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ARAB REPUBLIC OF
EGYPT

NATIONAL ORGANIZATION FOR
POTABLE WATER AND
SANITARY DRAINAGE

SUEZ CANAL
AUTHORITY

CANAL CITIES WATER AND WASTEWATER PHASE II PROJECT MASTER PLAN

USAID CONTRACT No. 263-C-00-98-00052-00
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VOLUME 2
SUEZ WASTEWATER MASTER PLAN

September 1999

BLACK & VEATCH INTERNATIONAL

In association with

MONTGOMERY WATSON

SABBOUR ASSOCIATES

PORT SAID

ISMAILIA

SUEZ

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Canal Cities Water & Wastewater Master Plans
USAID Contract No. 263-C-00-98-00052-00
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United States Agency for International Development (USAID)
Zahraa El Maadi
Maadi, Cairo, Egypt

Subject: Canal Cities Water & Wastewater Master Plans

Ladies and Gentlemen:

Black & Veatch International, in association with Montgomery Watson Americas and Sabbour Associates, is pleased to submit three copies of the Canal Cities Water and Wastewater Master Plans. The Master Plan documents consist of eight volumes, as listed below.

- Executive Summary
- Volume 1 – Suez Water Master Plan
- Volume 2 – Suez Wastewater Master Plan
- Volume 3 – Ismailia Water Master Plan
- Volume 4 – Ismailia Wastewater Master Plan
- Volume 5 – Port Said Water Master Plan
- Volume 6 – Port Said Wastewater Master Plan
- Volume 7 – Institutional and Financial Report

Concurrently, we are submitting three copies of the Master Plans to the National Organization for Potable Water and Sanitary Drainage (NOPWASD), one copy to the Suez Canal Authority (SCA), and one copy each to the Governorates of Suez, Ismailia, and Port Said.

This project represents an important achievement in USAID's continuing program to provide sustainable water and wastewater infrastructure in Egypt. We trust that the recommendations presented in the Master Plans will result in a well conceived and manageable program for NOPWASD and SCA as they prepare for development and growth in Suez, Ismailia, and Port Said.

It has been a pleasure working with USAID and we look forward to the next opportunity to be of service.

CANAL CITIES MASTER PLAN # BLACK & VEATCH INTERNATIONAL #

Very truly yours,
BLACK & VEATCH INTERNATIONAL

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In 1998 the United States Agency for International Development (USAID) contracted with Black & Veatch International (BVI) to prepare water and wastewater master plans for the three Canal Cities. The purpose of these master plans is to guide utility infrastructure development up to the year 2020. Black & Veatch International, in association with Montgomery Watson Americas and Sabbour Associates, conducted the Canal Cities Master Plan project during the period from June 1998 to September 1999. Heath Consultants, a firm specializing in field investigations for water systems, conducted field surveys and training for leak detection, system pressures, and flow measurement during the project

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ABBREVIATIONS, TERMS AND UNITS

Abbreviations

ABB	ABB Susa Dillingham
ARE	Arab Republic of Egypt
B&V	Black & Veatch International
CAPMAS	Central Agency for Public Mobilization and Statistics
CCMP	Canal Cities Master Plan, Prepared by B&V in association with Montgomery Watson and Sabbour Associates
CIP	capital improvements project
CMC	Construction Management Consultants (joint venture of Black & Veatch International and Montgomery Watson)
CTE	Compagnie Europeene de Traitement des Eaux
EEAA	Egyptian Environmental Affairs Agency
EU	European Union
GOPP	General Organization for Physical Planning
MOI	Ministry of Irrigation
NOPWASD	National Organization for Potable Water & Sanitary Drainage
SCA	Suez Canal Authority
USAID	United States Agency for International Development
USA	United States of America
USEPA	United States Environmental Protection Agency
WHO	World Health Organization

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Terms

ADD	average day demands
BOD	biochemical oxygen demand
CADD	computer aided drafting and design
COD	chemical oxygen demand
dia	diameter
DO	dissolved oxygen
D_{60}, D_{10}	sand sizes (based on sieve analysis) for which 60% (10% of grains (by weight) are finer
ea	each
GIS	geographic information system
I/S	infiltration/salinity
lcpd	liters/Capita/day
LE	Egyptian Pound
LS	lump sum
MDD	maximum day demands
Mld	megaliters/day
MPN	most probable number
N/A	not applicable
NTU	nephelometric turbidity units
O.D.	outside diameter
PHD	peak hour demands
ppb	parts per billion
ppm	parts per million
ppt	parts per thousand
S	slope
SS	suspended solids
STDO	salinity, temperature and dissolved oxygen
TDH	total dynamic head
ug/l	micrograms/liter
TU	turbidity units
TDS	total dissolved solids
UFW	unaccounted for water
WTP	water treatment plant
WWTP	wastewater treatment plant
Y	wye connection

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Units

cm	centimeter
d	day
gm	gram
ha	hectare
hr	hour
HP	horsepower
hz	hertz (cycles/sec)
kg	kilogram
km	kilometer
kV	kilovolt
kVA	kilovolt-ampere
kW	kilowatt
kWH	kilowatt hour
l	liter
lpcd	liters per capita per day
lps	liters per second
lpd	liters per day
lm	linear meter
m	meter
m^3	cubic meter
m^3/d	cubic meter per day
m^3/hr	cubic meters per hour
$m^3/d/km^2$	cubic meters per day per square kilometer
mg	milligram
mg/l	milligrams per liter
min	minute
ml	milliliter
mm	millimeters
m/sec	meters per second
m^3/yr	cubic meters per year
p/km^2	people per square kilometer
m^2	square meter
km^2	square kilometer
t	tonne (metric)
v	volt
yr	year
/	per

Executive Summary

The City of Suez is one of three major cities along the Suez Canal. It is the southernmost point of entry to the Suez Canal and is the northernmost city on the Gulf of Suez. It is located 120 km east of Cairo and 75 km south-southeast of Ismailia. Suez suffered considerable damage to utilities and other infrastructure during the 1967-73 war. After the war, massive reconstruction efforts were initiated to bring the original residents back to the City. In 1979, a Water and Wastewater Facilities Master Plan was prepared and completed for the City of Suez.

The wastewater collection and treatment facilities are owned by the Govenorate. Currently the wastewater treatment plant is operated by a contract operator, however ultimate control of the facility remains with the Govenorate. During the past few years significant improvements have been made to the Suez collection and treatment facilities. These improvement have been the result of a cooperative effort between the United States Agency for International Development, the Govenorate, the National Organization for Potable Water and Sanitary Drainage and other Egyptian government agencies.

In 1998 the United States Agency for International Development (USAID) contracted with Black & Veatch International (BVI) to prepare water and wastewater master plans for the three Canal Cities. The purpose of these master plans is to guide utility infrastructure development up to the year 2020. Black & Veatch International, in association with Montgomery Watson Americas and Sabbour Associates, conducted the Canal Cities Master Plan project during the period from June 1998 to September 1999.

Master Plan Objectives

The primary goal of this master plan is to adequately define water and wastewater needs in Suez for both existing and future conditions. Deficiencies of the existing water distribution system, the water treatment plant, the wastewater collection system and the wastewater treatment plant are identified. New and modified facilities to rectify these deficiencies are recommended. Similarly, deficiencies anticipated in the future have also been identified and facilities needed to accommodate future growth are also recommended.

Study Area Boundary

The study area includes both the existing urban built-up area and future build-out areas of the City of Suez as allocated by local and central authorities for future urban development projects. The total area within the study area boundary is approximately 97 km^2.

The study area boundary is based on ratified boundary coordinates prepared by the Governorate and planning documents prepared by the General Organization of Physical Planning (GOPP) or the local planning department affiliated with the Ministry of Housing. The study area boundary is shown on Figure V2-ES.1, Suez Study Area Boundary.

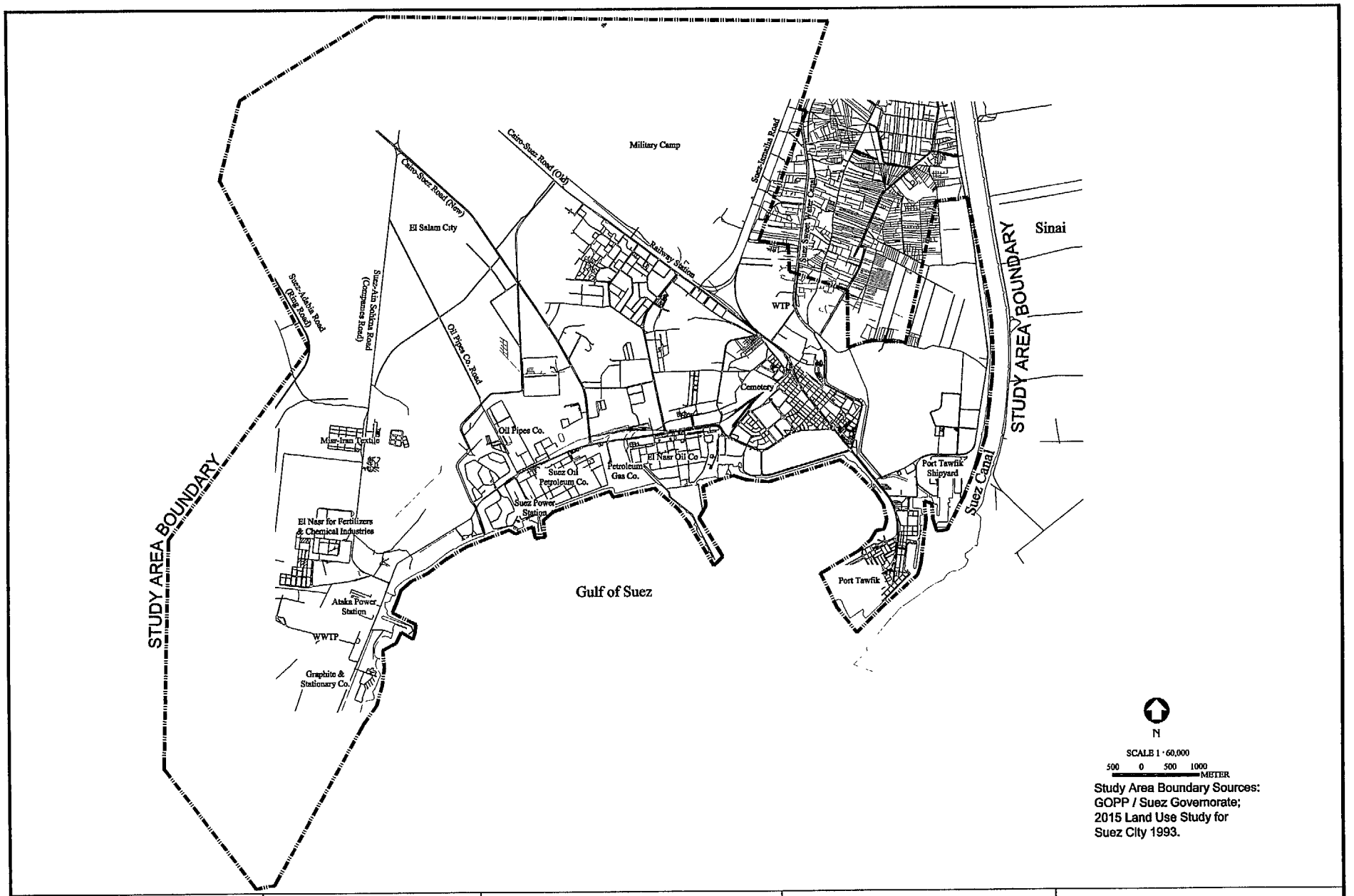
Population and Land Use

Existing and future land uses were developed for the City of Suez based on the current Land Use Master Plan approved by the General Organization for Physical Planning (GOPP). Water demand factors were applied to the different land use categories to estimate water demands. Similarly wastewater production factors were derived based on historical data and land use data. These wastewater factors were also applied to determine projected wastewater flows. Estimates of existing and projected population to year 2020 were used to obtain per capita water use and wastewater production. This was used to verify estimates for the entire study area.

