study phase.

The conceptual alternatives developed will include pumping stations where appropriate, and levels of treatment commensurate with the disposal methods proposed.

The conceptual alternatives will be evaluated and discussed with representatives of AGOSD, USAID and the Governorate, where appropriate, to identify no more than three alternatives to be developed in further detail.

Development of Final Selected Alternative.

Details of the three selected alternatives will be refined in order to:

- Identify alternative effluent disposal options
- Identify locations, capacities, and level of treatment of required wastewater treatment facilities

- Identify routes and approximate diameters and lengths of major collectors

- Identify locations and capacities of pumping stations, and routes and approximate diameters of force mains

Details will be refined to a degree at which budget cost estimates can be prepared for evaluation and comparison of alternatives.

The selected alternatives will be compared on the basis of:

- Capital and operating costs

- Level of sophistication of treatment technology

- Availability of land for pumping stations and treatment facilities

- Acceptability of effluent disposal methods

- Degree of environmental impact anticipated during construction and subsequent operation, and means of mitigating environmental impacts

The selected alternatives will be evaluated and discussed with representatives of AGOSD, USAID and the Governorate, where appropriate, to identify the most feasible alternative to be included in the BODR.

Preparation of Draft BODR.

Preliminary designs will be prepared of the selected alternative in sufficient detail to provide the Basis of Design Report. The designs will be based upon projected wastewater quantities in the year 2030, and will include a definition of initial facilities requirements, and incremental additions to keep pace with increases in populations and expansions of service areas from the year 2000.

Discussions and Finalization of BODR.

The draft BODR will be reviewed in workshop type meetings with representatives of AGOSD, USAID and the Governorate, where appropriate, in which design parameters, treatment and disposal philosophy, construction scheduling and incremental costs will be discussed.

Agreed-upon modifications resulting from the review meetings will be incorporated into the final BODR.

Final copies of the BODR will be distributed to AGOSD, USAID and the Governorate of Alexandria, as appropriate in quantities to be agreed upon during initial contract negotiations.

Kil

STAFFING, SCHEDULE AND COSTS

An estimate of proposed staffing requirements, and schedule for execution of the work to complete the BODR are shown in Figure 6-2.

The estimated costs for preparing the BODR are $ 1,500,000 plus LE 750,000. These costs are included as a line item in the costs summary presented in Chapter 7.

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TABLE 6-1
PUMP STATIONS TO REMAIN IN SERVICE*

PUMP STATION DESCRIPTION		
EAST ZONE	CENTRAL ZONE	WEST ZONE
1E 2E 4E 6E	Saniah El Abd Entrace of the City Mohsein Sannan	New Gheit El Enab 2W
Petty Officers' Housing Hagar El Nowatia Industrial Housing	El Bousery Old Kait Bey & Submersible Kait Bey	
Rushdy Khawaga Ibrahim Sidi Gaber Industrial Housing		

* AGOSD pump stations within the Master Plan Study Area to remain in full service beyond year 1994.

TABLE 6-2
PUMP STATIONS TO BE DECOMMISSIONED*

PUMP STATION DESCRIPTION		
EAST ZONE	**CENTRAL ZONE**	**WEST ZONE**
3E	Old Sporting	1W
5E		3W
7E		Industrial Collector
8E		El Matar School
9E		Ezbet El Motar
10E		Forn El Geraya
Old 11E		Old Gheit El Enab
Submersible 11E		Gheit El Seeidzt
El Sarayah		
Kobry El Montazah		
Tosson Officers' Housing		
New Company Housing		
Gelim		
Sarwat		
El Gawahar		
14th May		

* AGOSD pump stations within the Master Plan Study Area to be decommissioned or placed on stand-by service.

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TABLE 6-3
COLLECTORS AND FORCE MAINS
INFRASTRUCTURE NEEDS ASSUMPTIONS

ITEM	PERCENT OF TOTAL SYSTEM			
	REPLACED	REHABILITATED	CLEANED	TOTAL
Collectors				
600–1000 mm	10	5	10	25
1001–1500 mm	5	10	5	20
1501– up mm	5	5	5	15
Force Mains				
450–1000 mm	10	10	5	25
1001–1500 mm	0	10	10	20
1501– up mm	0	10	5	15

OPERATION & MAINTENANCE TECHNICAL ASSISTANCE

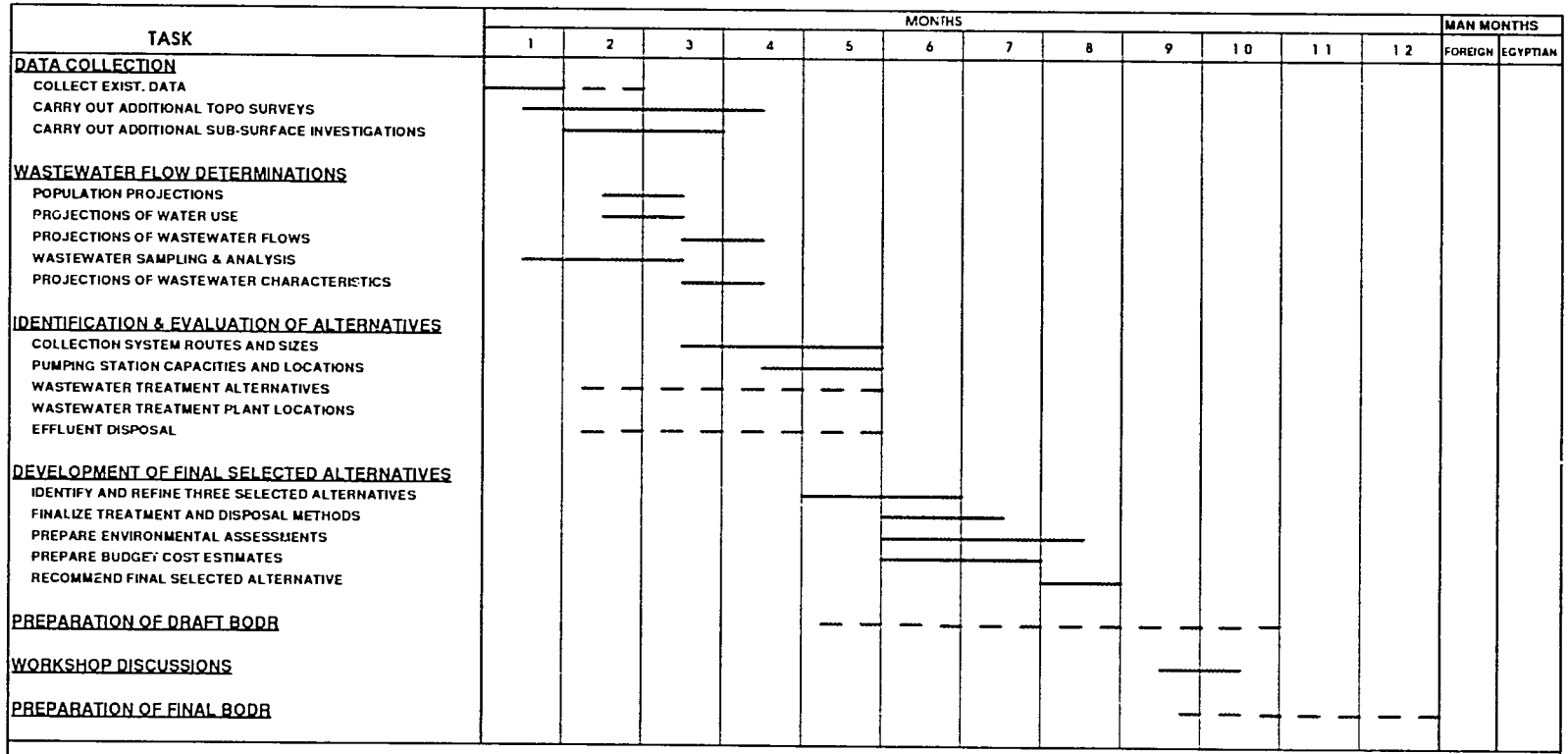
FOREIGN STAFF	3/93	4/93	1/94	2/94	3/94	4/94	1/95	2/95	3/95	4/94	1/96	2/96	3/96	4/96	1/97	2/97	3/97	4/97	1/98	2/98	3/98	4/98	M/M
O&M ASSISTANCE																							
O&M MANAGEMENT SPECIALIST																							48
MAINTENANCE MANAGEMENT SPEC.																							36
OPERATION SPECIALIST																							48
MAINTENANCE SPECIALIST																							48
FACILITIES MANAGEMENT ASST.																							
ETP MANAGEMENT ASST.																							24
WTP MANAGEMENT ASST.																							12
MDF MANAGEMENT ASST.																							36
SITE 9N MANAGEMENT ASST.																							18
TOTAL FOREIGN STAFF																							270
EGYPTIAN STAFF																							
SENIOR O&M MANAGER																							48
OPERATIONS SPECIALIST																							48
MAINTENANCE SPECIALIST																							48
TOTAL EGYPTIAN STAFF																							144

1992 WASTEWATER MASTER PLAN UPDATE
ALEXANDRIA WASTEWATER PROGRAM
FIGURE 6-1

SHEET1 XLS

6/4/93

OUTER WEST ZONE BODR
WORK SCHEDULE AND STAFFING REQUIREMENTS



1992 WASTEWATER MASTER PLAN UPDATE
ALEXANDRIA WASTEWATER PROGRAM
FIGURE 6-2

SHEET2.XLS

CHAPTER 7

COST ESTIMATES

CHAPTER 7

COST ESTIMATES

POTENTIAL PROGRAM COMPONENTS

Chapter 7 presents the capital costs for the various potential program components described and presented in Chapters 5 and 6. These capital costs are combined into six (6) complete Phase II program alternatives as presented in Chapter 8. Each of these six (6) alternatives provides effluent disposal and treatment needs for Alexandria's Wastewater Program. It is important to note, that some of these alternatives provide for a complete and permanent solution regarding effluent disposal. Others do so to lesser, or perhaps, only to an interim degree based on environmental considerations. These aspects are further described in Chapter 8.

Table 7-1 presents the estimated capital costs for each program component identified. These capital costs are used only for coarse screening of the alternatives in Chapter 8. No detailed estimates of the O&M costs for each alternative were prepared. Where appropriate, however, additional consideration of O&M costs is given in Chapter 8.

GENERAL OVERVIEW OF COST ESTIMATES

A cost estimate is a monetary reflection of a specific scope of work. Changes in the scope of work will **always** result in a change in the estimated cost of that work.

Cost estimates are classified into three different levels: Definitive, Budget and Order-of-Magnitude. The first two levels deal with projects whose concepts have been well-defined and whose design is partially completed. The Order-of-Magnitude estimate is used to define costs at the conceptual or planning stages of design and is usually based on costs of similar projects, cost curves, factored equipment data and cost-capacity ratios, as adopted by ANSI Z92.2 and defined by the American Association of Cost Engineers.

Most of the cost estimates presented in this report are based on a conceptual scope of work and as such will be classified as Order-of-Magnitude estimates. If the scope of work presented in this report remains the same, these estimates should reflect a bid cost for this project that will fall within a range of as much as 50% above to 30% below this estimate. In the particular case of the Central Zone tunnel and primary treatment facilities expansion at the ETP and WTP, the present design work is well beyond the conceptual stage. Accordingly, the costs estimate ranges for these elements would be plus 15% to minus 5%. Any budget planning must give consideration to these cost ranges. Overall, these percentage ranges should be viewed as statistical confidence limits and must not be confused with contingencies. The contingency contained in the estimate is the

estimators allowance for "scope vagueness". The final costs of the project will depend on actual labor and material cost, competitive market conditions, final project scope, implementation schedule, and other variable factors.

BASIS OF COST ESTIMATE

The estimates contained in this report have been developed using the following methodology.

- **PIPELINE COSTS** – Pipeline costs, with the exception of tunnelled or jacked sections, are based on work tendered and awarded in Cairo, Egypt during 1991 and 1992.

  Except for the ocean outfall, tunnelled and jacked pipeline costs are based on single-pass tunneling and on work completed or under construction in Alexandria as part of the current USAID-funded Alexandria Wastewater Program. Included in this single-pass tunneling methodology is the on-land gravity effluent conveyance system for the outfall. The cost of the ocean outfall, itself due to the uniqueness of this type of construction, has been developed through separate studies assembled by specialists in the field, assuming again single-pass tunneling constructions.

- **PUMP STATIONS AND TREATMENT PLANTS** – Pump station and treatment plant costs are based on work completed or under construction in Alexandria as part of the current USAID-funded Alexandria Wastewater Program.

- **OTHER POTENTIAL FUTURE PROGRAM COMPONENTS** – The remainder of the potential future program components have been previously reviewed in separate reports prepared as part of the Alexandria Wastewater Program. The data and costs presented in these reports have been factored to fourth quarter 1992 costs.

ASSUMPTIONS

The following assumptions were used to calculate the cost estimates presented in this report.

- Costs are presented as fourth quarter 1992 costs. No escalation is included due to the undetermined time frame for execution of this work.

- No allowance is included for import duties and taxes.

- Costs are segregated into U.S. dollars (USD) and Egyptian pounds (L.E.). The division of costs between the two currencies is based on the sources cited above. The current exchange rate used throughout the cost estimating task was 3.31 L.E. equals 1 USD.

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- The basis for the construction cost estimates assumes work to be performed almost exclusively by USA contractors under guidelines established by current USAID requirements regarding performing work in Egypt and in line with U.S. source and origin provisions.

Where markups for overhead and profit on labor and materials are not part of the historical pricing used in the estimate, the following markups were applied:

o	Overhead	=	25%
o	Profit	=	10%
o	Mob/bond/insurance	=	11.5%

Contingencies were applied as follows:

o	Sewer work	=	25% to 30%
o	Force mains	=	15% to 30%
o	Pump Stations	=	20% to 25%
o	Treatment Plants	=	20% to 25%
o	Outfalls	=	25% to 30%

Other key cost estimating assumptions are as follows:

- The scope of work detailed in the final design will be basically the same as that outlined in the conceptual design.

- Labor and material will be in adequate supply and no allowance for shortages has been included.

- Costs will not be incurred by the project due to schedule delays.

- Operation and maintenance costs have not been considered for these alternatives.

- Construction costs shown do not include engineering design costs, nor other administrative costs.

TABLE 7-1
CONSTRUCTION COST ESTIMATES
POTENTIAL PROGRAM COMPONENTS

COMPONENTS		TOTAL COST ESTIMATE	
		U.S.D. (x1000)	L.E. (x1000)
A.	**COLLECTORS & DRAINS**		
A.1	CENTRAL ZONE TUNNEL & CONNECTIONS	79,400	30,000
A.2	QABBARI RELIEF SEWERS	12,300	6,100
A.3	SMOUHA DRAIN IMPROVEMENTS	9,400	1,200
A.4	HYDRODROME DRAIN IMPROVEMENTS	0	1,000
A.5	REHABILITATION OF EXISTING WASTEWATER COLLECTORS AND FORCEMAINS (REPLACE, SLIPLINE & CLEAN)	111,400	226,100
B.	**PUMPING STATIONS**		
B.1	"USAID FUNDED" PUMP STATION EXPANSIONS (DESIGN YEAR 2010)		
	a) ABU QIR P.S.	15	15
	b) MAAMOURA P.S. AND F.M.	3400	4300
	c) SIDI BISHR P.S.	55	45
	d) RAS EL SODA P.S.	600	500
	e) SPORTING P.S.	150	200
	f) EAST ZONE P.S.	250	200
B.2	REHABILITATION OF EXISTING AGOSD PUMP STATIONS		
	a) 19 EXISTING AGOSD P.S. TO REMAIN IN SERVICE	46,800	38,700
C.	**TREATMENT PLANTS (DESIGN YEAR 2010)**		
C.1	PRIMARY TREATMENT ALTERNATIVE		
	a) EAST TREATMENT PLANT (544 Mℓ/d)	14,700	3,600
	b) WEST TREATMENT PLANT (475 Mℓ/d)	34,700	9,500
C.2	SECONDARY TREATMENT ALTERNATIVE		
	a) EAST TREATMENT PLANT (544 Mℓ/d) - Primary Effluent P.S. & Biotowers - Clarification & Chlorination	76,800	197,300

TABLE 7-1 (Cont'd)
CONSTRUCTION COST ESTIMATES
POTENTIAL PROGRAM COMPONENTS

COMPONENTS			TOTAL COST ESTIMATE	
			U.S.D. (x1000)	L.E. (x1000)
	b)	WEST TREATMENT PLANT (475 Mℓ/d) - Primary Effluent P.S. & Biotowers - Clarification & Chlorination	70,400	183,800
D.	**SLUDGE MANAGEMENT (DESIGN YEAR 2010)**			
D.1	SLUDGE CONVEYANCE FROM THE ETP TO THE WTP			
	a)	CONTINUED USE OF WEST ZONE COLLECTOR (PRIMARY SLUDGE)	0	0
	b)	DEDICATED SLUDGE FORCEMAIN AND PUMP STATION (PRIMARY SLUDGE)	15,900	5,800
		i) P.S. - Equalization Tanks - Blowers for Mixing - Grinders, Pumps - Building		
		ii) F.M. - Two Forcemains, 300 mm Ø Each 10 km in Length - Alignment within West Zone Collector right-of-way		
	c)	DEDICATED SLUDGE FORCEMAIN AND PUMP STATION (PRIMARY AND SECONDARY SLUDGE)	59,300	31,900
		i) P.S. - Equalization Tanks - Blowers for Mixing - Grinders, Pumps - Building		
		ii) F.M. - Two Forcemains, 750 mm Ø each 10 km in Length		
D.2	MECHANICAL SLUDGE DEWATERING			
	a)	SINGLE PRIMARY SLUDGE MECHANICAL DEWATERING SYSTEM @ WTP - Additional 12 BFP	22,500	17,700
	b)	SEPARATE PRIMARY SLUDGE MECHANICAL DEWATERING SYSTEMS @ ETP & WTP	33,400	26,200
		i) ETP - New 12 BFP	25,000	19,700
		ii) WTP - Additional 4 BFP	8,400	6,500
	c)	SINGLE PRIMARY & SECONDARY SLUDGE MECHANICAL DEWATERING SYSTEM @ WTP - Additional 28 BFP	40,700	32,000

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TABLE 7-1 (Cont'd)
CONSTRUCTION COST ESTIMATES
POTENTIAL PROGRAM COMPONENTS

COMPONENTS	TOTAL COST ESTIMATE	
	U.S.D. (x1000)	L.E. (x1000)
D.3 REMOTE SAND DRYING BEDS		
a) ETP (PRIMARY SLUDGE)	24,300	158,100
i) P.S. - Equalization Tanks - Blowers for Mixing - Grinders, Pumps - Building		
ii) F.M. - Two Forcemains each 32 km		
iii) SAND DRYING BEDS		
b) ETP & WTP (PRIMARY SLUDGE)	60,000	132,400
i) P.S. - Equalization Tanks - Blowers for Mixing - Grinders, Pumps - Building		
ii) F.M. - Two Forcemains each 32 km		
iii) SAND DRYING BEDS		
D.4 TRUCK TRANSPORT OF DEWATERED SLUDGE TO SITE 9N		
a) ETP AND WTP DEWATERED PRIMARY SLUDGE TRANSPORTED FROM WTP (11 SLUDGE TRUCKS)	2,400	0
b) DEWATERED PRIMARY SLUDGE TRANSPORTED FROM BOTH THE ETP AND WTP (11 SLUDGE TRUCKS)	2,400	0
c) DEWATERED PRIMARY & SECONDARY SLUDGE TRANSPORTED FROM THE WTP (30 SLUDGE TRUCKS)	6,700	0
D.5 SITE 9N DEWATERED SLUDGE DISPOSAL FACILITIES		
a) DISPOSAL OF PRIMARY SLUDGE GENERATED BY ETP & WTP (SCUM/SCREENING TRENCHES & SITE 9N ROLLING STOCK)	7,800	3,400
b) DISPOSAL OF SECONDARY SLUDGE GENERATED BY ETP AND WTP (SITE WORKS, SITE 9N ROLLING STOCK & SCUM/SCREENING TRENCHES)	12,500	8,300
D.6 TRUCK TRANSPORT OF SCREENINGS, GRIT AND SCUM TO SITE 9N FROM ETP & WTP (ROLLING STOCK)	1,900	0

TABLE 7-1 (Cont'd)
CONSTRUCTION COST ESTIMATES
POTENTIAL PROGRAM COMPONENTS

COMPONENTS		TOTAL COST ESTIMATE	
		U.S.D. (x1000)	L.E. (x1000)
E.	**INTERIM EFFLUENT DISPOSAL (DESIGN YEAR 2010)**		
E.1	CONTINUED EFFLUENT DISPOSAL TO LAKE MARYOUT	0	0
E.2	LAKE MARYOUT BYPASS ALTERNATIVE 1 – SEPARATE BYPASS FACILITIES FOR EACH TREATMENT PLANT		
a)	EAST TREATMENT PLANT: ETP/KALAA DRAIN/KALAA P.S./ABIS DRAIN/ABIS P.S./OMOUM DRAIN i) ABIS DRAIN EXPANSION ii) NEW ABIS P.S.	16,900	23,900
b)	EAST TREATMENT PLANT: ETP/KALAA DRAIN/KALAA P.S./MARYOUT DRAIN/DISHOUDY P.S./OMOUM DRAIN i) MARYOUT DRAIN EXPANSION ii) NEW DISHOUDY P.S.	16,900	23,900
c)	WEST TREATMENT PLANT: WTP P.S./ FORCEMAIN/OMOUM DRAIN i) WTP P.S. ii) F.M.	29,800	8,100
E.3	LAKE MARYOUT BYPASS ALTERNATIVE 2 – COMBINED BYPASS FACILITIES FOR BOTH TREATMENT PLANTS		
a)	WITH FINAL EFFLUENT DISPOSAL TO SEA i) F.M. – Three 1800 mm Diameter Forcemains or Equivalent, Each 10 km in Length ii) DISCHARGE STRUCTURE	124,300	26,000
b)	WITH FINAL EFFLUENT DISPOSAL TO LAND	1,000	1,500
F.	**FINAL EFFLUENT DISPOSAL (DESIGN YEAR 2030)**		
F.1	SEA DISPOSAL ALTERNATIVE		
a)	MARINE STUDIES SUBCONTRACTS	5,000*	0
b)	LAND-BASED GRAVITY CONVEYANCE SYSTEM	109,800	40,300
c)	EFFLUENT PUMP STATION	24,300	10,500
d)	LAND-BASED EFFLUENT FORCEMAIN TUNNEL	41,400	15,200
e)	SEA OUTFALL – SEGMENTED TUNNEL METHOD	115,200	42,200
	TOTAL	**295,700**	**108,200**

BASED ON CONVENTIONAL DESIGN/BUILD SEQUENCE.