The most recent topographical maps were purchased from the Central Agency for Public Mobilization and Statistics (CAPMAS) and reflected 1994 land use conditions. In order to portray the current land use conditions, additional site inspections were carried out, particularly in selected fringe areas. The inspection findings, as well as modifications to the land use registered by CAPMAS up to October 1998, were included in the land use plan of existing conditions. Lists of ongoing and future housing and industrial development projects were compiled with the help of the Housing Department of each Govenorate. The size, capacity, location, and progress status of each project were interpreted and then incorporated into the land use plan of existing conditions and, whenever applicable, into the 2020 land use plan.

The future land use plans were based on the land use master plan prepared in 1995 by the Third Region Planning Department and GOPP with the assistance of an independent consulting team. The current growth of Suez City follows the overall land use recommendations of the Suez City 1995 Master Plan concerning new growth urban areas. Current development status was evaluated for the overall feasibility of the land use categorizations allocated and assigned for future development by the Suez City 1995 Master Plan. Subdivisions on which construction work is progressing, as well as subdivisions that are unequivocally allocated for future development, were integrated into the CCMP future land use plans.

Preliminary results of the CAPMAS 1996 census indicated that the population of the Suez Governorate, including people living in Suez City and in rural areas of Qism Al Ganayin, had reached 417,610. Following a cartographic analysis and a density analysis of Al-Ganayin urban and rural districts, it was estimated that this figure may be two to three percent high. However, the CAPMAS figure was used as the basis for CCMP population projections up to the year 2020. Population projections were developed using different growth rates from historical data obtained from CAPMAS and the Suez Governorate. The projections were compared with population projections of approved planning studies prepared by official agencies such as the Governorate, NOPWASD, or GOPP. The projected population figures are listed in five-year increments in Table V2-ES.1, Suez Existing and Projected Population.



ARAB REPUBLIC OF **EGYPT** SUEZ CANAL AUTHORITY NATIONAL ORGANIZATION FOR POTABLE WATER AND SANITARY DRAINAGE	INTERNATIONAL ELLIPSOIDE - HAYFORD 1909 U.T.M. PROJECTION - ZONE 36 STEREOPLOTTING BASED ON GEODETIC TRIANGULATION OF EGYPTIAN SURVEY AUTHORITY	**USAID** CANAL CITIES WATER AND WASTEWATER MASTER PLAN	BLACK & VEATCH INTERNATIONAL IN ASSOCIATION WITH MONTGOMERY WATSON SABBOUR ASSOCIATES	SUEZ STUDY AREA BOUNDARY DATE: AUGUST 1999 FIGURE: V2-ES.1

Table V2-ES.1 Suez Existing and Projected Population

Year	Population
Current	417,610
2000	466,374
2005	515,039
2010	567,390
2015	633,346
2020	701,434
Ultimate	871,199

The low occupancy housing rate methodology assumes that new housing developments would have occupancy rates equivalent to 70 percent of their maximum capacity in year 2020. Ultimate condition assumes new housing developments would have a maximum occupancy rate equivalent to 100 percent of their capacity.

Ultimate conditions in the study area will occur after 2020 or earlier depending on variations to the projected population due to unforeseen factors such as gain in employment rates or change in the prevailing rate of housing occupancy.

The following recommendations are suggestions to improve and, whenever feasible, to modify the provisions of the Govenorate development plans:

- The Suez land use plan used for this master plan should be adopted and followed by Govenorate Authorities. If deviations from the land use plan occurs, appropriate measures should be taken by the utilities to modify infrastructure to meet the revised development needs.
- Population growth should be monitored regularly and utility development adjusted accordingly.
- Utilities and government agencies should form joint committees to monitor land development and communicate regularly on changing utility needs.

Other land use principles that are anticipated for Suez in this master plan are listed below.

Changes to this land use approach would result in changes to infrastructure needs and should be dealt with by utility planners accordingly.

- The amount of land assigned for development in the 1995 Suez City Master Plan exceeds the amount of land required to accommodate the projected year 2020 population in the CCMP land use plan. Therefore, the extra urban growth land which has not been allocated for specific projects, will not be needed before the year 2020.
- Urban growth in Ataqa and Faysal should continue westward, away from agricultural land.

- The growth of Suez should be oriented toward the Gulf of Suez waterfront. The land use plan proposes the creation of a public recreational area that would end the long-standing practice of using the land along the Gulf's shores exclusively for industrial purposes. The City could border the waterfront with much-needed landscaped recreational grounds and lagoons. The environmentally friendly and construction-free Corniche and beaches would extend south along the coastal road leading to Al Adabiya. This would reverse the City's image as an industrial center and would help promote it as destination for local recreation and tourism.
- To further enhance the City's image and to compensate for the lack of public areas in Qisms Al Arbaein and Suez, the conversion of several ponds near Port Tawfik low-density residential zones into lagoons surrounded by public playgrounds, is also recommended

Existing Wastewater Collection Facilities

The existing Suez wastewater service area covers approximately 12 square kilometers, the existing water service area covers approximately 43 square kilometers and both are expected to expand to over 90 square kilometers at ultimate build-out. The majority of the wastewater system in Suez is owned, operated and maintained by the Govenorate. Additionally, small portions of the system may be owned and/or controlled by the military, other government agencies or by private industry. The collection system consists of more than 230 kilometers of 175 mm to 1200 mm wastewater lines excluding service laterals.

During preparation of the Canal Cities Master Plans a number of sources were used to obtain data on the existing wastewater collection system. Information in the form of maps and construction drawings was obtained from, NOPWASD, the Govenorate, construction contractors and engineering consultants. It is important to note that no single source could be used to obtain information on the entire system. Additionally the scale of drawings, the reference datum and the level of detail varied from source to source. Ultimately a map of the system was developed by combining the available information. This map was used to plan future work and prepare the wastewater system model.

The map prepared for this project is a useful tool; however, it does have limitations. Specifically where no maps or as-builts were available, line locations were drawn from field observations. Some areas included horizontal data, but had little or no vertical data. In these areas manhole inverts were estimated using available slope data. Existing wastewater collection pipes included in the model are shown on Figure V2-9.1, Suez Wastewater System Recommended Improvements.

The gravity collector and interceptor lines, transport flow to 15 major lift stations. The Atakka station is the main lift station for the city and occupies a site approximately halfway between the old wastewater treatment plant and the new wastewater treatment plant.

Existing Wastewater Treatment Facilities

The Suez Wastewater Treatment Plant has been in operation since August 1995. Partial funding for the initial planning studies, plant design, plant construction and a one year operator training program were provided by the United States Agency for International Development, (USAID).

The plant is located approximately 8 km to the southwest of Suez on a site inland from the Suez - Ain El-Sokhna coastal road.

The plant has two treatment trains each designed for 65,000 m^3/d, or 130,000 m^3/d total, average daily flow. The plant was designed to treat wastewater with influent characteristics of 400 mg/l total suspended solids (TSS) and 280 mg/l biological oxygen demand (BOD_5). The plant design calls for effluent quality to meet a standard of 50 mg/l TSS and 60 mg/l BOD_5. This represents over 85% reduction of the TSS load and over 75% reduction of the BOD_5 load.

This wastewater treatment plant has been designed to use a biological process to remove nutrient material from the wastewater prior to discharge. Prior to initial design of the plant, two studies were performed. The *Receiving Waters Study* and the *Basis of Design Report* were used to determine the quality of plant effluent water that could be discharged without detrimental impact to the receiving waters or the native environment. These studies, which were reviewed and approved by all pertinent Egyptian agencies and authorities, showed that plant effluent meeting the 50 TSS, 60 BOD_5 would not have a negative impact on the receiving waters or on the native environment.

During the 12-month period ending January 1999, the average flow to the plant was approximately 95,400 m^3/d. During the same period the average TSS and BOD_5 loads were 194 mg/l and 169 mg/l respectively. When compared to the design capacity of the plant this represents approximately 50% of the TSS capacity and approximately 60% of the BOD_5 capacity. Since initial operation in 1995 the plant has consistently met or exceeded the required effluent standards.

The infiltration during dry weather and high groundwater conditions, estimated from the results of the previous Infiltration/Salinity study, is 29 percent of flow being transported for treatment. High groundwater is the principal cause of this infiltration.

Planning Criteria and Methodology

Average daily flow to the plant does not represent all wastewater generated in Suez. Some areas of Suez receive water service; however, do not have wastewater collection and treatment. If additional wastewater collection infrastructure were built to cover the entire Suez water system coverage area the total flow to the wastewater plant would be increased to approximately 170,000 m^3/day. This represents nearly an 80 percent increase to the current flow.

Capital plans outlined in this Master Plan were established to meet the goal of covering the entire water service area with wastewater collection by the year 2005. Additionally, population growth and growth in per capita wastewater production will also increase the flow of wastewater to the plant.

The increase in wastewater flow is used to plan future plant expansions; however, flow alone is not a sufficient indicator of wastewater treatment plant capacity. The ability of a wastewater treatment plant to successfully meet BOD_5 discharge limits is considered the limiting factor for a biological treatment plant.

Using anticipated flow into the wastewater treatment plant and using an estimate of wastewater strength, the projected TSS and BOD_5 loading was estimated. A projection of future BOD_5 mass loading is also shown in Table V2-ES.2, Suez Projected Wastewater Flow and BOD_5 Load. Additionally a graphical representation of this data is shown in Figure V2-ES.2, Suez WWTP Capacity vs. Projected BOD_5 Load .

Table V2-ES.2 Suez Projected Wastewater Flow and BOD_5 Load

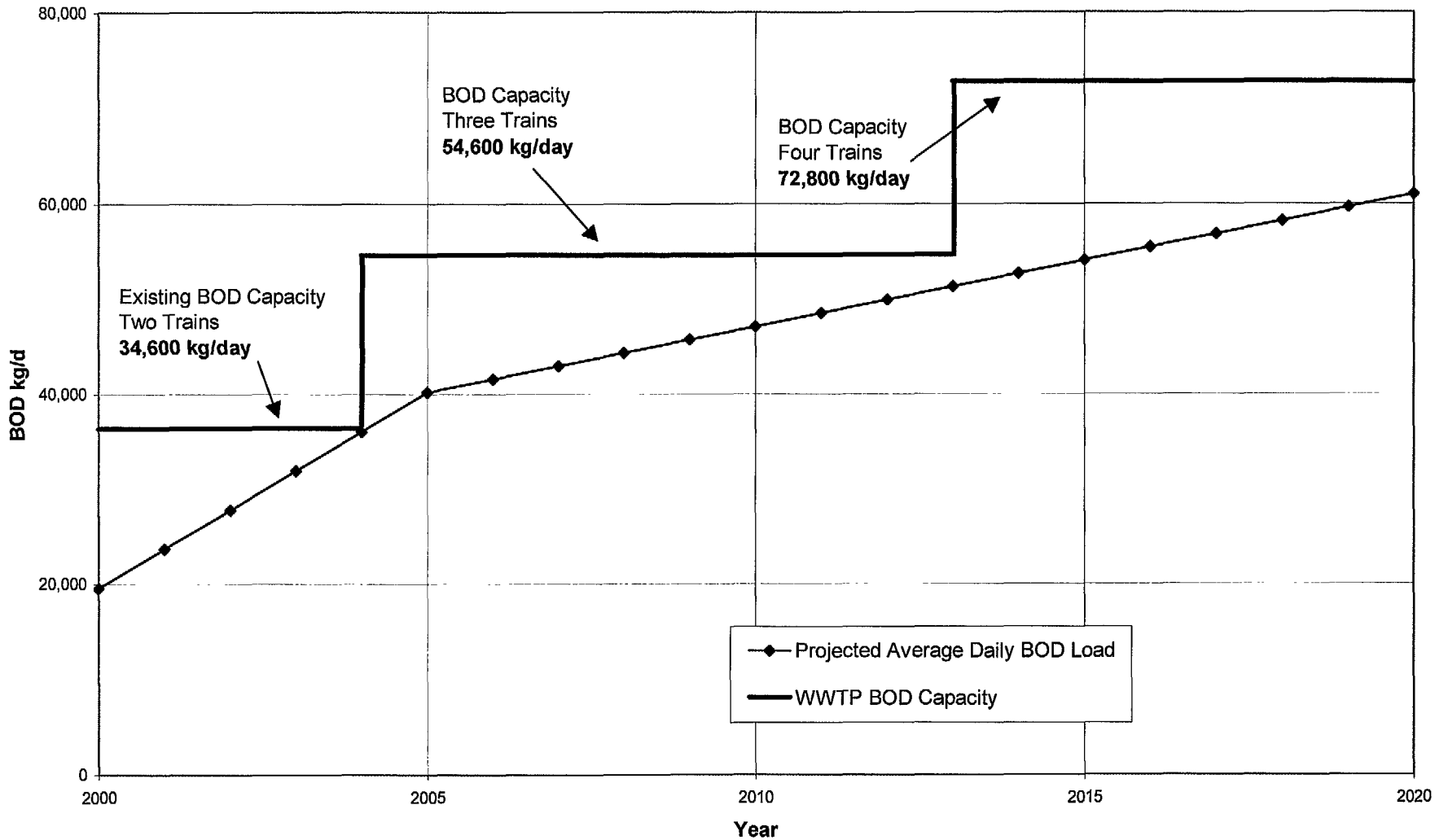
Year	Projected Flow (m^3/day)	Projected BOD_5 Load (kg/day)
2000 [1]	96,000	19,570
2005 [1]	195,000	40,170
2010 [1]	228,700	47,110
2015 [1]	262,400	54,050
2020 [2]	296,100	60,997
Ultimate [2]	310,900	64,040

Notes:
1) Estimated from growth rate curve.
2) Based on an analysis of future land use and wastewater production factors.