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TABLE 7-1 (Cont'd)
CONSTRUCTION COST ESTIMATES
POTENTIAL PROGRAM COMPONENTS

COMPONENTS		TOTAL COST ESTIMATE	
		U.S.D. (x1000)	L.E. (x1000)
F.2	LAND DISPOSAL ALTERNATIVE		
a)	LAND STUDIES SUBCONTRACTS	5,000	0
b)	LAND BASED GRAVITY CONVEYANCE SYSTEM	194,100	60,800
c)	EFFLUENT PUMP STATION	24,300	10,500
d)	EFFLUENT FORCEMAIN	517,700	62,600
e)	DESERT EQUALIZATION TANKS, PUMP STATION & FORCEMAIN	654,300	106,600
f)	LAND TREATMENT SYSTEM	94,900	314,200
	TOTAL	**1,490,300**	**554,700**
G.	**MISCELLANEOUS**		
G.1	STORES AND WORKSHOPS		
a)	LABORATORY FACILITIES	200	300
b)	SPARE PARTS STORAGE	930	1,100
c)	LARGE VEHICLE OVERHAUL FACILITY EXPANSION	1,900	2,100
d)	CENTRAL GARAGE	1,100	1,200
e)	SPECIALTY WORKSHOPS	4,900	1,200
f)	SHADED VEHICLE STORAGE/ PARKING & BULK FLAMMABLE STORAGE	1,800	1,400
G.2	OUTER WEST ZONE BODR	1,500	700
G.3	INSTITUTIONAL SUPPORT	5,000	1,700
G.4	OPERATIONS AND MAINTENANCE TECHNICAL ASSISTANCE PROGRAM	4,000	1,500

NOTE: COSTS CONTAINED IN ANY LINE ITEM OF THIS TABLE MAY BE ADDITIVE TO COSTS FROM OTHER LINE ITEMS & BY THEMSELVES WILL NOT REPRESENT THE TOTAL COST OF ANY SINGLE ALTERNATIVE. Also, engineering, construction management services are not included, while a contingency allowance is included. Values shown are not escalated and represent 4th quarter 1992 costs.

CHAPTER 8

ALTERNATIVES AND RECOMMENDATIONS

CHAPTER 8

ALTERNATIVES AND RECOMMENDATIONS

GENERAL

The previous chapters presented various program aspects and needs for the Phase II work of Alexandria. This chapter presents six (6) specific alternatives for meeting the effluent disposal needs of the city, along with the associated expansion requirements to accommodate Phase II growth. As previously noted in Chapter 7, some of these alternatives provide a permanent solution to the long-term effluent disposal needs of Alexandria. Other alternatives may not. The advantages and disadvantages of each alternative are presented in this Chapter. In addition to the specific process alternatives, other related program structural and institutional needs are also discussed and summarized.

Before proceeding with the six (6) process alternatives, the design population, flows and loads for the Phase II program are summarized below.

PHASE II DESIGN POPULATIONS FLOWS AND LOADS

The wastewater flows used throughout the Master Plan Update are based upon the best available data of the items listed below. In addition, allowances are made for industrial, commercial, institutional, and infiltration/inflows.

- Population
- Per capita water consumption
- Per capita wastewater contribution
- Rate of expansion of services to unsewered areas

During the preparation of this Master Plan Update, new study reports were examined, and research of existing studies and historical data carried out in all of the areas listed above. Results of this examination and research have been evaluated and good engineering judgement employed to determine the most accurate projections of wastewater flows.

It must be recognized, however, that all of the assumptions of population, per capita wastewater contributions and percent connected to the sewer system are subject to a presently unknown margin of error. It is imperative, therefore, that a comprehensive flow monitoring program be initiated immediately following the commissioning of Phase I works. Data from this monitoring program can then be used to more accurately assess future flows. Flow sampling and analysis at each of the treatment plants will provide a more accurate basis for adjustment of design wastewater flow and characteristics.

Nevertheless, with due consideration for the preceding assumptions and limitations, the following recommendations are made regarding the projection of Phase II design populations, flows and loads:

- Adopt the year 2010 as the design year for Phase II facilities expansion.

- In the expansion of existing facilities or the design of new facilities consider the possible need for further expansion to handle increases in flows to the year 2030.

- Carry out a comprehensive flow monitoring program, at the following major pump stations:

  - Abu Qir
  - Maamoura
  - Ras El Soda
  - Sporting
  - Sidi Bishr
  - East Zone
  - Smouha

  and use the resulting data to substantiate or amend pump station design flow recommendations contained in this report.

- Carry out a comprehensive flow monitoring program, sampling, and analysis program at the East and West Treatment Plants and use the resulting data to substantiate or amend design wastewater and sludge flows to the treatment plants and dewatering facilities.

- Adopt Phase II design pump station capacities for the year 2010 as follows:

	Average	Maximum (Peak Hourly)*
- Abu Qir	10.2 Ml/d	19.0 Ml/d
- Maamoura	42.7 Ml/d	75.6 Ml/d
- Ras El Soda	167.9 Ml/d	302.8 Ml/d
- Sporting	16.8 Ml/d	33.6 Ml/d
- Sidi Bishr	61.9 Ml/d	102.8 Ml/d
- East Zone	369.2 Ml/d	535.3 Ml/d
- Smouha	174.5 Ml/d	252.6 Ml/d

- Adopt a Phase II design average wastewater flow to the East Treatment Plant of 544 Ml/d

- Adopt a Phase II design average wastewater flow to the West Treatment Plant of 475 Ml/d

* Based on peaking factors shown in Table 5-19.

- Adopt design raw BOD and Suspended Solids values of 520 mg/L and 530 mg/L in the design of Wastewater Treatment and Sludge handling and disposal facilities.

- Based on peaking factors shown in Table 5-19.

PHASE II CONSTRUCTION ALTERNATIVES

GENERAL

Based upon the various program objectives, needs, and considerations, six (6) Phase II alternatives were developed for evaluation as listed below. These alternatives satisfy to varying degrees the long-term program objectives of providing effluent disposal, as well as safe wastewater collection, pumping, treatment, and sludge disposal. The six (6) alternatives are as follows:

- Alternative A – Primary Treatment And Sea Outfall.
- Alternative B – Primary Treatment With Lake Discharge.
- Alternative C – Primary Treatment With Lake Bypass.
- Alternative D – Secondary Treatment With Lake Discharge.
- Alternative E – Secondary Treatment With Lake Bypass.
- Alternative F – Land Treatment.

The capital costs for these alternatives are presented in Tables 8–1 through 8–7. Table 8–1 provides an overall cost summary for all the alternatives, while Tables 8–2 through 8–7 provide the detail costs associated with each specific alternative. Note that the costs shown in these tables are based upon the various sub–components that make up each alternative, as previously listed in Table 7–1. A discussion of these costs and the advantages and disadvantages of each alternative are also presented below. Other optional Phase II components that are common to all six (6) alternatives are listed in Table 8–8.

ALTERNATIVE A - PRIMARY TREATMENT AND SEA OUTFALL

The elements of Alternative A have previously been twice recommended, initially by the PHASED IMPLEMENTATION PLAN of 1982, and then again by the PHASED IMPLEMENTATION PLAN UPDATE of 1990. This alternative provides for expansion of the treatment plants, and is based on continued use of primary treatment. The Central Zone would also be incorporated into the service area by means of a tunnelled collector. Final effluent disposal would be accomplished by constructing a 3.66 m diameter deep sea outfall about 10 km in length. The outfall would be located at one of the three (3) locations shown in Figure 5–4. However, because of the inland location of the East and West Treatment Plants, the outfall would require an extensive on–land conveyance system and pump station.

The advantages of this alternative are as follows:

- Provides a safe, long-term solution to effluent disposal.
- Allows for long-term recovery of Lake Maryout by removing sewage effluent from the Lake.
- Provides for continued use of primary treatment at lower annual O&M costs.
- Sea disposal of treated wastewater is recognized and generally accepted world-wide as capable of providing environmentally safe effluent disposal.
- Alternative A probably conforms to existing EIS regulations.

Potential disadvantages of Alternative A are as listed below:

- Construction of the outfall, along with the on-land conveyance system, has a relatively high initial capital cost.
- Some public objections will be raised concerning this alternative. The basis for these objections will be the concern that wastewater should be considered a resource and therefore should reused through land application. It should not simply be discharged to the sea.

Refer to Table 8-2 for a listing of the various key elements that comprise this alternative.

ALTERNATIVE B - PRIMARY TREATMENT WITH LAKE DISCHARGE

This alternative is largely based on a recognition of the present severely polluted state of Lake Maryout. Alternative B further recognizes that the options for more environmentally appropriate effluent disposal are very limited. And that these options are extremely expensive, such as the cost for constructing a sea outfall. As a result, Alternative B comes to the somewhat reluctant conclusion that perhaps the best value that can now be derived from the Lake is to rely upon it for future wastewater disposal. This would undoubtedly be a difficult value judgement that the people of Alexandria and Egypt would have to make. And it is likely a decision that would be reluctantly made, considering the pristine condition that the Lake was in at one time. Nevertheless, it is an alternative which cannot be dismissed out of hand, because it may not comply with U.S. environmental standards.

Therefore, by relying upon Lake Maryout for final effluent disposal, the costs for Alternative B are considerably less than those for Alternative A, as shown in Figure 8-3. The overall advantages of this alternative are as follows:

- Lowest system capital costs by avoidance of construction of a sea outfall or other similar capital intensive effluent disposal means.

- Direct disposal into Lake Maryout may offer a reasonable interim means of effluent disposal until a more suitable and acceptable method can be constructed.

Disadvantages of Alternative B are:

- The water quality of Lake Maryout will not only continue to degrade, but will decline even more rapidly as additional growth takes place within the urbanized area.

- Lake disposal may not be acceptable as a long-term solution to Alexandria's wastewater disposal needs.

- Egyptian law may prohibit Alternative B as a permanent disposal option. A legal and environmental waiver may be required in this regard.

- Significant public objection could be expected since any hope of Lake restoration is removed.

ALTERNATIVE C - PRIMARY TREATMENT WITH LAKE BYPASS

Alternative C attempts to not only avoid further degradation of Lake Maryout, but to begin a gradual process of Lake revitalization. These goals would be achieved by keeping the treated primary wastewater out of the Lake and routing the effluent around the Lake's perimeter. Alternative C would also keep the existing agricultural runoff out of the Lake as well. This is because the effluent from the treatment plants and the flows from the agricultural drains would be routed together in upgraded and improved channels around the Lake. This rerouting of the plant wastewater and agricultural flow would rely upon the existing agricultural drains, as generally shown in Figure 5-2. The specific components of this approach are as described below, while the capital costs are indicated in Table 8-4.

- For the East Treatment Plant, the flow would be routed to the Kaala Drain and Pump Station. The effluent from Kaala P.S. would be connected with the existing Abis Agricultural Drain and Pump Station. From here, the effluent would flow to the Omoum Drain and onto Mex Pump Station.

- For the West Plant, a new force main would need to be constructed pumping the effluent to Omoum Drain and discharging it near Mex Pump Station. The possibility of routing this flow by gravity would also need to be explored.

The advantages of Alternative C are as listed below:

- Overall project costs are significantly lower than Alternative A, and only slightly higher than Alternative B.

- Keeps all treated wastewater out of the Lake and allows for long-term recovery of Lake Maryout.

- Also keeps all nutrient rich agricultural runoff and drainage water out of the Lake. This volume of water is estimated to be about 10 times greater in volume than the primary effluent.

The disadvantages of this alternative are as follows:

- Construction work associated with upgrading and restoring the integrity of the agricultural drains may be difficult and costly.

- Long-term pollution of the shore line around Mex Pump Station would result. By U.S. standards, Alternative C would not provide a long-term effluent disposal solution.

- Alternative may not be acceptable as a long-term, permanent solution to effluent disposal.

ALTERNATIVE D - SECONDARY TREATMENT WITH LAKE DISCHARGE

Alternative D provides a considerably higher level of wastewater treatment than the previous three alternatives. Additional biological treatment is provided by means of bio-towers. By increasing the level of treatment to this degree, Alternative D assumes that the final effluent would then be suitable for direct disposal into Lake Maryout. And thereby, the possibility of long-term recovery of the Lake is enhanced. This possibility of Lake improvement, however, comes at a significantly higher capital high cost, as shown in Table 8-5.

Advantages of Alternative D are as follows:

- Significantly better effluent quality is obtained for Lake disposal. Lake water quality may improve with time.

Disadvantages of providing secondary treatment are as follows:

- It is possible that secondary treatment may not meet the requirements of Egyptian Law 48. Depending on interpretation of Law 48, an even higher degree of treatment may be required, such as chemically assisted primary treatment in conjunction with secondary effluent filtration.

- The expected high content of toxic industrial wastes may inhibit cost-effective secondary biological treatment.

- Site limitations at the East Treatment Plant will likely dictate the need for additional land. Such land is not expected to be readily available for expansion beyond the Design Year 2010.

- Annual operational costa for secondary will be considerably increased above those expected for primary treatment. These costs are preliminarily projected to be an additional 25–30 million LE per year.

- The large additional quantities of secondary sludge to be disposed of would greatly increase O&M costs. Additional land for sludge disposal would need to be acquired. The prospects for this would not be good based upon past history at Site 9N.

- Complexity of the entire treatment process would be increased by a considerable degree.

- Additional electrical and chemical costs would be significant.

ALTERNATIVE E - SECONDARY TREATMENT WITH LAKE BYPASS

This alternative is similar to the previous one, except that the final plant effluent would not be discharged to the Lake. Instead, the effluent would be routed around the Lake as was done for Alternative C. As a result, the costs for this alternative are similar to Alternative D, except that the cost of the bypass system must be included. Refer to Table 8–6.

Advantage of this alternative are similar to those of Alternative C, as indicated below:

- Keeps all treated wastewater out of the Lake and allows for long–term recovery of Lake Maryout.

- Keeps all also nutrient rich agricultural runoff and drainage water out of the Lake. This volume of water is estimated to be bout 10 times greater in volume than the primary effluent.

- A lower level of long–term pollution will result around Mex Pump Station, which may or may not be environmentally acceptable.

The disadvantages of Alternative E are similar to those listed for Alternative D, since both employ secondary treatment.

- The expected high content of toxic industrial wastes may inhibit cost–effective secondary biological treatment.

- Site limitations at the East Treatment Plant will likely dictate the need for additional land. Such land is not expected to be readily available for expansion beyond the Design Year 2010.

- Annual operational costs for secondary will be considerably increased above those expected for primary treatment. These costs are preliminarily projected to be an additional 25–30 million LE per year.

- The large additional quantities of secondary sludge to be disposed of would greatly increase O&M costs. Additional land for sludge disposal would need to be acquired. The prospects for this would not be good based upon past history at Site 9N.

- Complexity of the entire treatment process would be increased by a considerable degree.

- Additional electrical and chemical costs would be significant.

ALTERNATIVE F - LAND TREATMENT

Alternative F reuses all primary treated wastewater as part of an extensive agricultural reuse program. The reuse of wastewater effluent for agricultural purposes has one major advantage over other disposal methods, in that it conserves a valuable resource. And it should be noted that there are presently some increasing concerns over future water supplies and potential upstream international dam construction on the Nile. Nevertheless, it is believed that water supplies are generally abundant both for human consumption and industrial and irrigation uses within proximity of Alexandria. The need for conservation, therefore, involving an elaborate and costly irrigation project does not exist. Without this driving force for water conservation, the need to expend the capital costs summarized in Table 8–7 are difficult to justify.

The overall advantages of land treatment are as follows:

- Reuse of potentially valuable water.

- Public acceptance of wastewater reuse and land irrigation may be higher than that involving construction of a sea outfall.

- Overall system would be relatively simple and be less mechanically intensive.

On the other hand, the disadvantages of land treatment are formidable as listed below:

- The total area of land required is approximately 31,000 hectares. Such an area is not available within 100 kilometers of Alexandria

- The initial cost of this alternative is prohibitive. With efficient operation, irrigation of high value crops with recovered wastewater effluent could result in significant economic returns. However, with the high degree of risk involved, it is unlikely that sufficient funds could be made available to cover the high initial cost.

- Feasibility of Alternative F would depend on having an absolute commitment towards project implementation and success at the very highest levels of the Egyptian Government.

- Toxic components within the treated primary effluent may have negative impacts on crop production and use.

- Possibility of groundwater contamination exists.

RECOMMENDATIONS

Based upon the descriptions and cost evaluations presented and with due consideration for overall project Phase II funding limitations, it is difficult to judge and select one of the preceding alternatives as clearly superior over all the others. The level of detail project development of each alternative was limited by the time and funding constraints of this Master Plan Update Report. As a result, it is recommended that of the six (6) alternatives presented, only those which offer a distinct possibility of being implementable should be further evaluated as part of follow-up Environmental Impact Studies. The implementability of each alternative involves consideration for both governmental and legal issues, public concerns, funding constraints, and environmental benefits.

With these aspects in mind, it is recommended that of the six (6) alternatives presented, the four listed below be evaluated in greater detail as part of further environmental impact and technical/economic feasibility studies.

- Alternative A – Primary Treatment and Sea Outfall.

- Alternative B – Primary Treatment with Lake Discharge.

- Alternative C – Primary Treatment with Lake Bypass.

- Alternative D – Secondary Treatment with Lake Discharge.

As can be seen from the above list, the Land Treatment alternative has been deleted for the basic reason that it's judged not to be implementable from both a cost standpoint and also from a technical standpoint. Namely, the feasibility of finding the large tract of land required is extremely remote. And having to pump all wastewater at least 100 km from Alexandria, with the attendant energy costs, makes this alternative today impractical.

The other alternative involving secondary treatment with Lake bypass is judged to offer no significant advantages over direct discharge into the Lake.

In the following pages, additional specific recommendations are presented concerning the following aspects of the Phase II Alexandria wastewater program.

- TREATMENT PLANT EXPANSIONS
- SLUDGE HANDLING DISPOSAL
- COLLECTION AND PUMPING SYSTEM IMPROVEMENTS
- ADDITIONAL PROGRAM NEEDS

TREATMENT PLANT EXPANSIONS

EAST TREATMENT PLANT

Design of the second phase expansion of the primary treatment facilities at the East Treatment Plant for a design average flow of 525 Ml/d was completed in August, 1985. Review of population, flows and loads carried out as a part of this Master Plan Update indicates a design year 2010 projected average wastewater flow to the treatment plant of 544 Ml/d. This represents an increase of only 3.5 percent over the original design flow, and would have no significant effect upon the efficiency of the treatment facilities already designed.

The Master Plan review of populations, flows and loads found no basis for amending, at this time, the BOD and Suspended Solids values for raw wastewater used in the design of wastewater treatment and sludge handling and dewatering in Phase I.

Specific Phase II recommendations for expansion of the East Treatment Plant, therefore, are:

- Construct four new primary clarifiers and a new primary sludge pump station as designed in 1985, together with all associated ancillary pipelines, roadworks and siteworks.

- Review, update and amend the original designs, and design and contract documents as necessary to incorporate changes in site conditions, technology and/or equipment improvements and treatment philosophy that have occurred since the original design was completed.

The review of populations, flows and loads also identified the need for a further expansion of treatment capacity beyond the year 2010 to handle a projected wastewater flow of 718 Ml/d in the year 2030. As a result of this future need, it is further recommended that:

- Design of Phase II expansion facilities should take account of the need for additional treatment facilities beyond Phase II.

WEST TREATMENT PLANT

Design of the second phase expansion of the primary treatment facilities at the West Treatment Plant for a design average flow of 485 Ml/d was completed in October, 1985.

Review of populations, flows and loads carried out as a part of this Master Plan Update indicates a design year 2010 projected average wastewater flow to the treatment plant of only 475 Ml/d. Although the new projected flow closely follows the original design flow, for overall project consistency, amend the original design criteria to 475 Ml/day. Other specific recommendations for expansion of the West Treatment Plant, therefore, are:

- Provide and install mechanical equipment within the headworks constructed in Phase I, together with all associated electrical equipment and instrumentation.

- Upgrade eight existing primary sedimentation tanks with the provision of new sludge and scum removal mechanisms, sludge and scum pumping equipment, and all associated ancillary piping, electrical equipment and instrumentation.

- Construct eight new primary sedimentation tanks complete with sludge and scum removal mechanisms, sludge and scum pumping equipment, and all associated ancillary piping, electrical equipment and instrumentation.

- Review, update and amend the original designs, and design and contract documents as necessary to incorporate changes in site conditions, technology and/or equipment improvements and treatment philosophy that have occurred since the original design was completed.

- In the review of the original design, take account of the need for additional treatment facilities beyond Phase II.

- Provide the following additional rolling stock to convey grit and other materials from both treatment plants for disposal at Site 9N:

    - 5 – 8 m^3 Grit/Screenings trucks
    - 7 – 11 m^3 Vacuum Scum Trucks
    - 2 – Front end leaders

- Provide a duplication of the Phase Sludge Dewatering Building, containing 12 additional Belt Filter Presses, and all associated ancillary equipment similar to that provided for Phase I.

- Provide 11 additional 27-m^3 sludge trucks for hauling dewatered sludge to Site 9N.

SLUDGE HANDLING AND DISPOSAL

SLUDGE DEWATERING

Chapter 5 present five (5) alternatives for sludge dewatering, transportation, and disposal. The advantages and disadvantages of each were discussed and evaluated. As a result of this evaluation, two of the alternatives were deleted from further consideration. This left the three (3) alternatives listed below ...

- Alt. No. 1: Continuation of sludge dewatering at the West Treatment Plant using Belt Filter Presses.
- Alt. No. 2: Separate Belt Filter Press dewatering at the East and West Treatment Plant.
- Alt. No. 4: Belt Press Dewatering at the West Plant and Sand Drying Dewatering at remote site for ETP.

Alternative No. 1 involves transporting sludge by gravity from the ETP to the WTP using the West Zone Tunnel. Because of AGOSD's expressed concern over the viability of this concept, AGOSD would prefer to use a force main to pump the sludge directly from one plant to the other. Since this sludge transport system does not basically affect the actual sludge dewatering, this concept has been added as another alternative, Alternative 1A. Overall, with the addition of this Alternative, four (4) sludge handling options remain, and their capital costs are shown in Table 8-9.

As can be seen from Table 8-9, Alternative No. 1 has the lowest overall capital costs. Based on this aspect, and the advantages presented in Chapter 5, as well as input received during Master Plan Update review meetings, Alternative No. 1 is generally recommended. As previously indicated, this alternative would involve expanding the WTP belt filter press installation provided under Phase I. With regard to transporting sludge from the ETP to the WTP, it is recommended that the dedicated sludge force main from the ETP and WTP only be implemented once the Phase I primary sludge production volumes are confirmed, and full operation of sludge gravity transfer by means of the West Zone Tunnel has been assessed. If this gravity transfer system is successful, the cost of a separate sludge force main can be avoided at a savings of over $16 Million. It should also be noted that such a primary sludge force main would lack the capacity to effectively serve in any future conveyance of secondary sludge. If, however, based upon the Phase I operation, transfer of sludge by gravity to the WTP is indeed difficult and troublesome, then construction of a force main will need to be provided in the Phase II program.

In addition, because of the simplicity and overall advantages operational, sand drying bed dewatering for the ETP should still be considered if suitable land can be made available.

SLUDGE TRANSPORTATION

Recognizing the reservations of USAID to the continued use of trucks to haul sludge cake from the West Treatment Plant to Site 9N, the following recommendations are provided:

- Continue with the planning of Phase II on the assumed use of trucks for hauling sludge cake to Site 9N, and provide funding for the following additional rolling stock:

  - 11 – 27m^3 sludge trucks
  - 2 – 2m^3 front-end loader
  - 2 – 1m^3 skid-steer loaders

- Conduct a detailed design study and prepare an estimate of the capital and O&M costs of providing rail haul from the West Treatment Plant to Site 9N.

- Allocate funds in Phase II for the preparation of the above study report on rail haul, and include in Phase II a provisional sum of money, to cover the additional costs of construction and purchase of railroad equipment, to be used to change from truck haul to rail haul in Phase II.