Preparation of the Suez Wastewater Master Plan included a review of existing facilities and historical data. Wastewater flow analyses were conducted to identify current and projected wastewater flows. Flows were developed using a land use methodology with wastewater use factors developed for each land use category based on historical water records and estimated wastewater return rates. Future land use was based on local and government general land use plans.

A hydraulic model of the Suez wastewater collection system was developed as part of this project. The hydraulic model was then used to identify system deficiencies and to develop and evaluate potential facility improvements for correcting the deficiencies. The hydraulic model includes wastewater collection lines 300 mm and larger in diameter.

The peak flows in the wastewater collection system reflect the water supply system. The gravity system, however, includes storage capacity, resistance to excessive flow velocities and a wide range of transmission distances and times from various parts of the system, all of which tend to mitigate the downstream effect of peaks. In addition, infiltration will not increase as the user flow increases; rather, it will probably decrease as the water level and pressure in the pipe increase.



ARAB REPUBLIC OF EGYPT SUEZ CANAL AUTHORITY NATIONAL ORGANIZATION FOR POTABLE WATER AND SANITARY DRAINAGE	USAID CANAL CITIES WATER AND WASTEWATER MASTER PLAN	SUEZ WWTP BOD TREATMENT CAPACITY VS PROJECTED BOD MASS LOADING RATE	BLACK & VEATCH INTERNATIONAL IN ASSOCIATION WITH MONTGOMERY WATSON SABBOUR ASSOCIATES DATE: AUGUST 1999 FIGURE: V2-ES.2

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To the extent that infiltration constitutes a significant portion of the average daily flow in Suez, it reduces the amplitude of peak and low flows. Peaking factors, expressed as a multiple of the average daily flow (ADF), have been developed based on the existing WWTP records and existing water demand patterns. Table V2-ES.3, Suez Historical Flows and Peaking Factors, presents a summary of the historical peaking factors.

Table V2-ES.3 Suez Historical Flows and Peaking Factors

	Rate (m^3/d)	Peaking Factor
Annual Average Daily Flow (ADF) (1)	95,000	1.00
Maximum Monthly Flow(2)	101,600	1.09
WWTP Minimum Day(2)	61,500	0.66
WWTP Minimum Nighttime Flow (MNF)(3)	38,800	0.63 x Min. day = 0.42
WWTP Maximum Day MDF(2)	116,200	1.24
WWTP Peak Hour PHF(4)	133,600	1.15 x MDF = 1.43

1) The annual average daily wastewater flow to WWTP.
2) Based on treatment plant records.
3) Minimum day on record multiplied by diurnal nighttime minimum hour.
4) Maximum day on record multiplied by diurnal daytime maximum hour.

The recommended improvement plan is based on the following criteria for phasing infrastructure needs:

Phase 1

- Construction of relief lines to alleviate hydraulic deficiencies in existing wastewater system.
- Upgrading deficient lift stations.
- Construction of extension lines to serve areas currently served by the water system, which do not have wastewater facilities.
- Construction of new lift stations to serve areas currently served by water system, which do not have wastewater facilities.
- Expansion of the Suez Wastewater Treatment Plant to meet the demand of additional flow.
- Wastewater System Management Plan to include an annual program for inspecting, maintaining, and rehabilitating the existing wastewater system.

Phase 2

- Construction of new lift stations to serve growth areas without water or wastewater service.
- Construction of extensions to wastewater lines to serve growth areas currently without water or wastewater service.

The function and future expansion of the wastewater collection system is directly related to the land use development. Population and land development should be routinely monitored and appropriate changes made to the wastewater facility plans. The pipe sizes and flow rates

for the recommended relief lines should be reviewed prior to construction, based on the actual growth patterns.

Recommendations

It is recommended that the wastewater treatment process currently used in Suez be continued. The wastewater treatment plant should be expanded by the year 2004 by adding a third treatment train approximately equivalent to the existing trains. Intermediate sampling and testing should be conducted at the plant to monitor and adjust the rated performance of the plant. Disinfection should be added only if mandated by EEAA and only after further evaluation of the effects on the receiving waters. As the plant is currently meeting all required effluent standards and as disinfection is not required, it is not included in the improvement program at this time.

A biosolids testing program should be established to determine the suitability of the biosolids for beneficial use. The current procedure of drying biosolids in the drying lagoons should continue. Dried biosolids can be used for agricultural application after they have been shown to be biologically stable and within acceptable guidelines for metals and chemicals.

A program should be implemented to survey and inventory the wastewater collection system. Wastewater system surveys for system maintenance and control of infiltration should be performed at least every 5 years. Before this Master Plan the Suez Infiltration/Salinity survey was conducted and most of the urgent and cost effective repairs are being implemented. Routine monitoring of infiltration should be conducted and if expected levels of infiltration removal are not achieved, additional studies and rehabilitation projects may be required. The recommended wastewater system management plan should include the following components:

- An annual program of cleaning and inspection of wastewater lines by closed circuit television cameras and other inspections as needed.
- System inspections to identify areas in need of rehabilitation.
- Updating the hydraulic model at least every 5 years in order to ensure that the model reflects the current land use and demographic changes.

The characteristics of the effluent from the Suez Wastewater Treatment Plant indicate that the effluent must have additional treatment before it is made available for reuse. Two of the most notable characteristics are the total dissolved solids and the coliform bacteria. The average TDS of the effluent for the 12-month period ending in October 1998 was approximately 2,645 mg/L. Because of this high concentration of TDS, the effluent will support only the most salt-tolerant crops if used as irrigation water without further treatment. These crops may be date palms or certain forage crops. Additional testing should be performed to determine soil conditions and drainage. It is recommended that desalination of the effluent be considered if the effluent is to be used for irrigation.

The total projected capital cost of the Phase 1 Implementation Plan is $121.6 million. The current value of the Phase 2 Implementation Plan is $145.9 million. The recommended capital improvement projects are summarized in Table V2-ES.4, Summary of Probable Capital Costs - Phase 1, and Table V2-ES.5, Summary of Probable Capital Costs - Phase 2. The approximate location of each project is indicated on Figure V2-9.1, Suez Wastewater System Recommended Improvements. Construction costs include allowances for mobilization/demobilization, shoring, dewatering, and surface restoration. Additionally these costs are based on use of international contractors, management and inspection. Costs will vary depending on the actual surface and subsurface conditions. The projected capital costs listed for capital improvement projects include construction cost plus allowances of 20 percent for contingencies and 20 percent for engineering, legal, and administrative costs. No costs are included for land, rights-of-way, or rock excavation.

Table V2-ES.4 Summary of Probable Capital Cost – Phase 1

CIP No.	Construction Cost, US $ (1)	Total Capital Cost, US $ (2)
CIP 1 - Existing System Critical Improvements	12,073,000	14,488,000
CIP 2 - Port Tawfik Dock Area Collection System	312,000	374,000
CIP 3 - Westside Lower Trunk	15,600,000	18,720,000
CIP 4 - Old Drainage Channel Interceptor	2,340,000	2,808,000
CIP 5 - West Gabalaya Collector	1,680,000	2,016,000
CIP 6 - Coastal Interceptor, Lift Stations, and Force Mains	21,480,000	25,776,000
CIP 7 - Industrial Zone Collection System	6,600,000	7,920,000
CIP 8 - SCA Zone Interceptor System	8,040,000	9,648,000
CIP 9 - Phase I Wastewater Treatment Plan Expansion	26,808,000	32,170,000
Wastewater System Management Plan	0	7,650,000
Phase 1 Totals	**$94,933,000**	**$121,570,000**

1) Construction cost includes 20 percent construction contingency.
2) Capital Cost includes construction cost and 20 percent engineering and administration cost

Table V2-ES.5 Summary of Probable Capital Cost - Phase 2

CIP No.	Construction Cost, US $ (1)	Total Capital Cost, US $ (2)
CIP 10 - Existing System Phase 2 Improvements	6,014,000	7,217,000
CIP 11 - Local Development Interceptor	840,000	1,008,000
CIP 12 - Isolated Development Interceptor	1,320,000	1,584,000
CIP 13 - Cross Trunk Interceptor	3,708,000	4,450,000
CIP 14 - East Lowlands Development Collector System	13,032,000	15,638,000
CIP 15 - Northwest Development Area Collection System,	40,920,000	49,104,000
CIP 16 - Southwest Suez Industrial Zone	11,640,000	13,968,000
CIP 17 - Phase 2 Wastewater Treatment Plan Expansion	44,142,000	52,970,000
Phase 2 Totals	**$121,616,000**	**$145,939,000**

1) Construction cost includes 20 percent construction contingency.
2) Capital Cost includes construction cost and 20 percent engineering and administration cost

End of Executive Summary section

1.0 Introduction

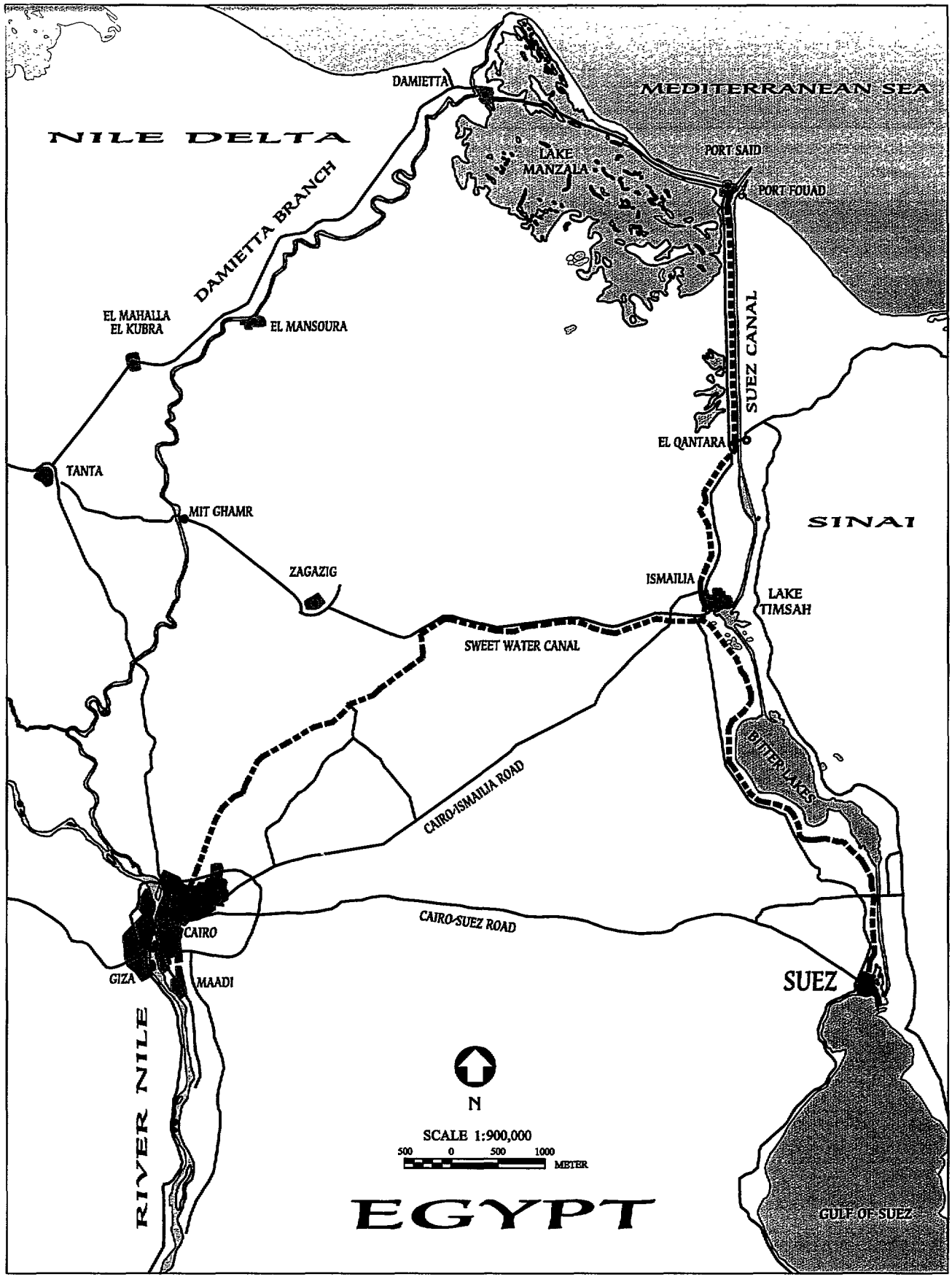
This section provides an overview of the work and objectives for the Suez Wastewater Master Plan as part of the Canal Cities Master Plan Project.

1.1 Background

The City of Suez is one of three major cities along the Suez Canal. Figure V2-1.1, Suez Location Map, shows the locations of the three cities studied. Suez suffered considerable damage to utilities and other infrastructure during the 1967-73 war. After the war, massive reconstruction efforts were initiated to bring the original residents back to the City. In 1979, a Water and Wastewater Facilities Master Plan was prepared and completed for the City of Suez.

The wastewater treatment facilities in Suez are owned by the Govenorate and operated by the Suez Canal Authority (SCA). Day to day operation of the wastewater treatment plant is under the direction of the Timsah Company which is a subsidiary of SCA. The Suez collection system is owned and operated by the Suez Govenorate. Since 1980, the National Organization for Potable Water and Sanitary Drainage (NOPWASD) and the Suez Governorate have made significant improvements to the collection system. In 1995, the current wastewater treatment plant was commissioned. Significant portions of the funding for the planning, design and construction of this treatment plant were provided by the United States Agency for International Development.

In 1998 the United States Agency for International Development (USAID) contracted with Black & Veatch International (BVI) to prepare water and wastewater master plans for the three Canal Cities. The purpose of these master plans is to guide utility infrastructure development up to the year 2020. Black & Veatch International, in association with Montgomery Watson Americas and Sabbour Associates, conducted the Canal Cities Master Plan project during the period from June 1998 to September 1999. Heath Consultants, a firm specializing in field investigations for water systems, conducted field surveys and training for leak detection, system pressures, and flow measurement during the project



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ARAB REPUBLIC OF **EGYPT** SUEZ CANAL AUTHORITY NATIONAL ORGANIZATION FOR POTABLE WATER AND SANITARY DRAINAGE	**USAID** CANAL CITIES WATER AND WASTEWATER MASTER PLAN	BLACK & VEATCH INTERNATIONAL IN ASSOCIATION WITH MONTGOMERY WATSON SABBOUR ASSOCIATES	SUEZ LOCATION MAP DATE: AUGUST 1999 FIGURE:V2-1.1

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1.2 Objectives

The objective of this volume is to provide a wastewater facilities master plan to guide wastewater development in the City of Suez from year 2000 to year 2020. It includes the following activities:

- Define the Study Area and describe the physical setting.
- Develop 20-year population and anticipated land use projections.
- Define the existing and projected wastewater flows and loads.
- Obtain available inventory data for the hydraulic model.
- Describe and evaluate the existing wastewater treatment and collection system.
- Develop a hydraulic model to identify collection system deficiencies and to analyze system extensions.
- Recommend system extensions to serve future areas.
- Recommend treatment improvements and identify expansion needs.
- Identify and prioritize capital improvement projects.

A prioritized list of capital improvement projects includes the recommended wastewater treatment plants, lift stations, force mains and gravity trunk lines, with order-of-magnitude cost estimate that could be used by NOPWASD to establish budgets and funding requirements.

1.3 Organization of the Report

The Suez Wastewater Master Plan report is one of eight volumes comprising the Canal Cities Master Plan (CCMP). The CCMP final reports address both the water and wastewater facilities requirements of the three Canal Cities of Port Said, Ismailia, and Suez. It consists of the Executive Summary and Volumes 1 through 7, listed below:

Executive Summary
Volume 1 – Suez Water Master Plan
Volume 2 – Suez Wastewater Master Plan
Volume 3 – Ismailia Water Master Plan
Volume 4 – Ismailia Wastewater Master Plan
Volume 5 – Port Said Water Master Plan
Volume 6 – Port Said Wastewater Master Plan
Volume 7 – Institutional and Financial Report

End of Chapter 1: Introduction

2.0 Physical Conditions, Land Use and Population

The objectives of this section of the CCMP Report are as follows:

- To present an analysis of physical conditions, land use and population in the City of Suez in support of the master planning of the City's water and wastewater infrastructure to the year 2020.
- To prepare Land Use Plans representative of existing conditions and projections of future conditions on a phased basis to the year 2020.
- To incorporate the findings and recommendations of present and future urban development plans approved by central and/or local government authorities into the Land Use Plan for 2020 and into projections of ultimate development conditions.

Study Area

2.1.1 Study Area Boundaries

The primary focus of the Canal Cities Water and Wastewater Master Plan is on the existing built-up areas of Suez. The urban area of interest extends approximately 17 km along the Gulf of Suez and 14 km from the Suez Canal west to the Ring Road of Suez City.

The Study Area Boundary (SAB) for Suez was determined according to the following criteria:

- The SAB demarcates either existing urban built-up areas or future build-out areas, or land allocated by local or central authorities for future urban development projects. These authorities include the Governorate Housing Department, the Ministry of Defense, the General Authority for Investment and the General Authority for Free Zones.
- The SAB marks urban districts but does not integrate all fringe area villages or rural satellite clusters. Such rural zones are excluded from the SAB even when located within the borders of districts administratively classified as urban. The exclusion is particularly applicable in the case of the Suez Governorate, since it ranks as an Urban Governorate. This jurisdictional classification means that the limits of the capital city are equivalent to the boundaries of the whole Governorate.
- The SAB is based on ratified boundary coordinates prepared by the Governorate. The boundary is defined based on the most recent available map and/or planning document(s) with precise cartographic coordinates, or is clearly marked on scaled maps. The planning document(s) have been prepared by an official planning agency, such as the General Organization of Physical Planning (GOPP) or the local planning department affiliated with the Ministry of Housing.

- The National Building Code and the National Urban Planning Code are applicable within the official limits of the City. The application of the Building Code is not compulsory in rural areas located outside the SAB.

A representation of the Study Area Boundary according to the above criteria is presented in Figure V2-2.1, Suez Study Area Boundary. The SAB is based on the officially ratified borders for development up to the year 2015 and shows land use allocations for future urban development.

The most comprehensive document establishing the borders of the SAB is the scaled map titled *Urban Limits of Suez City: The Approbation of Suez Build-out Area*, issued by the Third Region Planning Department of GOPP in January 1994. The urban limits were approved by the Governor of Suez, the President of the City's Local Council, and the President of Suez Urban Planning Department. The scaled limits of the City's build-out area were integrated into the GIS database.

2.1.2 Administrative Boundary

Study Area Boundaries also relate to administrative boundaries or official district borders. Administrative boundaries are classified as Muhafaza (Governorate), Markaz (District), Madina (Town), Hayy (Quarter), Qism (Police District), and Shiyakha (Neighborhood). These boundaries are used to register the corresponding population data in the survey system established by Central Agency for Public Mobilization and Statistics (CAPMAS). CAPMAS census data, and other available information based on the same survey system, were used in CCMP land use categorization and population projections as discussed further in this report.

Other administrative boundaries considered in CCMP future land use planning were Natural Reserve Boundaries of protected zones declared as National Parks by official decrees or laws. National Parks are excluded from all forms of development.

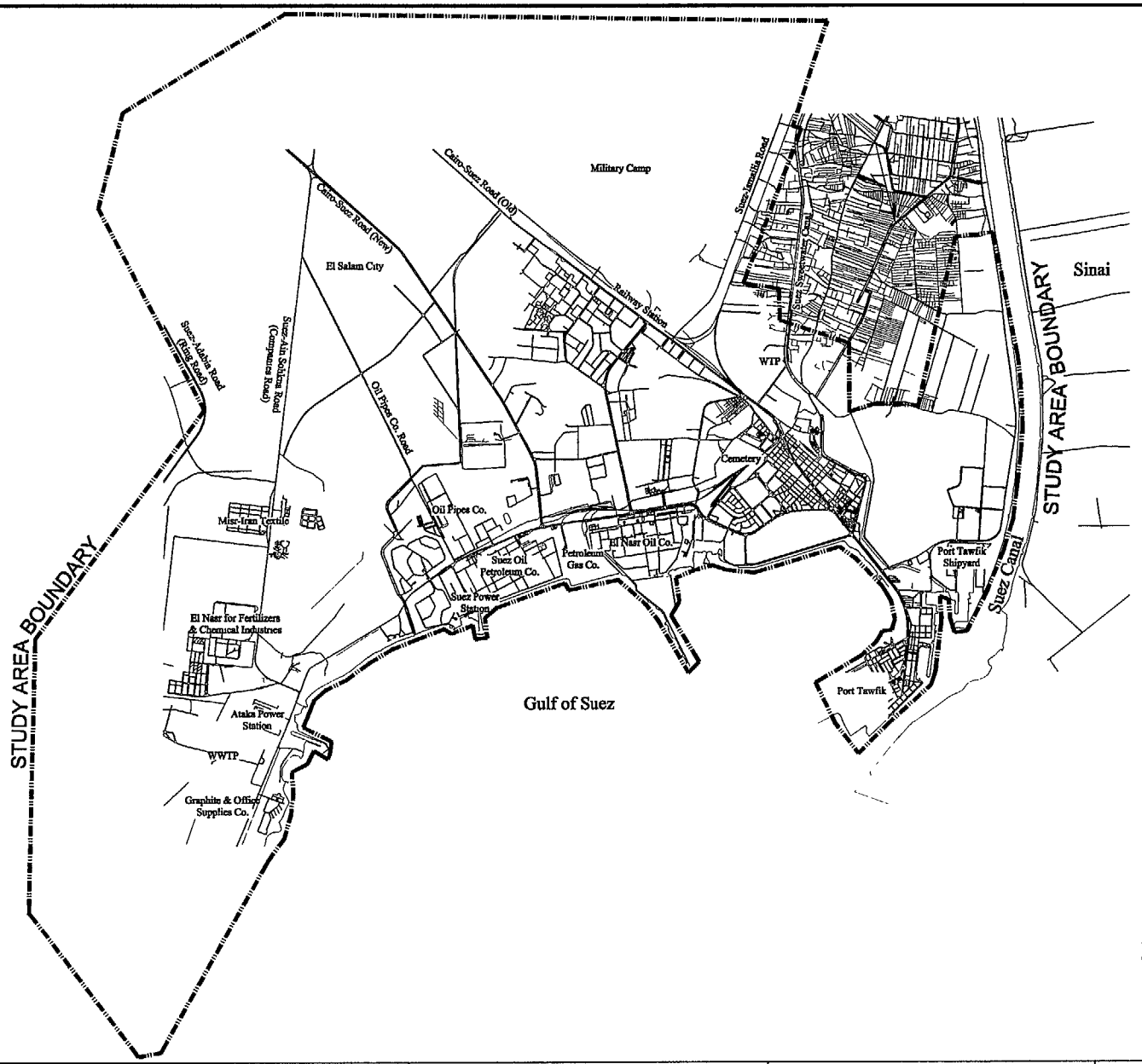
Based on the above criteria, the Administrative Boundaries of the City of Suez are presented in Figure V2-2.2, Suez Administrative Boundaries. The area within these boundaries consists of six Qisms divided into eight Shiyakhas.