SLUDGE DISPOSAL

Selection of the method of sludge dewatering and the means for ultimate disposal of dewatered sludge are inter-related.

The recommended method of sludge dewatering is a continuation, and expansion, of mechanical dewatering at the West Treatment Plant as provided in Phase I. On this basis, sufficient space is available for sludge cake disposal at Site 9N. It is recommended, therefore, that disposal of dewatered sludge by Dedicated Land Disposal at Site 9N be continued in Phase II.

Mechanical equipment provided in Phase I was based on a design disposal method in which 90 percent of the sludge cake would be directed to Dedicated Land Disposal and 10 percent would be directed to the Pilot Composting Plant. Assuming a continuation of this breakdown in sludge quantity between the two disposal methods, it is recommended that the following additional equipment be provided in Phase II:

- 5 – 4.5m^3 Front-end Loaders
- 1 – 1m^3 Front-end Loader
- 6 – 140 HP Tractors
- 6 – Trailer-mounted Sludge Spreaders
- 2 – Trailer-mounted Wastewater Spreaders
- 2 – Offset Disks
- 2 – Rippers

- 2 – Rear–mounted Blades
- 2 – Excavators
- 2 – Composters
- 1 – 300–400 Gallon Fuel Wagon

It is further recommended that the results of the pilot composting activities be critically examined to determine:

- o If successful composting of primary sludge presently generated at the two treatment plants is possible

- o If a market for compost is available and, if so, the potential capacity of that market

Result of this examination will give rise to a future recommendation regarding sludge composting in Phase II.

SUMMARY

Recommendations of methods for sludge dewatering and transportation in the future have been made with regard for the extreme difficulties and delays experienced in obtaining a site for sludge disposal, and the opposition to other than mechanical means for sludge dewatering. However, it is still WWCG's opinion that Sand Drying Beds offer the most reliable, least cost method of sludge dewatering. This alternative can only be pursued with the full commitment of the GOE to provide another suitable dewatering/disposal site within reasonable access of the East and West Treatment Plants.

COLLECTION AND PUMPING SYSTEM IMPROVEMENTS

COLLECTION SYSTEM IMPROVEMENTS

Improvements to the collection system in Phase II are directed towards three basic objectives:

- To convey flows from the Central Zone to the West Treatment Plant.
- To relieve overflowing and flooding in the El-Mafrouzah and El-Wardeyan Districts by construction of the Qabbari Relief Sewers.
- To improve the Smouha and Hydrodrome Drains conveying effluent from the East Treatment Plant.

CENTRAL ZONE DRAINAGE

The design of the Central Zone Tunnel, which forms the major element for conveying flows to the West Treatment Plant, was completed in 1985.

Review of populations, flows and loads carried out as a part of this Master Plan Update indicates a reduction in projected contributory population in the design year 2030 from 1,060,000 to 716,900. This results in a reduction in the total projected flow from the Central Zone from 275 Ml/d to 219 Ml/d in the year 2030. This matter should be addressed, however, prior to solicitation of construction bids. Specific recommendations with regard to the Central Zone Tunnel are as follows:

- Carry out a review of the Basis of Design Report to confirm or amend the original design based upon the projected reduction in design population.
- Review, update and amend the original design, design drawings and contract documents as a result of potential changes to the BODR, and changes and advances in tunneling technology since design completion. Based upon a preliminary design review conducted in September, 1991, a single smooth surface, precast concrete liner should be used for the tunnel in lieu of the two pass system previously recommended. Other recommendations were also made concerning access shaft locations, minimum tunnel horizontal radius, dredged caisson construction, and segmental liner joint sealant.
- Construct the Central Zone Tunnel based upon these revisions to the original design.

As part of this project, it will be necessary to divert flows in the existing Central Zone Collection system to the new Central Zone Tunnel. This will involve a series of direct and indirect connections between the existing collectors and the new tunnel. These proposed connections were investigated in general terms during the design of the Central Zone Tunnel. The investigations at that time, however, were carried out only in sufficient detailed to define a broad scope of work.

Work to be carried out in Phase II with respect to Central Zone Connections, therefore, will be:

- Carry out necessary investigations, and prepare a Basis of Design Report covering the necessary diversions, direct and indirect connections to convey wastewater flow generated in the Central Zone to the new Central Zone Tunnel.

- Upon approval of the BODR, carry out the detailed design and construction of all necessary diversions, direct and indirect connections.

QABBARI RELIEF SEWERS

The Basis of Design Report for the El Malik Shaha Relief Collector and the El Khafal Street Collector was completed in March, 1989.

Review of populations, flows and loads carried out as a part of this Master Plan Update indicates a decrease in total flow in the design year 2030 of approximately 20 percent. This decrease in projected flow may necessitate a revision to the original preliminary design. With this in mind, specific recommendations are as follows:

- Carry out a review of the original Basis of Design Report to confirm or amend the original preliminary design and make any necessary changes to the BODR.

- Upon approval of the revised BODR, carry out the detailed design and construct the two relief connectors.

DRAIN IMPROVEMENTS

As explained in Chapter 3, approximately one half of the Smouha Drain Improvements were constructed in Phase I. At that time work was curtailed due to a lack of available funds. To complete this work, it is recommended that:

- The design be reviewed to take account of any changes that may occur after completion of the first part of the work.

- Construction of the remaining section of the pipeline be completed as early as possible in the Phase II Program.

A review of the Hydrodrome Drain was carried out in 1992 and indicated only minor widening and deepening of the drain was necessary. It is recommended that this work be carried out as early as possible in Phase II.

PUMPING SYSTEM IMPROVEMENTS

The expansions and improvements listed below for USAID funded pump stations provided in Phase I are recommended for inclusion in the Phase II program.

Abu Qir Pump Station. It is recommended that the impellers of both pumps be changed as originally planned to increase the station's average capacity to 10.2 Ml/d, and a maximum (peak hourly) capacity of 19.0 Ml/d.

It is further recommended that studies be carried out to determine the magnitude of further pump station and possibly force main capacity increases required beyond Phase II, and how these future additions may be achieved.

Maamoura Pump Station. It is recommended that the two pump motors be changed as originally planned to increase the average station capacity to 42.7 Ml/d, and a maximum (peak hourly) capacity of 75.6 Ml/d.

Again it is further recommended that studies be carried out to determine the magnitude of station and force main capacity increases beyond Phase II and how these future increases may be achieved.

Ras El Soda Pump Station. A budget cost has been included for the replacement of all six pumps and motors. Before any action is taken, however, it is recommended that the results of flow studies recommended earlier be examined to determine the magnitude of needed expansion. A further, more definitive recommendation can then be made of the magnitude of expansion required and on the most feasible means of achieving it.

Sidi Bishr Pump Station. It is recommended that the impellers of all five pumps be changed as originally planned.

East Zone Pump Station. Original plans called for the addition of a sixth pump to increase the average station capacity from 400 to 610 Ml/d. Although current flow projections indicate that this pump will not be required in Phase II, a cost has been included for its purchase and installation. It is recommended, however, that flow studies be completed as recommended earlier before a firm and final decision for purchase is made.

ADDITIONAL PROGRAM NEEDS

INFRASTRUCTURE SUPPORT

Details of necessary Infrastructure Support were presented in Chapter 6 under five categories:

- Rehabilitation of AGOSD Pump Stations
- Decommissioning of AGOSD Pump Stations
- Rehabilitation of existing Collection System
- Provision of Stores and Workshops Areas
- Operation & Maintenance Technical Assistance

Rehabilitation of AGOSD Pump Stations

A total of nineteen AGOSD Pump Stations were identified as being required to remain in full service as integral parts of the Alexandria Wastewater Program. These are old pump stations in need of extensive mechanical and electrical rehabilitation. The extent and details of necessary rehabilitation is beyond the scope of this Master Plan Update. It is recommended, therefore, that detailed examinations at all nineteen pump stations be carried out early in the Phase II program. Results of these examinations can be used to identify needed rehabilitation work and replacement equipment.

The estimated costs for this work presented in Table 7-1 are order-of-magnitude costs only, and these should be refined based upon the findings of the detailed examinations.

Decommissioning of AGOSD Pump Stations

A total of twenty-six AGOSD Pump Stations were identified as not being required in the future operation of the Alexandria Wastewater Program. These Pump Stations should be withdrawn from service at completion of the Phase I Program and retained for possible emergency use only.

No funds have been included in this Master Plan Update for decommissioning of these Pump Station or for rehabilitation.

Rehabilitation of Existing Collection System

The collection system within the Alexandria Wastewater Program Area comprises gravity sewers, gravity collectors and force mains varying in diameter from the smaller 150 mm laterals to the large 2250 mm collectors constructed as a part of the Phase I program. Many of these sewers and force mains date back to the early stages of development of the Sewerage System over forty years ago. The total lengths of the

sewers and force mains within the present collection system are indeterminate. Similarly the condition of much of the system is unknown. The development of firm data on sizes, lengths and conditions of the sewers and force mains is obviously beyond the scope of this Master Plan Update. For this reason, assumptions were made, as shown in Table 6-3, on which to base an order-of-magnitude cost estimate for rehabilitation work to be carried out during the course of the Phase II Program.

However, as an early task in Phase II, it is recommended that a condition survey be conducted before any rehabilitation work is undertaken. Because of the uncertainties surrounding, the sizes, lengths and locations of the existing sewers and force mains, it is recommended that the survey be carried out on the larger sized pipes first and continuing through pipelines of diminishing size. It is also recommended that accurate sewerage maps be prepared as the condition survey proceeds.

The extent and costs of needed rehabilitation works should be developed as a result of the condition survey, and these works prioritized such that the most urgent remedial works are carried out within the funds available.

Provision of stores and Workshops Area

The need for additional stores and workshops areas was identified in Chapter 6 under the six categories presented below.

Administration and laboratory facilities. No additional facilities are required in Phase II, however, a cost has been included for the purchase of additional vehicles and equipment to support an expanded industrial monitoring program. It is recommended that detailed requirements be identified as an early task in the Phase II Program.

Spare Parts Storage. It is recommended that adequate Spare Parts Storage be provided in expansion plans at the East and West Treatment Plants for storage of spare parts associated with these two plants. Although such storage capacity was designed and included in the Phase I Program, these facilities were not constructed due to lack of available funding.

Large Vehicle Overhead Facilities. It is recommended that a second major vehicle overhaul facilities be provided adjacent to the facility provided at the East Treatment Plant in Phase I.

Central Garage. It is recommended that the existing central AGOSD Central Garage be rehabilitated and expanded to provide space for the additional vehicles, especially sewer cleaning and maintenance vehicles to be provided in Phase II. Detailed plans for expansion should be developed as an early task in Phase II.

Shaded Vehicle Storage/Parking and Bulk Storage Areas. It is recommended that the Bulk Storage Areas provided in Phase I be duplicated in Phase II, and that Shaded Vehicle Storage/Parking be added. As was the case for the Spare Parts Storage facilities, Shaded Vehicle Parking was designed and included in the Phase I Program. However, these facilities were not constructed due to lack of available funding.

Specialty Workshops. It is recommended that a suitable building be constructed to house the following maintenance/trouble shooting workshops for hands-on-training purposes:

- Electrical/Instrumentation Workshop
- Pumps Workshop
- Diesel Engine Workshop
- Laboratory Workshop

It is further recommended that the workshop be complete with all necessary equipment, spare parts and consumable supplies to provide for the training of AGOSD engineers, technicians and plant operators. Details of equipment and spare parts requirements should be developed as an early task in Phase II.

Operations & Maintenance Technical Assistance

Chapter 6 of this Master Plan Update identified two components of the program that are essential for the continued successful operation of the USAID – funded facilities and of the Alexandria Wastewater System as a whole. These are:

- Competent and experienced Facilities Management
- Skilled Operation and Maintenance

The O&M Program initiated in 1990 has set the foundations for development within AGOSD of the necessary O&M Management System. However, to ensure the continued development and expansion of this system, it is imperative that AGOSD be provided with an uninterrupted program of Facilities Management Assistance and O&M Assistance.