2.2 Physical Conditions

2.2.1 Geography and Topography

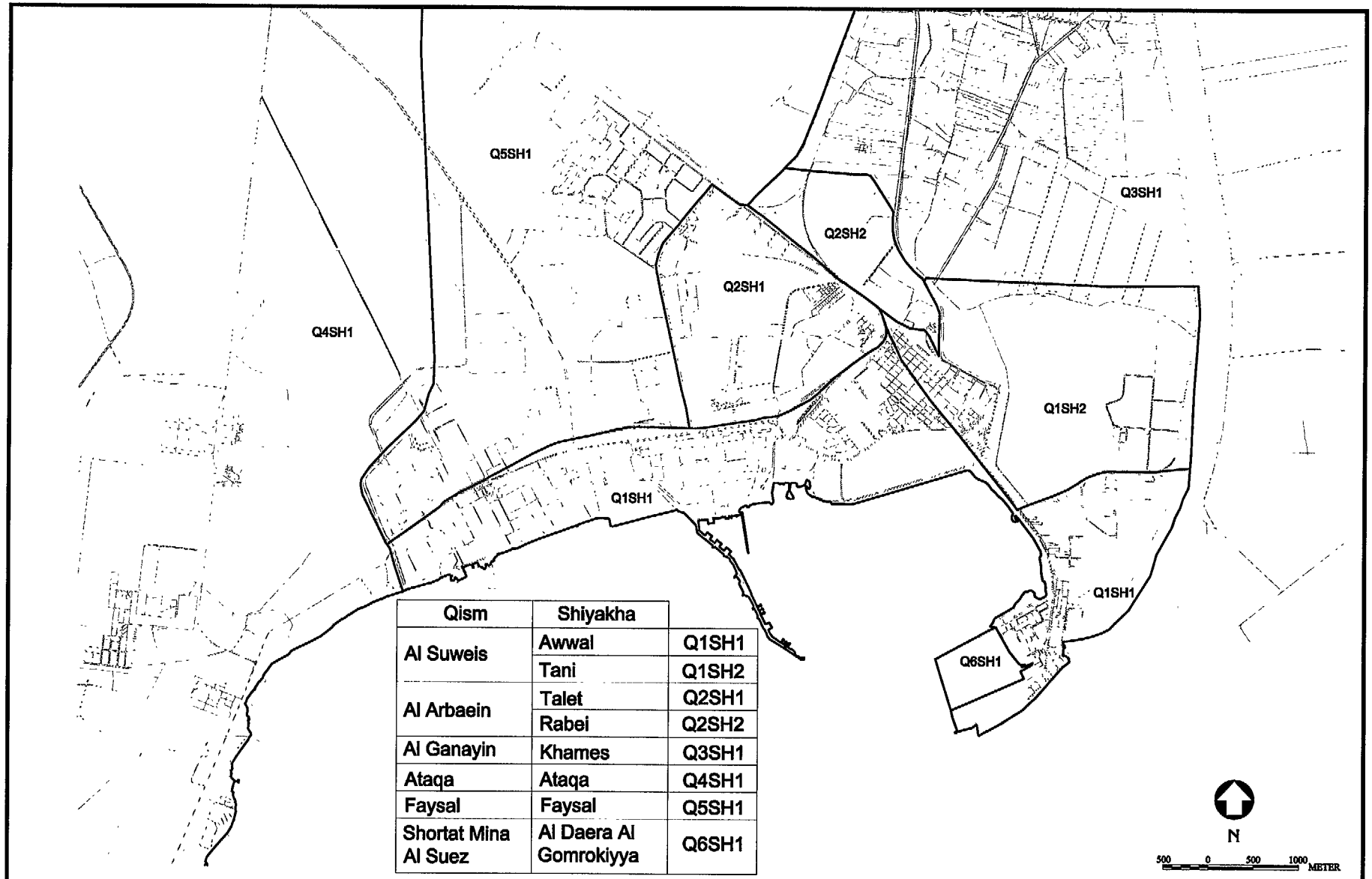
Suez is the southernmost point of entry to the Suez Canal and is the northernmost city on the Gulf of Suez. It is located 120 km to the east of Cairo and 75 km south-southeast of Ismailia.

Suez is bounded on the south by Suez Bay, on the east by the Suez Canal, and on the west by Gabal Ataqa (Ataqa Mountain), which rises up to 871 m above mean sea level outside the defined Study Area.



Study Area Boundary Sources:
GOPP / Suez Governorate;
2015 Land Use Study for
Suez City 1993.

ARAB REPUBLIC OF **EGYPT** SUEZ CANAL AUTHORITY NATIONAL ORGANIZATION FOR POTABLE WATER AND SANITARY DRAINAGE	INTERNATIONAL ELLIPSOIDE - HAYFORD 1909 U.T.M. PROJECTION - ZONE 36 STEREOPLOTTING BASED ON GEODETIC TRIANGULATION OF EGYPTIAN SURVEY AUTHORITY	**USAID** CANAL CITIES WATER AND WASTEWATER MASTER PLAN	BLACK & VEATCH INTERNATIONAL IN ASSOCIATION WITH MONTGOMERY WATSON SABBOUR ASSOCIATES	**SUEZ** **STUDY AREA BOUNDARY** DATE: AUGUST 1999 FIGURE: VI-2.1



Qism	Shiyakha	
Al Suweis	Awwal	Q1SH1
	Tani	Q1SH2
Al Arbaein	Talet	Q2SH1
	Rabei	Q2SH2
Al Ganayin	Khames	Q3SH1
Ataqa	Ataqa	Q4SH1
Faysal	Faysal	Q5SH1
Shortat Mina Al Suez	Al Daera Al Gomrokiyya	Q6SH1

ARAB REPUBLIC OF
EGYPT
SUEZ CANAL AUTHORITY
NATIONAL ORGANIZATION FOR
POTABLE WATER AND SANITARY DRAINAGE

USAID
CANAL CITIES
WATER AND WASTEWATER
MASTER PLAN

SUEZ
ADMINISTRATIVE BOUNDARIES

BLACK & VEATCH INTERNATIONAL
IN ASSOCIATION WITH
MONTGOMERY WATSON SABBOUR ASSOCIATES

DATE: AUGUST 1999 FIGURE: V2-2.2

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Physically, the Suez area is diverse, consisting of mountains, plains, coastline, desert, and fertile areas. Its main physical features are Gabal Ataqa, Suez Bay, and the Suez Canal itself. Soil in the Suez area is composed of rocks of the Pleistocene era (the plain) and of the Eocene era (Gabal Ataqa). Limestone predominates; however, there is a diversity of minerals, e.g., dolomite, basalt, clays, sands, and gravels. The sands and gravels typically contain chlorides and sulfates. The Nile, via the Ismailia Sweetwater Canal, is the only source of freshwater for the area.

The area north of Suez is best characterized as desert plain. As one progresses southwest, along the western shore of Suez Bay, this plain surrenders to the foothills and plateaus of Gabal Ataqa.

Wadi Risis, the major wadi within the study area, flows southeast into Suez Bay. South of Wadi Risis are Wadi Al Ghal, Wadi Al Abar, and Wadi Abu Saiyala, all of which flow from the foothills of Gabal Ataqa into Suez Bay.

The Gulf of Suez is a shallow water shelf of the northwestern part of the Red Sea. It averages 19 to 24 km in width and has an overall average depth of 56 m – from 20 to 30 m near Suez, to 70 to 80 m at its southernmost end.

2.2.2 Climate

Climate within the Study Area is characteristic of the northern Red Sea desert region of eastern Egypt. Studies of the local climate indicate a dry, hot, relatively rainless seasonal pattern. Sporadic, localized rain showers occur from late October to early December and again from late January through February. Rainfall through the remainder of the year is rare to non-existent. Mean annual rainfall in Suez is approximately 24 mm.

As shown in Table V2-2.1, Suez Climatic Data, air temperatures range from about 9°C to 36°C.

Table V2-2.1 Suez Climatic Data

	Maximum Temperature °C	Minimum Temperature °C	Percent Humidity	Total Rainfall, mm
Summer	36	21	56	0
Winter	24	9	62	24

Perhaps of more consequence than the seasonal variation in temperature is the wide diurnal-nocturnal fluctuation characteristic of desert climates. Daily fluctuations range from 8°C to 15°C, with the widest daily fluctuations occurring during the hot, dry summer months when cloud cover is sparse. These changes in temperature make a significant contribution to the formation of dew during early morning hours. The depositions often tend to be heaviest during the spring and fall, when the moisture content of the air (relative humidity) is high and the evaporative power of the atmosphere is low.

Prevailing winds are from the north and northwest. Monthly average wind speeds vary from 13 km/h in December to 21 km/h in May, and are typically higher during summer

months, from May to September. During the spring months, from February to April, wind direction is more uniform than at other times of the year. Average wind velocities are highest during the evening, reaching 23 km/h.

Relative humidity ranges from about 55 percent to 65 percent, with an annual mean of 59 percent. The overall monthly mean values indicate that humidity is slightly higher during the winter months and is also higher in early morning than in mid-afternoon. Diurnal variations are between 10 and 21 percent, with periods of widest fluctuation during June to September.

The rate of water evaporation is moderate, with the highest monthly average of 14 mm/d during June, and the lowest values during the winter months, November through February.

2.2.3 Geology, Geomorphology, Soils, and Seismicity

Most of the region surrounding Suez is composed of Eocene or younger sediments, with the exception of one small area of Cretaceous age material near Gabal Ataqa. Major topographic features are composed of Eocene limestone which forms the escarpments and dip-slopes. The escarpments of Gabal Ataqa are composed of hard crystalline limestone, which is chalky white when first exposed, but eventually weathers to a gray or brown color.

Oligocene deposits in the region consist of sands and gravel, usually loose or poorly cemented, and many basalt flows are found near Suez.

Extensive coarse sands from the Pleistocene era are present in and around Suez, filling the alluvial fans of smaller wadis and the sides of major wadis. The plain on which Suez lies consists of Pleistocene out-wash sands and gravel, randomly interbeded with alluvial clays.

Geomorphological processes in the Suez area have resulted in surface-deposited sediments, which can be grouped depending on their depositional environment into fluvial deposits, old marine deposits, and young marine deposits. The area north of the Cairo-Suez Road contains old, thin, piedmont deposits consisting mainly of dense quartz and limestone sands. Areas of younger piedmont material are found south of Cairo-Suez Road and near Wadi Risis.

The soils of the Suez area have morphological features common to arid regions. Soils have sandy or loamy sand texture and typically contain considerable amounts of gravel and coarse fragments. Sandstone, siltstone, and mudstone are usually encountered within the top 1 to 5 m of the soil and can occur as rock outcrops. Salic, gypsic, and natric horizons are also common.

Soil salinity is highest in areas where the water table is or has been near the soil surface. Generally, the carbonate content is very low in upper soil layers; however, in wadis, the carbonate content tends to be higher as a result of rainwater periodically washing limestone from the surrounding plateaus into the wadi beds. The water-holding capacity of the soil is low – about 35 percent under saturated conditions.

Suez is located about 225 km west of the Dead Sea shear zone where major earthquakes have occurred, some of which have produced perceptible shaking in Suez. In recent years, the

major energy content of such shaking has been at a low frequency, with little impact on the integrity of man-made structures. However, examination of historical records indicates that Suez is in a region of epicentral destructive or damaging events. A number of earthquakes have occurred on a northeast-to-southwest belt about 70 km north of Suez. The earthquakes appear to have been minor adjustments to stress, similar to those experienced in relatively stable parts of the world.

Earthquakes under the Red Sea are the probable cause of tidal waves that have occurred in Suez in the past. However, the tidal waves are very infrequent and have typically given at least half an hour's warning of their arrival in Suez.

2.2.4 Groundwater, Surface Water and Flood Hazard

Major sources of groundwater supply near Suez include deep artesian aquifers, unconsolidated deposits along the Sweetwater Canal, and shallow regional aquifers. Large quantities of groundwater may be available from deep sandstone strata near Suez which form part of a regional aquifer system. Groundwater in these deep artesian aquifers is typically high in mineral content. Limited supplies of groundwater at shallow depths are also available in the vicinity of Suez, but low annual precipitation limits the overall amount of groundwater recharge.

Highly saline groundwater underlies the Suez coastal area. Occasional lenses of less saline water can be found floating on the denser saline groundwater bodies in some areas, such as Shiyakha Faysal. Sources of the lower salinity water may include seepage from wastewater pipes, canals, streams, and irrigated plots.

The cause of high salinity in the coastal deposits may be seawater and the concentration of groundwater through evaporation.

The shallow water table and poor drainage near Suez have contributed to the salinity of the soil. Where capillary rise from the water table extends to the soil surface, evaporation of groundwater results in the formation of a dry salt crust. Where the water table is within 300 mm of the ground surface, soils are damp and spongy.

Surface waters in the project area are the Suez Canal and the Gulf of Suez. The relatively narrow width and shallow depth of the gulf limits exchange of water with the open part of the Red Sea. Waters in the northern part of the gulf are especially noted for their high salinity, slow currents, and distinct high and low tides. Because of constant evaporation at the water surface, the absence of rivers contributing freshwater to dilute gulf water, and the low rate of water exchange with the Red Sea, the Gulf of Suez water is among the saltiest in the world

Suez Bay is 13.2 km long (northwest-southeast axis) and 8.8 km wide (northeast-southwest axis). The mean sea level at Suez is 360 mm higher than at Port Said in March and April, and 23 mm lower than at Port Said in September. During ten months of the year, the net movement of water is north through the Suez Canal. During August and September, net movement is south through the Canal into Suez Bay.

Water samples collected in Suez Bay show a relative uniformity in temperature and salinity in the horizontal and vertical gradients. Wind drift, density mixing, and tide mixing contribute to the complete homogeneity of the waters in the bay and in the northernmost parts of the Gulf of Suez. In deeper parts of the northern gulf, tidal currents cause northward movement of less dense, warmer waters, and southward movement of more dense, colder waters.

Waves in the bay seldom exceed 0.6 m and the current is gentle. The tidal range at Suez is 0.9 m to 1.5 m at neap tide.

Like in Ismailia and Port Said, the freshwater system in Suez is supplied by the Ismailia Sweetwater Canal and its extensions southward and northward, and by subsequently developed irrigation channels and agricultural drains. The Ismailia Sweetwater Canal is the main source of freshwater in the Governorate. It brings Nile water to the Suez Canal Region, including the three main cities of Port Said, Ismailia, and Suez. The canal is 125 km long, has a total flow of 9.5 million m^3/day, and contains three main branches:

- Suez Branch: 90 km long, including 50 km within the Suez Governorate.
- Port Said Branch: 77 km long, including 45 km within the Port Said Governorate.
- El Manayef Branch: 24 km long, entirely within the Ismailia Governorate.

While flooding is infrequent, potential flood hazards do exist in Suez. The effects are varied and include possible erosion, deposition and inundation. Evidence of surface runoff in Suez includes scour and fills in channel beds, bank erosion, and gully development where flow has been concentrated, with signs of width and depth expansion. Boulders and large gravel in channel beds indicate some flows have had high intensities. Depth of flow is indicated in some locations by scour marks and mud veneers on channel banks, and the height of brush and rubbish accumulations. This evidence shows that depth of flow in the Suez area rarely exceeds 1 meter and only in the larger channels. The same evidence also indicates that the width of most flows rarely exceeds a few meters.

Wadi Risis, which serves as a drain for surface water from the entire area north and east of Gabal Ataqa, has the greatest potential for flooding in the area. Other potentially hazardous areas are along the larger channels of the piedmont plain and the younger alluvial fans with large mountain catchments.

2.2.5 Marine Biota, Terrestrial Biota, and Environmental Pollution

Approximately 138 fish species representing 63 families have been recorded in the Gulf of Suez. Of this number, 28 species are of significant economic importance.

In terms of invertebrate species, the number and diversity of organisms increase seaward, in the direction of the prevailing winds. Invertebrates found in shallow, muddy bottoms included eight species of sponges, two types of coelenterates, 13 polychaetes, 22 mollusks, 22 crustaceans, and 12 echinoderms.

Terrestrial vertebrate fauna found in the Suez area are limited in distribution and population, primarily by the harsh environmental conditions prevalent in the region. Altogether, 32 forms of amphibians and reptiles have been recorded in the Suez area.

A significant number of avian species inhabit the Suez area, either as year-round local residents or as transients in migration. Over 170 species have been sighted, most of them associated with the area bordering the Suez Canal or the coastline of the Bay and Gulf of Suez. Several species have been seriously reduced in numbers during the past 30 years and are now very rare. These include the white-tailed sea eagle (*Haliaetus Albicilla*), flamingo (*Phoenicopterus Ruber*), caspian tern (*Hydroprogne Caspia*), red-billed tropic bird (*Phaethon Indicus*), and gray heron (*Area Cinerea*). Many of these rare birds are not tolerant of human activities and have been indirectly eliminated from the fauna of Egypt.

Twenty-five species of mammals either inhabit or are periodically encountered within the Suez area. This number includes the giant shrew (*Crocidura Oliveri*), hedgehog (*Hemiechinus Auritus*), seven bat species, four gerbils, two sand rats, black and Norway rats, two jerboas (*Jaculus sp.*), Egyptian fox (*Vulpes vulpes*), sand fox (*Vulpes ruppellii*), and Egyptian mongoose (*Herpestes Ichneumon*). Other interesting mammals include the rare nubian dorcas gazelle (*Gazella Dorcas*) found in vegetated wadis and hills west and south of Suez.

Considering pollution of land, air, and water in Suez, it appears that marine oil spills and discharges into Suez Bay are the dominant threats, with oil refinery operations constituting a limited local hazard. Other sources of water pollution include relief wastewater outfalls that discharge untreated sewage to the Suez Bay and Suez Creek, wastewater treatment plant and industrial waste discharges, flotsam and waste material discharged from passing ships, polluted groundwater, and agricultural runoff. Air quality measurements indicate that sulfur dioxide and particulate matter are the pollutants of the greatest concern in Suez. The major sources of sulfur dioxide are the refineries on the coastline. However, their impact on urban areas is minimized because prevailing winds are from the north 70 percent of the time.

2.3 Socio-Economic Conditions

2.3.1 Historical Background

The opening of the Suez Canal in 1869 enabled the small fishing and trading port of Suez to develop into an important mixed cargo port with direct communications to Cairo and Ismailia. With the development of an oil terminal in the early 1950s, Suez became the focus for industrial growth. Today, Suez is recognized as an important seaport and center of heavy industry.

In 1966, Suez had a population of over 250,000 and was a primary port on the Red Sea. During the 1967-1973 hostilities, most of the inhabitants were evacuated. Shelling destroyed much of the built-up area, causing heavy damage to water and wastewater facilities. After

resettlement of Suez, which began in June 1974, the population increased from an estimated 8,000 to 194,000 at the time of the 1976 census, and to about 417,000 according to the 1996 census.

The evolution of development conditions in Suez may exert considerable influence on the City and area. If successfully exploited, these conditions can potentially be adapted to generate substantial economic growth and consequently important employment opportunities, which would increase both the population and the economic status of Suez. These conditions can be summarized as follows:

- The creation of Ain El-Sukhna new port is expected to add to the Suez area's maritime transport capacity and to attract industries associated with export markets in East Africa, Asia, and the Arab Gulf states.
- The number of the City's industrial establishments is expected to increase due to the availability of vacant developable sites within its four existing industrial zones and three future industrial zones south and southeast of Suez.
- Additional employment could be generated by the tourism development projects along the Gulf of Suez.

2.3.2 Socio-Economic Profile

Historic and current data on socioeconomic conditions and population statistics required to analyze present conditions and to anticipate future conditions to the year 2020 were obtained from several official sources, including:

- CAPMAS National Census of 1960, 1966, 1976, 1986 and 1996.
- Comparative surveys conducted in 1992, 1995 and 1996 by the Center of Information and Support to Decision Making, a research center affiliated with the Prime Minister Bureau.
- The local Information Center of Suez Governorate.

Additional information related to the urban environment was obtained through site reconnaissance and interviews with key officials in Suez.

Within the recent past, the Suez Governorate Center of Information and Support to Decision Making has compiled statistics on a variety of subjects. The following tables display some of this information, Table V2-2.2, Comparison of Types of Buildings Within Suez Qisms, Table V2-2.3, 1996 Suez Manpower Data and Table V2-2.4, Suez Unemployment Rates.

Table V2-2.2 Comparison of Types of Buildings Within Suez Qisms

Qism	Residential Housing	Commercial	Combined Housing and Commercial	Vacant	Other	Total No. of Buildings in Qism
Al Suèz	2,357	1,212	573	264	196	4,602
Al Arbaein	12,878	1,004	492	1,095	598	16,067
Atakka	1,153	319	3	111	24	1,610
Al Ganayin	8,823	437	14	263	405	9,942
Shortat Mina		20				20
Faysal	910	910	124	1,480	102	3,526
Total	26	3,882	1,206	3,213	1,325	35,747

Table V2-2.3 1996 Suez Manpower Data

Workforce Statistics	
Employed	117,462
Unemployed	1,584
Never Been Employed	12,279
Total Workforce	131,325

Suez Governorate Information Center with the Center of Information and Support to Decision Making: Prime Minister Bureau, November 1997.

Table V2-2.4 Suez Unemployment Rates

Unemployment Rate	
1992	8.53%
1995	15.26%
1996	10.56%

Suez Governorate Information Center with the Center of Information and Support to Decision Making: Prime Minister Bureau, November 1997.

Suez may not be considered a major tourist destination; however, the number of beds in hotels and resort establishments in the city has increased to more than 1,300 beds. Table V2-2.5, Suez Hotels and Resorts, shows a breakdown of tourist accommodations in Suez and Table V2-2.6, Suez Hotel Rooms and Tourist Nights, shows that between 1992-1996, there was a nearly 17 percent growth in the number of hotel rooms and a similar growth in the number of nights these rooms were occupied by tourists.

Table V2-2.5 Suez Hotels and Resorts

Type of Establishment	Number
3 to 5 Star Hotels	3
Other Hotels	2
Holiday Resorts	4
Chalets	48
Youth Hostels	1
Total Number of Beds	1,314

Suez Governorate Information Center with the Center of Information and Support to Decision Making: Prime Minister Bureau, 1997.

Table V2-2.6 Suez Hotel Rooms and Tourist Nights

	Number of Tourist Rooms	Number of Tourist Nights
1992	532	61,907
1995	645	75,056
1996	622	72,380

Suez Governorate Information Center with the Center of Information and Support to Decision Making: Prime Minister Bureau, 1997.

2.3.3 Urban Environment

Before the 1967 war, urbanization in Suez was confined primarily to the area along the north shore of Suez Bay. Since then, the City has gradually expanded from Qism Al Suez and Qism Al Arbaein to the northwest of town. Growth to the north and west has been restricted by agricultural land and by the Sweetwater Canal. The location of oil refineries has encouraged expansion to the west of the town, along the northern shore of the bay. Between 1979 and 1990, the Army vacated part of the land it controlled along the Suez Canal and north of the City. One large military base remains north of Qism Faysal, but this base is not considered a major constraint to logical city growth.