It is recommended, therefore, that a total of 90 man-months of expatriate Facilities Management Assistance be provided at the East and West Treatment Plants, the Sludge Dewatering Facility and Sludge Disposal Site 9N. This Assistance should begin with the start-up of the Phase I facilities in mid-1993 and continue through 1995-1996.

It is also recommended that 180 man-months of expatriate Operation and Maintenance Assistance be provided to advise and assist AGOSD in the continued successful operation of all of their wastewater facilities. This advice and assistance should be timed to begin at the end of 1994 and continue, as a minimum, through the end of 1998.

It is further recommended that a total of 144 man-months of Egyptian counterpart staff be provided to support the expatriate staff.

The need for additional Assistance beyond 1998, as Phase II facilities come on line, can be determined in the future when the success of the program now proposed can be determined.

INSTITUTIONAL SUPPORT

Detailed descriptions are contained in Chapter 6 of activities that must be carried out through the Institutional Support Program to assist AGOSD in attaining the status of a modern, self-sustaining wastewater utility. The Program is a means of strengthening the management capabilities and increasing the administrative capacity of the organization.

Although the basic building blocks are already in place, to achieve the goal of full autonomy will require a long-term commitment of technical assistance.

Certain tasks of the program have been included in the final stages of the Phase I Wastewater Program. A further commitment is required in Phase I, as well as Phase II, to allow the Program to continue without interruption.

The development of precise details of activities to be included in the Institutional Support Program is beyond the scope of this Master Plan Update. However, it is recommended that the Program be started immediately and continue without interruption for a period of five to eight years. The ISP for Phase I will provide specific and detailed recommendations to USAID for the tasks and activities to be included in the Phase II ISP.

It is recommended that $24 million in 1992 dollars be allocated for a period of eight years to support this Program. Furthermore, a 2 year program of Industrial Waste Management technical support, estimated to cost $1.8 million is recommended. For immediate planning and budgetary purposes, however, only $5.0 million and LE 1.7 million is allocated for this program, as shown in Table 7-1. This level of funding is based on an additional 2-year follow-on program starting in 1995. Since such a 2-year program, however, is deemed to be inadequate to fully support AGOSD in its transition to autonomy and financial self-sufficiency, additional allocations would be necessary in the 1997 and beyond time frame.

OUTER WEST ZONE BODR

The preparation of a Basis of Design Report of wastewater management in the Outer West Zone has been included in this Master Plan Update for two reasons:

- There is an apparent and urgent need for a wastewater program for the area. The preparation of a BODR will provide the scope and cost of immediate works which may provide the basis for identifying and securing alternative funding sources.

- It is possible that elements of a wastewater system in the Outer West Zone may have an impact on facilities to be provided in the second phase of the Alexandria Wastewater Program. It is important that any potential impacts on the Phase II facilities be identified early in the Phase II Program.

It is recommended, therefore, that the Outer West Zone BODR be carried out as a priority project early in Phase II.

SCHEDULING OF PHASE II PROGRAM

A detailed schedule of works to be carried out in Phase II is contained in Chapter 9, together with explanations of the interrelationships between the design and construction periods presented.

From its inception, the objectives of the Alexandria Wastewater Program have been and remain as follows:

- To eliminate the ponding and flooding of wastewater throughout the City, as well as the discharge of untreated wastewater to the beaches, by providing appropriate systems to collect and convey wastewater to treatment facilities
- To provide basic wastewater treatment and safe disposal of treated effluent
- To provide facilities for the treatment and safe disposal of wastewater sludges
- To expand the collection, treatment and disposal systems systematically to keep pace with development and population increases
- To upgrade the level of wastewater treatment or provide an alternative method of effluent disposal that is environmentally acceptable to the community and to USAID

Although not specifically stated, one of the conditions of the Program has always been that the objectives should be achieved as quickly as possible.

With the completion of Phase I of the Program, not all of the objectives will have been addressed, and none will have been achieved in all areas of the City. Tasks to be carried out in the second phase of the Program include:

- Conveyance of wastewater from the Central Zone to the treatment plant. This will eliminate ponding and flooding of wastewater in the streets, and the discharge of raw sewage to the beaches
- Expansion of the collection system in the West Zone to eliminate ponding and flooding of wastewater in the streets
- Expansion of the capacity of wastewater and sludge treatment facilities
- Provision of an environmentally sound and acceptable means of effluent disposal.

Until an environmentally sound and acceptable means of effluent disposal is provided, effluent from the two treatment plants must, by necessity, continue to be discharged to Lake Maryout if pollution of the beaches is to be avoided.

With this in mind, an early and basic decision must be made between two alternative courses of action in order that the second phase of the Program may continue unimpeded.

Alternative No. 1

Proceed with the construction of collection facilities to improve the health and welfare of all inhabitants of the City, by removing sewage from the streets and beaches, and continue discharge of partially treated effluent to Lake Maryout.

Alternative No. 2

Continue to jeopardize the public health and welfare of sections of the population within the City by delaying construction of further collection facilities until an acceptable and final effluent disposal method has been agreed upon.

In making this important decision, the following factors should be considered:

- Discharges to Lake Maryout of industrial effluents and polluted drainage run-off in addition to smaller quantities of wastewater have polluted the main basin of the Lake beyond the point where recovery is economically viable

- Industrial effluent and drainage discharges to the Lake will continue after the diversion of wastewater effluent elsewhere

One important factor which could affect the early achievement of the objective to eliminate ponding and flooding of wastewater throughout the City, is the US Federal requirement to prepare a new and complete Environmental Impact Statement (EIS) for the Program. This despite the facts that:

- An EIS was prepared and released to USAID in April 1979. Modifications to the 1978 Master Plan were made as a result of the Final EIS which was issued in August 1979

- An Environmental Review of the sludge management systems was completed in August 1990

It is recognized that funding of the Program is contingent upon the completion of an acceptable EIS. However, recognizing the urgent need to improve the environment and welfare of the people of Alexandria, and the obvious benefits and environmental improvements that have accrued from the Program to date, any delay or interruption in the execution of the second phase of the Program would adversely affect the successful completion of the Program as a whole. It is also believed that unnecessary delay would result in further deterioration in overall environmental conditions within the Program area.

It is recommended, therefore, and the Program Schedule be so prepared that preliminary designs, marine studies, BODRs and any necessary surveys would be carried out simultaneously with the preparation of the EIS.

It is also recommended that construction of those specific Program elements directed towards the elimination and ponding of wastewater within the City proceed in advance of final acceptance of the EIS.

TABLE 8-1

CONSTRUCTION COST COMPARISON OF ALTERNATIVES A-F (a)
ALEXANDRIA WASTEWATER EXPANSION AND UPGRADE PROGRAM - PHASE 2

PROGRAM COMPONENT	ALTERNATE A	ALTERNATE B	ALTERNATE C	ALTERNATE D	ALTERNATE E	ALTERNATE F
	PRIMARY TRMT. SEA OUTFALL	PRIMARY TRMT. WITH LAKE DISCHARGE	PRIMARY TRMT. WITH LAKE BYPASS	SEC. TRMT. WITH LAKE DISCHARGE	SEC. TRMT. WITH LAKE BYPASS	LAND TRMT.
	$ (x1000)	$ (x1000)	$ (x1000)	$ (x1000)	$ (x1000)	$ (x1000)
CENTRAL ZONE & DRAIN IMPROVEMENTS	101,100	101,100	101,100	101,100	101,100	101,100
PUMPING STATIONS EXPANSIONS	4,500	4,500	4,500	4,500	4,500	4,500
TREATMENT PLANT EXPANSIONS	49,400	49,400	49,400	196,600	196,600	49,400
SLUDGE MANAGEMENT SYSTEM EXPANSIONS	34,600	34,600	34,600	128,900	128,900	34,600
EFFLUENT DISPOSAL	452,300	0	46,700	0	46,700	1,490,300
TOTAL - US DOLLAR PORTION ONLY	**485,300**	**189,600**	**236,300**	**431,100**	**477,800**	**1,673,300**
LE PORTION IN EQUIVALENT USD USD Equivalent Cost @ 3.31 LE	56,200	23,500	33,200	155,100	164,800	191,100
TOTAL COST IN EQUIVALENT USD	**541,500**	**213,100**	**269,500**	**586,200**	**642,200**	**1,864,400**

NOTES:

(a) Engineering, construction Management, and program management services are NOT included; contingency is included; values are NOT escalated and represent 4th quarter '92 values. Also, costs of collection system and pump station rehabilitation are not included.

TABLE 8-2

ALTERNATIVE - A
CONSTRUCTION COSTS FOR PRIMARY TREATMENT AND SEA OUTFALL
ALEXANDRIA WASTEWATER EXPANSION AND UPGRADE PROGRAM - PHASE 2

PROGRAM COMPONENT	TOTAL COST (a) ESTIMATED (1000's)	
	$ (x1000)	LE (x1000)
A. CENTRAL ZONE EXPANSION	**$91,700**	**36,100**
1. CENTRAL ZONE TUNNEL & CONNECTIONS	$79,400	30,000
2. QABBARI RELIEF SEWERS	$12,300	6,100
B. DRAIN IMPROVEMENTS	**$9,400**	**2,200**
1. SMOUHA DRAIN	$9,400	1,200
2. HYDRODROME DRAIN	$0	1,000
C. PUMPING STATIONS EXPANSIONS (ROUNDED)	**$4,500**	**5,300**
1. ABU QIR P.S.	$15	15
2. MAAMOURA P.S. & FORCE MAIN	$3,400	4,300
3. SIDI BISHR P.S.	$55	45
4. RAS EL SODA P.S.	$600	500
5. SPORTING P.S.	$150	200
6. EAST ZONE P.S.	$250	200
D. TREATMENT PLANT EXPANSIONS (PRIMARY)	**$49,400**	**13,100**
1. EAST PLANT: 410 Ml/d to 544 Ml/d	$14,700	3,600
2. WEST PLANT: 175 Ml/d to 475 Ml/d (b)	$34,700	9,500
E. SLUDGE MANAGEMENT SYSTEM EXPANSIONS (c)	**$34,600**	**21,100**
1. SLUDGE DEWATERING: WEST PLANT	$22,500	17,700
2. SLUDGE HAUL TRUCKS	$2,400	0
3. SLUDGE DISPOSAL AT SITE 9N	$7,800	3,400
4. GRIT/SCREENING TRUCK TRANSPORT	$1,900	0
F. EFFLUENT DISPOSAL FACILITIES	**$295,700**	**108,200**
1. MARINE STUDIES & DESIGN	$ 5,000	0
2. LAND-BASED GRAVITY CONVEYANCE SYSTEM	$109,800	40,300
3. EFFLUENT PUMP STATION	$24,300	10,500
4. LAND-BASED EFFLUENT TUNNEL (F.M.)	$41,400	15,200
5. SEA OUTFALL	$115,200	42,200
ALTERNATIVE - A TOTAL	**$485,300**	**186,000**
	$56,200	<———
USD EQUIVALENT COST @3.31 LE=	**$541,500**	

NOTES:

(a) Engineering, construction management, and project management services are NOT included; contingency is included; values are NOT escalated and represent 4th quarter '92 values.

(b) Includes cost of grit, scum and screening trucks for both treatment plants at $5,700,000.

(c) Assumes ETP primary sludge is conveyed by gravity in West Zone Tunnel to WTP and is mechanically dewatered there. The dewatered sludge is hauled by truck to Site 9N. Site 9N is continued to be used for Grit/Scum/ Screenings disposal.