Suez is home to over 60 industrial establishments. Table V2-2.7, Suez Industrial Establishments, provides a categorical list of these establishments.

Table V2-2.7 Suez Industrial Establishments

Type of Industry	No. of Establishments
Chemical Industries	3
Construction Materials	9
Metallic Work	1
Engineering Industries	11
Wooden Products	6
Spinning and Weaving	2
Paper Industries	8
Food Processing Industries	18
Miscellaneous	3
Total	61

Suez Governorate Information Center with the Center of Information and Support to Decision Making: Prime Minister Bureau, November 1997.

Three types of structures are common in Suez: wood-framed buildings with mud or stone in-fill, load-bearing brick walls and wood floors are found in areas built before 1950s and in semi-rural parts of Al Ganayin; load-bearing brick walls with concrete floors have been constructed more recently; and concrete frame construction with brick or block in-fill is the current building technique of choice.

Informal sector housing has been gradually expanding in several settlements in the City. It is concentrated mainly in Qism Al Ganayin, on the fringes of the rural area, and southward along Ain El-Sukhna Road where desert land is affordable and available.

Suez can be subdivided into six areas, or Qisms, according to the quality, density scale, and type of development. The morphological patterns of the six most distinct neighborhoods in Suez are shown and compared in Figure V2-2.3, Suez Typical Building Densities.

2.3.3.1 Qism Al Suez

Qism Al Suez is composed of two distinct neighborhoods, Shiyakha Awwal and Shiyakha Tani.

Shiyakha Awwal, the original main industrial zone of Suez, consists of oil refineries, storage facilities, and confined housing sectors for the companies' employees. The industrial area is bordered by a railroad track used for oil transport. The ground along the track is considered to be contaminated and to be a constraint to urban development in the central part of the City. The rail line is planned for removal within three years.

Shiyakha Tani, northeast of the Gulf, consists of three smaller quarters: Al Ghareeb, New Suez, and Tal El Qalzam. Tal El Qalzam is the oldest inhabited part of Suez. All three neighborhoods were heavily damaged during the 1967 to 1973 hostilities and were rebuilt or rehabilitated in the early 1980s. Shiyakha Tani contains a number of government and educational facilities constructed next to post-1973 government housing.

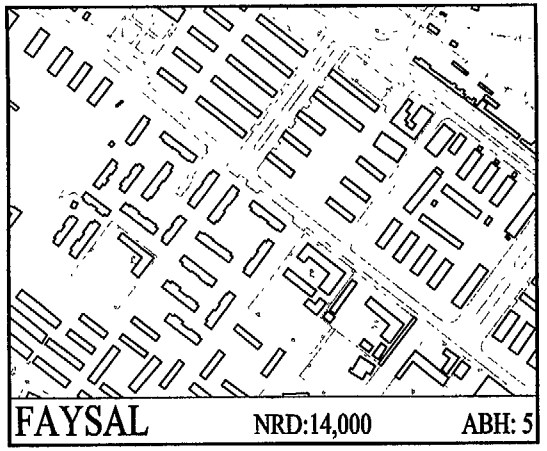
Two large landscaped green areas were recently created along the seafront at both ends of the industrial area in Shiyakha Awwal. These areas include recreational facilities, gardens, and lagoons. They are becoming the predominant green feature of Suez and help offset the town's industrial image.

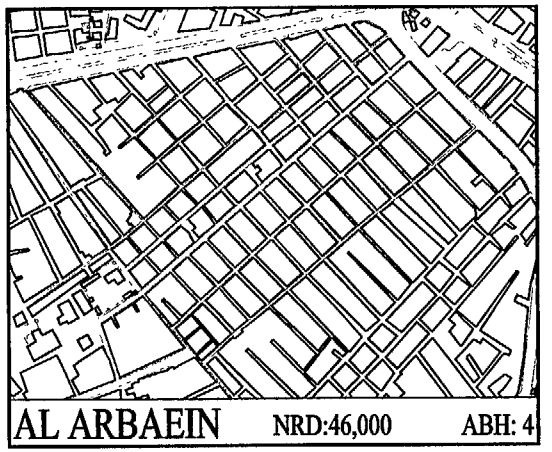
Port Tawfik is also part of Shiyakha Awwal. It is a man-made island, connected to the rest of Suez by a road and rail causeway. In addition to the port facilities, the administrative offices of the Suez Canal Authority, housing for its staff, and community facilities are located on the island.

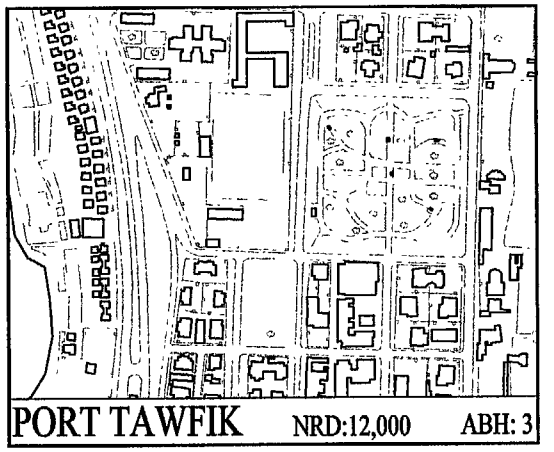
2.3.3.2 Qism Al Arbaein

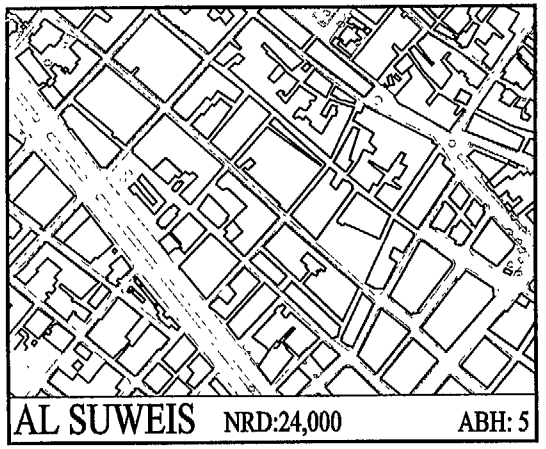
Al Arbaein is the old, traditional core of Suez. It consists of somewhat decayed buildings and is classified as a high-density area. Al Arbaein houses the poorest segment of the population. The Qism consists of two residential and mixed residential-commercial districts, Shiyakha Talet and Shiyakha Rabei, located on both sides of the railroad track along the Cairo-Suez Road. Approximately half of the Suez population resides in Al Arbaein.

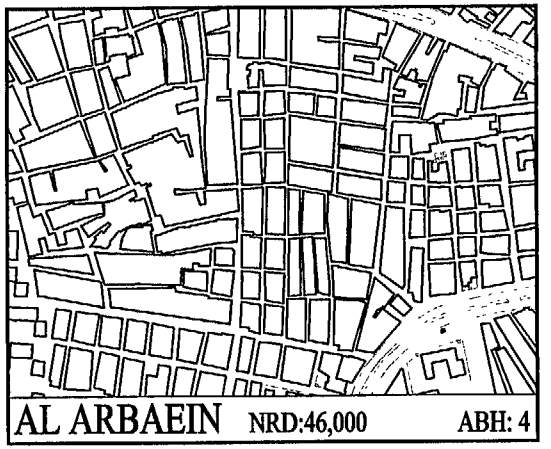
Shiyakha Talet is built on a small block grid pattern and consists mainly of four- and five-story buildings in reasonable to poor condition, occupied primarily by commercial or service oriented businesses on the ground floor and residential housing on the upper floors. Owing to the very compact nature of this Qism, there is little open space other than the roads and circulation areas surrounding the buildings. In general, all urban services need substantial improvement. Over the years, expansion has tended to take place vertically, with the replacement of old buildings or the addition of extra floors on concrete buildings.

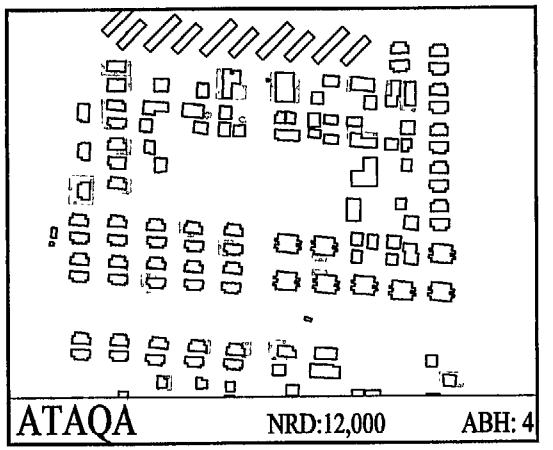












N

SCALE 1:5,000

500 0 500 1000 METER

NRD = NET RESIDENTIAL DENSITY (persons/km²)

ABH = AVERAGE BUILDINGS HEIGHT (no. of floors)

ARAB REPUBLIC OF EGYPT SUEZ CANAL AUTHORITY NATIONAL ORGANIZATION FOR POTABLE WATER AND SANITARY DRAINAGE	INTERNATIONAL ELLIPSOIDE - HAYFORD 1909 U.T.M. PROJECTION - ZONE 36 STEREOPLOTTING BASED ON GEODETIC TRIANGULATION OF EGYPTIAN SURVEY AUTHORITY	USAID CANAL CITIES WATER AND WASTEWATER MASTER PLAN	BLACK & VEATCH INTERNATIONAL IN ASSOCIATION WITH MONTGOMERY WATSON SABBOUR ASSOCIATES	SUEZ TYPICAL BUILDING DENSITIES DATE: AUGUST 1999 FIGURE: V2-2.3

Despite the development of new residential settlements in Faysal and Ataqa, Al Arbaein still accommodates most of the commercial and business activities of Suez. The Master Plan prepared in 1979 included a new City Center in the northwestern extension of Suez, but this new center has not been developed.

2.3.3.3 Qism Faysal

Qism Faysal is adjacent to the western and northern extension of Al Arbaein. It is expected to accommodate the largest share of the residential population increase up to the year 2020. The Qism has little commercial or service-oriented activity.

Development of the Qism began with the reopening of Suez in 1975 when a number of government housing developments were built west and northwest of the City Center. Among the housing developments were Herafien, Sabah City, and Faysal City along the Cairo-Suez Road, and employee housing near the oil refineries and the fertilizer factory in Ataqa. The more recent developments by private and public sectors west of Faysal and Al Sabah districts occupy the area south of the railway track. Buildings consist of four- to six- story apartment blocks. The typical occupancy rate is between 50 and 70 percent, despite the very high-density design.

2.3.3.4 Qism Al Ganayin

Qism Al Ganayin is located north of the built-up portion of Suez and borders on private agricultural land. As elsewhere, this agricultural land cannot be exploited for urban use.

The principal Shiyakha in the Qism is Shiyakha Khames, which is divided into two distinct quarters, an informal settlement near Shiyakha Rabei and an initially rural settlement north of Shiyakha Tani. In both settlements, the original rural housing has been gradually replaced with urban structures constructed of concrete and brick. Buildings in the Qism have an average height of three stories. Streets are narrow and winding.

2.3.3.5 Qism Ataqa

Qism Ataqa is the largest Qism in Suez. It occupies the southern extension of Faysal and is the planned site of future industrial development. A regional power plant and the new wastewater treatment plant are located in Qism Ataqa. Some worker housing is in Qism Ataqa and the qism is expected to accommodate a small share of the population increase expected by the year 2020.

2.3.3.6 Qism Shortat Al Mina Suez

Qism Shortat Al Mina Suez includes restricted port, shipyards, and customs facilities, and a portion of Port Tawfik. The area is used for docking facilities, Suez Canal Port Authority's offices, fuel storage, and shipyards.

2.3.3.7 Suez Industrial areas

Two future large industrial zones west of Ain El-Sukhna and the expansion of the existing industrial zone in Ataqa are planned for the year 2005. These projects would add substantially to the four existing industrial zones in the vicinity of Suez.