TABLE 8-3

ALTERNATIVE - B
CONSTRUCTION COSTS FOR PRIMARY TREATMENT WITH LAKE DISCHARGE
ALEXANDRIA WASTEWATER EXPANSION AND UPGRADE PROGRAM - PHASE 2

PROGRAM COMPONENT	TOTAL COST (a) ESTIMATED (1000's)	
	LE (x1000)	LE (x1000)
A. CENTRAL ZONE EXPANSION	**$91,700**	**36,100**
1. CENTRAL ZONE TUNNEL & CONNECTIONS	$79,400	30,000
2. QABBARI RELIEF SEWERS	$12,300	6,100
B. DRAIN IMPROVEMENTS	**$9,400**	**2,200**
1. SMOUHA DRAIN	$9,400	1,200
2. HYDRODROME DRAIN	$0	1,000
C. PUMPING STATIONS EXPANSIONS (ROUNDED)	**$4,500**	**5,300**
1. ABU QIR P.S.	$15	15
2. MAAMOURA P.S. & FORCE MAIN	$3,400	4,300
3. SIDI BISHR P.S.	$55	45
4. RAS EL SODA P.S.	$600	500
5. SPORTING P.S.	$150	200
6. EAST ZONE P.S.	$250	200
D. TREATMENT PLANT EXPANSIONS (PRIMARY)	**$49,400**	**13,100**
1. EAST PLANT: 410 Ml/d to 544 Ml/d	$14,700	3,600
2. WEST PLANT: 175 Ml/d to 475 Ml/d (b)	$34,700	9,500
E. SLUDGE MANAGEMENT SYSTEM EXPANSIONS (c)	**34,600**	**21,100**
1. SLUDGE DEWATERING: WEST PLANT	$22,500	17,700
2. SLUDGE HAUL TRUCKS	$2,400	0
3. SLUDGE DISPOSAL AT SITE 9N	$7,800	3,400
4. GRIT/SCREENINGS TRUCK TRANSPORT	$1,900	0
ALTERNATIVE - B TOTAL	**$189,600**	**77,800**
	$23,500	<———
USD EQUIVALENT COST @3.31 LE=	**$213,100**	

NOTES:

(a) Engineering, construction management, and project management services are NOT included; contingency is included; values are NOT escalated and represent 4th quarter '92 values.

(b) Includes cost of grit, scum and screening trucks for both treatment plants at $5,700,000.

(c) Assumes ETP primary sludge is conveyed by gravity in West Zone Tunnel to WTP and is mechanically dewatered there. The dewatered sludge is hauled by truck to Site 9N. Site 9N is continued to be used for Grit/Scum/ Screenings disposal.

TABLE 8-4

ALTERNATIVE - C
CONSTRUCTION COSTS FOR PRIMARY TREATMENT WITH LAKE BYPASS
ALEXANDRIA WASTEWATER EXPANSION AND UPGRADE PROGRAM - PHASE 2

PROGRAM COMPONENT	TOTAL COST (a) ESTIMATED (1000's)	
	$ (x1000)	LE(x1000)
A. CENTRAL ZONE EXPANSION	**$91,700**	**36,100**
1. CENTRAL ZONE TUNNEL & CONNECTIONS	$79,400	30,000
2. QABBARI RELIEF SEWERS	$12,300	6,100
B. DRAIN IMPROVEMENTS	**$9,400**	**2,200**
1. SMOUHA DRAIN	$9,400	1,200
2. HYDRODROME DRAIN	$0	1,000
C. PUMPING STATIONS EXPANSIONS (ROUNDED)	**$4,500**	**5,300**
1. ABU QIR P.S.	$15	15
2. MAAMOURA P.S. & FORCE MAIN	$3,400	4,300
3. SIDI BISHR P.S.	$55	45
4. RAS EL SODA P.S.	$600	500
5. SPORTING P.S.	$150	200
6. EAST ZONE P.S.	$250	200
D. TREATMENT PLANT EXPANSIONS (PRIMARY)	**$49,400**	**13,100**
1. EAST PLANT: 410 Ml/d to 544 Ml/d	$14,700	3,600
2. WEST PLANT: 175 Ml/d to 475 Ml/d (b)	$34,700	9,500
E. SLUDGE MANAGEMENT SYSTEM EXPANSIONS (c)	**$34,600**	**21,100**
1. SLUDGE DEWATERING: WEST PLANT	$22,500	17,700
2. SLUDGE HAUL TRUCKS	$2,400	0
3. SLUDGE DISPOSAL AT SITE 9N	$7,800	3,400
4. GRIT/SCREENINGS TRUCK TRANSPORT	$1,900	
F. EFFLUENT DISPOSAL FACILITIES	**$46,700**	**32,000**
1. ETP LAKE BYPASS	$16,900	23,900
2. WTP LAKE BYPASS	$29,800	8,100
ALTERNATIVE - C TOTAL	**$236,300**	**109,800**
	$33,200	<———
USD EQUIVALENT COST @3.31 LE=	**$269,500**	

NOTES:

(a) Engineering, construction management, and project management services are NOT included; contingency is included; values are NOT escalated and represent 4th quarter '92 values.

(b) Includes cost of grit, scum and screening trucks for both treatment plants at $5,700,000.

(c) Assumes ETP primary sludge is conveyed by gravity in West Zone Tunnel to WTP and is mechanically dewatered there. The dewatered sludge is hauled by truck to Site 9N. Site 9N is continued to be used for Grit/Scum/ Screenings disposal.

TABLE 8-5

ALTERNATIVE - D
CONSTRUCTION COSTS FOR SECONDARY TREATMENT WITH LAKE DISCHARGE
ALEXANDRIA WASTEWATER EXPANSION AND UPGRADE PROGRAM - PHASE 2

PROGRAM COMPONENT	TOTAL COST (a) ESTIMATED (1000's)	
	$ (x1000)	LE (x1000)
A. CENTRAL ZONE EXPANSION	**$91,700**	**36,100**
1. CENTRAL ZONE TUNNEL & CONNECTIONS	$79,400	30,000
2. QABBARI RELIEF SEWERS	$12,300	6,100
B. DRAIN IMPROVEMENTS	**$9,400**	**2,200**
1. SMOUHA DRAIN	$9,400	1,200
2. HYDRODROME DRAIN	$0	1,000
C. PUMPING STATIONS EXPANSIONS (ROUNDED)	**$4,500**	**5,300**
1. ABU QIR P.S.	$15	15
2. MAAMOURA P.S. & FORCE MAIN	$3,400	4,300
3. SIDI BISHR P.S.	$55	45
4. RAS EL SODA P.S.	$600	500
5. SPORTING P.S.	$150	200
6. EAST ZONE P.S.	$250	200
D. TREATMENT PLANT EXPANSIONS (PRIMARY)	**$49,400**	**13,100**
1. EAST PLANT: 410 Ml/d to 544 Ml/d	$14,700	3,600
2. WEST PLANT: 175 Ml/d to 475 Ml/d (b)	$34,700	9,500
E. TREATMENT PLANT EXPANSIONS (SECONDARY)	**$147,200**	**381,100**
1. EAST PLANT	$76,800	197,300
2. WEST PLANT	$70,400	183,800
F. SLUDGE MANAGEMENT SYSTEM EXPANSIONS (c)	**$128,900**	**75,600**
1. SLUDGE P.S. & F.M. EAST PLANT TO WEST PLANT	$59,300	31,900
2. PRI./SEC. SLUDGE DEWATERING AT WEST PLANT	$40,700	32,000
3. HAUL TRUCKS FOR SECONDARY SLUDGE	$6,700	0
4. PRIMARY/SECONDARY SLUDGE DISPOSAL AT SITE 9N	$20,300	11,700
5. GRIT/SCUM SCREENINGS TRUCK TRANSPORT	$1,900	0
ALTERNATIVE - D TOTAL	**$431,100**	**513,400**
	$155,100	<———
USD EQUIVALENT COST @ 3.31 LE =	**$586,200**	

NOTES:

(a) Engineering, construction management, and project management services are NOT included; contingency is included; values are NOT escalated and represent 4th quarter '92 values.

(b) Includes cost of grit, scum and screening trucks for both treatment plants at $5,700,000.

(c) Assumes ETP primary and secondary sludge is pumped to WTP. All combined ETP/WTP sludge is mechanically dewatered at WTP and dewatered sludge is hauled by truck to Site 9N. Grit/scum/screenings will continue to be hauled by truck from ETP & WTP to Site 9N for disposal.

TABLE 8-6

ALTERNATIVE - E
CONSTRUCTION COSTS FOR SECONDARY TREATMENT WITH LAKE BYPASS
ALEXANDRIA WASTEWATER EXPANSION AND UPGRADE PROGRAM - PHASE 2

PROGRAM COMPONENT	TOTAL COST (a) ESTIMATED (1000's)	
	$ (x1000)	LE (x1000)
A. CENTRAL ZONE EXPANSION	**$91,700**	**36,100**
1. CENTRAL ZONE TUNNEL & CONNECTIONS	$79,400	30,000
2. QABBARI RELIEF SEWERS	$12,300	6,100
B. DRAIN IMPROVEMENTS	**$9,400**	**2,200**
1. SMOUHA DRAIN	$9,400	1,200
2. HYDRODROME DRAIN	$0	1,000
C. PUMPING STATIONS EXPANSIONS (ROUNDED)	**$4,500**	**5,300**
1. ABU QIR P.S.	$15	15
2. MAAMOURA P.S. & FORCE MAIN	$3,400	4,300
3. SIDI BISHR P.S.	$55	45
4. RAS EL SODA P.S.	$600	500
5. SPORTING P.S.	$150	200
6. EAST ZONE P.S.	$250	200
D. TREATMENT PLANT EXPANSIONS (PRIMARY)	**$49,400**	**13,100**
1. EAST PLANT: 410 Ml/d to 544 Ml/d	$14,700	3,600
2. WEST PLANT: 175 Ml/d to 475 Ml/d (b)	$34,700	9,500
E. TREATMENT PLANT EXPANSIONS (SECONDARY)	**$147,200**	**381,100**
1. EAST PLANT	$76,800	197,300
2. WEST PLANT	$70,400	183,800
F. SLUDGE MANAGEMENT SYSTEM EXPANSIONS (c)	**$128,900**	**75,600**
1. SLUDGE P.S. & F.M. EAST PLANT TO WEST PLANT	$59,300	31,900
2. PRI./SEC. SLUDGE DEWATERING AT WEST PLANT	$40,700	32,000
3. HAUL TRUCKS FOR SECONDARY SLUDGE	$6,700	0
4. PRIMARY/SECONDARY SLUDGE DISPOSAL AT SITE 9N	$20,300	11,700
5. CREATE/SCREENINGS TRUCK TRANSPORT	$1,900	0
G. EFFLUENT DISPOSAL FACILITIES	**$46,700**	**32,000**
1. ETP LAKE BYPASS	$16,900	23,900
2. WTP LAKE BYPASS	$29,800	8,100
ALTERNATIVE - E TOTAL	**$477,800**	**545,400**
	$164,800	<———
USD EQUIVALENT COST @ 3.31 LE =	**$642,600**	

NOTES:

(a) Engineering, construction management, and project management services are NOT included; contingency is included; values are NOT escalated and represent 4th quarter '92 values.

(b) Includes cost of grit, scum and screening trucks for both treatment plants at $5,700,000.

(c) Assumes ETP primary and secondary sludge is pumped to WTP. All combined ETP/WTP sludge is mechanically dewatered at WTP and dewatered sludge is hauled by truck to Site 9N. Grit/scum/screenings will continue to be hauled by truck from ETP & WTP to Site 9N for disposal.

TABLE 8-7

ALTERNATIVE - F
CONSTRUCTION COSTS FOR EFFLUENT
LAND DISPOSAL ALTERNATIVE
ALEXANDRIA WASTEWATER EXPANSION AND UPGRADE PROGRAM - PHASE 2

PROGRAM COMPONENT	TOTAL COST (a) ESTIMATED (1000's)	
	$ (x1000)	LE(x1000)
A. CENTRAL ZONE EXPANSION	**$91,700**	**36,100**
1. CENTRAL ZONE TUNNEL & CONNECTIONS	$79,400	30,000
2. QABBARI RELIEF SEWERS	$12,300	6,100
B. DRAIN IMPROVEMENTS	**$9,400**	**2,200**
1. SMOUHA DRAIN	$9,400	1,200
2. HYDRODROME DRAIN	$0	1,000
C. PUMPING STATIONS EXPANSIONS (ROUNDED)	**$4,500**	**5,300**
1. ABU QIR P.S.	$15	15
2. MAAMOURA P.S. & FORCE MAIN	$3,400	4,300
3. SIDI BISHR P.S.	$55	45
4. RAS EL SODA P.S.	$600	500
5. SPORTING P.S.	$150	200
6. EAST ZONE P.S.	$250	200
D. TREATMENT PLANT EXPANSIONS (PRIMARY)	**$49,400**	**13,100**
1. EAST PLANT: 410 Ml/d to 544 Ml/d	$14,700	3,600
2. WEST PLANT: 175 Ml/d to 475 Ml/d	$34,700	9,500
E. SLUDGE MANAGEMENT SYSTEM EXPANSIONS	**$34,600**	**21,100**
1. SLUDGE DEWATERING: WEST PLANT	$22,500	17,700
2. SLUDGE HAUL TRUCKS	$2,400	0
3. SLUDGE DISPOSAL AT SITE 9N	$7,800	3,400
4. GRIT/SCREENINGS TRUCK TRANSPORT	$1,900	0
F. LAND DISPOSAL	**$1,483,700**	**554,700**
ALTERNATIVE - F TOTAL	**$1,673,300**	**632,500**
	$191,100	<———
USD EQUIVALENT COST @3.31 LE=	**$1,864,400**	

NOTES:

(a) Engineering, construction management, and project management services are NOT included; contingency is included; values are NOT escalated and represent 4th quarter '92 values.

(b) Includes cost of grit, scum and screening trucks for both treatment plants at $5,700,000.

(c) Assumes ETP primary sludge is conveyed by gravity in West Zone Tunnel to WTP. Combined ETP/WTP primary sludge is mechanically dewatered at WTP and dewatered sludge is hauled by truck to Site 9N. Grit/Scum/screening continue to be hauled by truck from ETP & WTP to Site 9N for disposal.

TABLE 8-8

PHASE II OPTIONAL COMPONENTS

ITEM	USD (x1000)	L.E. (x1000)
Studies and Workshops	10,830	7,300
O&M Technical assistance	4,000	1,500
Institutional Support	5,000	1,700
Rehabilitation of Existing Collectors & Force Mains	111,400	226,100
Rehabilitation of Existing AGOSD Pump Station	46,800	38,700
Sludge Force Main From ETP to WTP	15,900	5,800

TABLE 8-9

SLUDGE HANDLING ALTERNATIVES

	TOTAL COST	
	$(x1000)	LE(x1000)
Alt. 1 – Mechanical Dewatering at WTP with Gravity Sludge Transport		
1. Mech. Sludge Dewatering at WTP	22,500	17,700
2. Sludge Transport to Site 9N	2,400	0
3. Site 9N Sludge Disposal Facilities	7,800	3,400
4. Screenings/Grit/Scum Truck Transport to Site 9N	1,900	0
Alt. No. 1 – TOTAL	$34,600	21,100
Alt. 1A – Mechanical Dewatering at WTP with Force Main Sludge Transport		
1. Dedicated Sludge Force Main and P.S.	15,900	5,800
2. Mech. Sludge Dewatering at WTP	22,500	17,700
3. Sludge Truck Transport to Site 9N	2,400	0
4. Site 9N Sludge Disposal Facilities	7,800	3,400
5. Screenings/Grit/Scum Truck Transport to Site 9N	1,900	0
Alt. No. 1A – TOTAL	$50,500	26,900
Alt. 2 – Mechanical Dewatering at ETP and WTP		
1. Separate Mech. Dewatering at ETP and WTP	33,400	26,200
2. Sludge Truck Transport to Site 9N	2,400	0
3. Sit 9N Sludge Disposal Facilities	7,800	3,400
4. Screenings/Grit/Scum Truck Transport to Site 9N	1,900	0
Alt. No. 2 – TOTAL	$45,500	29,600
Alt. No. 4 – Mechanical Dewatering at WTP and Remote Sand Drying Bed Dewatering for ETP		
1. Remote Sand Drying Beds for ETP	24,300	158,100
2. Sludge Truck Transport to Site 9N	2,400	0
3. Site 9N Sludge Disposal Facilities	7,800	3,400
4. Screenings/Grit/Scum Truck Transport to Site 9N	1,900	0
Alt. No. 4 – TOTAL	$36,400	161,500

CHAPTER 9

IMPLEMENTATION SCHEDULE

CHAPTER 9

IMPLEMENTATION SCHEDULE

An implementation schedule is included in this chapter for all the elements unbodied in one or more of the 4 recommended alternatives in Chapter 8 (Alternatives A, B, C & D). The scheduled elements include:

1. Those common to all four alternatives
2. The sea outfall system
3. The secondary treatment system
4. The Lake Maryout bypass system

In each of these 4 categories the element of longest duration is begun first with all other related elements terminating with it. For example in the list of common elements the sludge dewatering engansion has the longest duration so all other common elements finish concurrently with it at the end of year 3 3/4. At this point in time the effluent of the expanded system could continue into Lake Maryout pending completion of either the Sea Outfall or the secondary treatment alternative, etc.

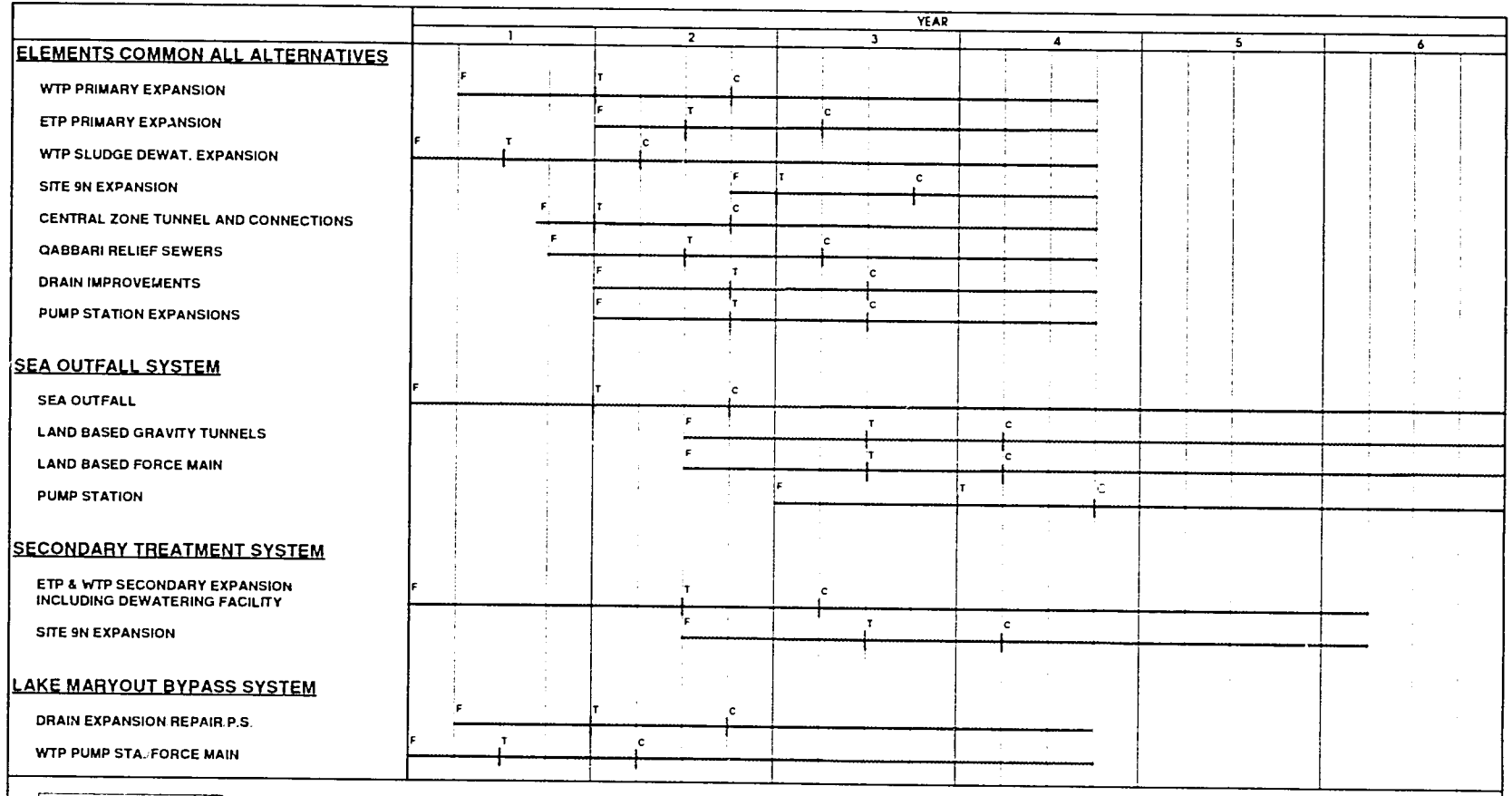
This schedule in all cases assumes at least a level of preliminary design (20 percent complete) has previously been accomplished. The design durations are only for production of final bid documents and do not include any study work.

This schedule also makes no reference as to when final design and construction might start in relation to EIS studies, Sea Studies, AID Project Documentation approval, etc.

This schedule does not include any rehabilitation of existing AGOSD facilities and it does not include converting the West Zone Collector between the WTP and ETP to a dedicated Force Main. This conversion is assumed to not be necessary for normal operations.

This schedule includes a standard period of 6 months for all tendering activities. The tender period includes advertizing though the construction Contractor notice to proceed. The time allowances for construction in this schedule are, like the cost estimates for various alternatives, subject to significant change as more definitive design scope emerges.

BASIC ALTERNATIVES - FINAL DESIGN & CONSTRUCTION SCHEDULES



LEGEND
F-- FINAL DESIGN
T-- TENDER
C-- CONSTRUCT

1992 WASTEWATER MASTER PLAN UPDATE
ALEXANDRIA WASTEWATER PROGRAM
FIGURE 9-1

4/4/93

REFERENCES

REFERENCES

Reference No.	Title
1	Alexandria Wastewater Master Plan Study – May 1978
2	Final Environmental Impact Statement – 1979
3	Review and Update of the 1978 Alexandria Wastewater Master Plan – May 1981
4	Phased Implementation Plan for the Rehabilitation and Expansion of the Alexandria Wastewater System – July 1982
5	Phased Implementation Plan for the Rehabilitation and Expansion of the Alexandria Wastewater System – April 1990
6	Environmental Review for Sludge Mechanical Dewatering and Sludge/Solids Disposal – August 1990
7	Off-Site Sludge Management Reconnaissance Study – May 1982
8	Basis of Design Report for the Sludge Management System – April 1987
9	Report on Sludge Management System Alternatives – December 1987
10	Basis of Design Report for the Mechanical Sludge Dewatering System – May 1989
11	Demographic Characteristics of Alexandria Population (Year 1980–2030)
12	Industrial Wastewater Survey and Impacts on Alexandria Sewerage System – July 1991
13	Study of Sludge Hauling Alternatives from West Treatment Plant to Site 9N Train versus Truck – May 1991
14	Consolidated Pump Station Condition Report – January 1992

15 Comparative Evaluation of Sludge Dewatering Processes: Belt Filter Presses vs Centrifuges – November 1988

16 Standard Methods for the Examination of Water and Wastewater. APHA 1989

17 Limnology; Wetzel, R.G. – 1983