- Two light industrial zones along the Ismailia-Suez Road. The first, 169 ha, is about 20 percent vacant and 20 percent occupied by the Army. The second, 80 ha, is approximately 15 percent vacant.
- The industrial zone along Nasser Road, south of Qism Faysal and Al Sabbah residential districts. Currently, only 4.5 ha of the 5.5 ha zone are in industrial use. The remaining area is being gradually occupied by informal housing.
- The 878 ha industrial zone in Qism Ataqa is the main concentration of industries in Suez. Approximately 130 ha of this zone is vacant land.

2.4 Current Land Use

The methodology used in the land use plans for existing conditions in each of the three cities is summarized below.

2.4.1 Collecting and Interpreting Relevant Cartographic Data

More than 120 maps at different scales and coordinate systems showing land use information were compiled. The maps provide detailed data relative to the following:

- Built-up areas and building utilization.
- Administrative district divisions linked to the corresponding population data for each district.
- Topographical features.
- Soil and land suitability.
- Land management organization.
- Agricultural use.
- Built-out areas.

The maps were prepared or published by several institutions and agencies, including the following:

- Central Agency for Public Mobilization and Statistics.
- Centre Français d'Etudes Demographiques et Juridiques.
- Egyptian Geographical Society.
- Egyptian Survey Authority.
- General Organization of Physical Planning.
- Information Centers of Port Said, Ismailia, and Suez Governorates.
- Military Survey Authority.
- Ministry of Agriculture.

- Military Aerial Photographic Authority.
- National Organization for Potable Water and Sanitary Drainage.
- Several national and international consulting firms.

2.4.2 Selection of Standard Mapping System

Based on an evaluation of the collected maps, the mapping system used by CAPMAS was selected as the most appropriate for CCMP. Particular reasons for this selection include the following:

- It is a comprehensive system that includes all the layers of cartographic data required for CCMP work.
- It covers all the urban areas of the three Canal Cities.
- It is the most up-to-date system identified.
- It is the only map available in electronic digital format.
- It incorporates the population data of the most recent CAPMAS census.

Following this evaluation, the CCMP project purchased a license from CAPMAS to use a set of 52 electronic maps.

2.4.3 Primary Land Use Categorization

Cartographic data from the compiled maps were interpreted to determine the land use of buildings and open areas. Buildings and areas used for similar activities were grouped into polygons which were color-coded according to use, with each color representing a specific land use or facility. This categorization approach was adopted (a) to facilitate water and wastewater master planning and system modeling and (b) to interpret current and projected urban environment conditions. The aim of interpreting urban environments is to allow the incorporation of general land use recommendations pertaining to sustainable planning approaches for the year 2020 into the CCMP Report.

2.4.4 Site Reconnaissance: Validating Primary Land Use Categorization

The findings of the primary land use categorization were confirmed through six site reconnaissance visits to each of the three cities. The site reconnaissance examined specific urban characteristics to identify the following:

- Locations of unserved areas.
- Overall major urban rehabilitation requirements and sanitary conditions.
- Urban morphology and housing typologies.
- Future development trends in neighborhoods.
- Environmental constraints.

The most recent maps available reflected 1994 land use conditions. In order to portray the 1998 land use conditions, additional site inspections were carried out, particularly in selected

fringe areas. The inspection findings, as well as modifications to the land use registered by CAPMAS up to October 1998, were included in the land use plan of existing conditions.

Lists of ongoing and future housing and industrial development projects were compiled with the help of the Housing Department of each Governorate. The size, capacity, location, and progress status of each project were interpreted and then incorporated into the land use plan of existing conditions and, whenever applicable, into the 2020 land use plan.

2.4.5 Calculating Net Residential Densities

Net residential densities at existing conditions were calculated according to the following steps:

1. Administrative boundaries of shiyakhas were demarcated on the land use plan of existing conditions.
2. Residential areas within each shiyakha were marked to form residential polygons.
3. The area of each residential polygon was computed and calculated.
4. The Net Residential Density of each residential polygon was calculated by dividing the population of the respective shiyakha by the area of the polygon. Net Residential Density is a value that indicates the number of residents per square kilometer.
5. Residential polygons with net residential densities of the same or similar nature were combined into larger polygons.
6. Residential polygons were classified as having Very Low, Low, Moderate, High, or Very High Net Residential Densities.

2.4.6 Land Use Categories

Land use categories, taking into account current and future land use and population densities, were applied to the land use map of existing conditions as shown in Figure V2-2.4, Suez Existing Land Uses. The map defines areas, major facilities, and boundaries for both existing and future conditions. Table V2-2.8, Land Use Categories, describes the areas identified in the Land Use Legend on these figures and, where applicable, defines the net residential densities for that category. The same land use categories are applied to the land use maps for future conditions.

2.5 Current and Future Populations

2.5.1 Current Population

Preliminary results of the CAPMAS 1996 census indicated the population of Suez Governorate, including people living in Suez City and in rural areas of Qism Al-Ganayin, had reached 417,610. Following a cartographic analysis and a density analysis of Al-Ganayin urban and rural districts it was estimated that this figure may be two to three percent higher. However, the CAPMAS figure was used as the basis for CMP population projections up to the year 2020.

At the time this report was prepared, the final results of the CAPMAS 1996 census had not been published. Yet, because the preliminary results include socioeconomic data relevant to CCMP work, and assuming that the difference between the preliminary and final results would be minor, the adjusted preliminary figures were used in CCMP review of the current socioeconomic conditions in Suez.

Table V2-2.8 Land Use Categories

Land Use Category	Description
Residential – Very Low Density	Predominantly residential area with population density of less than 20,000 people/km^2.
Residential – Low Density	Predominantly residential area with population density of 20,000 to 30,000 people/ km^2.
Residential – Medium Density	Predominantly residential area with population density of 30,000 to 45,000 people/ km^2.
Residential – High Density	Predominantly residential area with population density of 45,000 to 65,000 people/ km^2.
Residential – Very High Density	Predominantly residential area with population density greater than 65,000 people/ km^2.
Commercial, Office and Governmental	Area mostly occupied by government administration and office buildings with some residential use. It may also include services and commercial uses and seaport facilities such as docks and Port Authority's administration buildings.
Irrigated Parks and Open Spaces	High water use irrigated parks, large landscaped gardens, and greenhouses. It may also include lower water use irrigated areas, such as outdoor sports facilities, large school playgrounds, and large parking lots.
Industrial – Low Water Use	Low water use industrial activities such as auto workshops, warehouses, and oil companies including on-dock seafront areas with fuel storage reservoirs and related equipment.
Industrial – Moderate Water Use	Moderate water use industries, within or outside designated Industrial Zones.
Unique Water Use	Exceptionally high water use industries such as refineries and chemical plants.
Future Development	Land or water surface (to be landfilled) allocated for future development.
Beach Setback	Undeveloped seafront areas and beaches.
Military Camps	Land designated for use by military or security forces. These are controlled by the Armed Forces and may be independently supplied with water and wastewater services.
Commercial Tourism	Areas occupied by hotels, resorts, or camping sites.
Water Bodies	Sea, Suez Canal, and major irrigation and drainage canals.
Large Educational Facilities	Group of buildings occupied by large educational facilities, such as universities, schools, or vocational training centers.
Fish Farms and Salt Ponds	Aquaculture or salt production.
Agricultural Land.	Agriculture land with little or no residential
Cemetery	Cemetery and related facilities

Industrial Road
Cairo - Suez Road
Suez - Ismailia Road
Suez Sweetwater Canal
WTP
Gulf of Suez
Port Tawfik
Suez Canal
Sinai
WWTP
LEGEND
Study Area Boundary
WWTP- Wastewater Treatment Plant
WTP- Water Treatment Plant
SUEZ EXISTING LAND USE
Agricultural Land
Beach Setback
Cemetery
Commercial - Office & Gov't
Commercial - Tourism
Educational Facilities
Future Development
Industrial - Low Water Use
Irrigated Parks & Open Spaces
Military Camps
Residential - High Density
Residential - Low Density
Residential - Very Low Density
NOTE: Land use categories shown represent average densities derived from GOPP land use maps
N
ARAB REPUBLIC OF
EGYPT
USAID
SUEZ EXISTING LAND USE
MONTGOMERY WATSON
SABBOUR ASSOCIATES
DATE AUGUST 1999
FIGURE V2-2.4

2.5.2 Projection Methodology

The methodology of projecting the number of inhabitants from 1996 to 2020 and the potential distribution of population on future development land is summarized in the following steps:

1. Compile historic population data by qism and shiyakha according to CAPMAS National Census data for 1960, 1966, 1976, 1986, and 1996, and according to the Govenorate surveys for 1992, 1995, and 1996. These data are presented in Figures V2-2.5, CAPMAS Historical Population Data, and V2-2.6, Suez Govenorate Historical Population Data.
2. Project the population of each qism in five-year stages, starting with 1996 and through the years 2000, 2005, 2010, 2015, and 2020. Use the following growth rates in three projection scenarios:
3. Population growth rate from 1986 to 1996 according to CAPMAS Census.
4. Average growth rate for the years 1992, 1995, and 1996 according to the surveys conducted by the Govenorate.
5. 1996 growth rate assumed by the Govenorate.
6. Compare the results of the three scenarios illustrated in Figures V2-2.7, V2-2.8, and V2-2.9, with the population projections of approved planning studies prepared by official agencies such as the Govenorate, NOPWASD, or GOPP, illustrated in Figure V2-2.10.
7. Select the most likely scenario. Ideally this would be the closest to the approved projection described above.

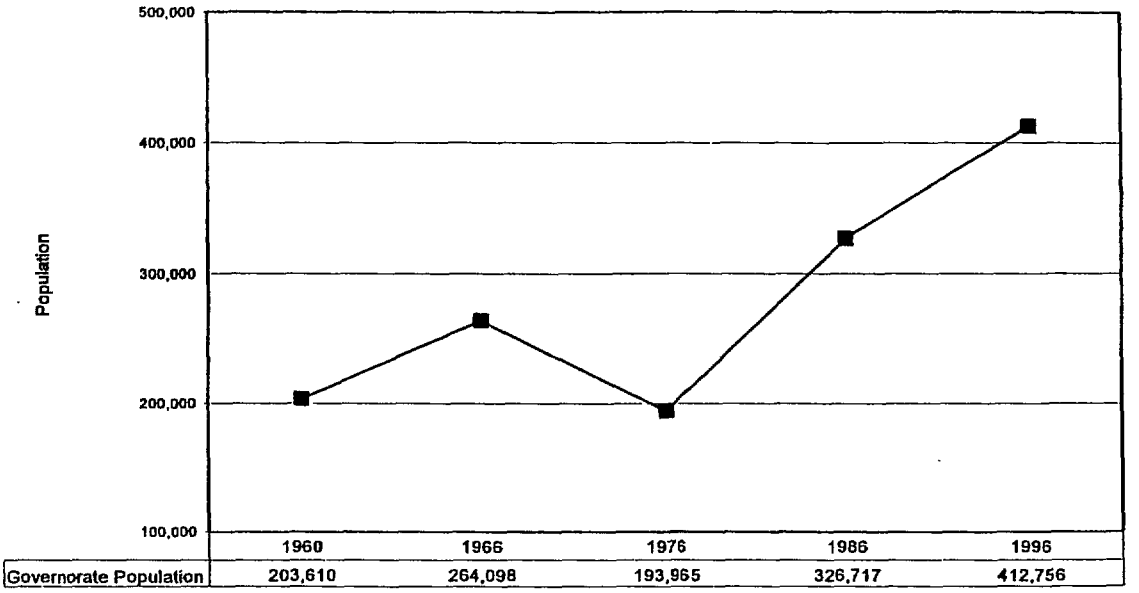
The selected "most likely scenario" is the projection based on CAPMAS population growth rate from 1986 to 1996. This is the closest to GOPP projection in the official report titled "Study of the Urban Boundaries of Suez" prepared in September 1992.

Figure V2-2.11, CCMP Population Projection, presents line-chart graphical depictions of population projections based on the three scenarios described in Item 2 above.

2.5.3 Reconciliation of Projected Employment Figures

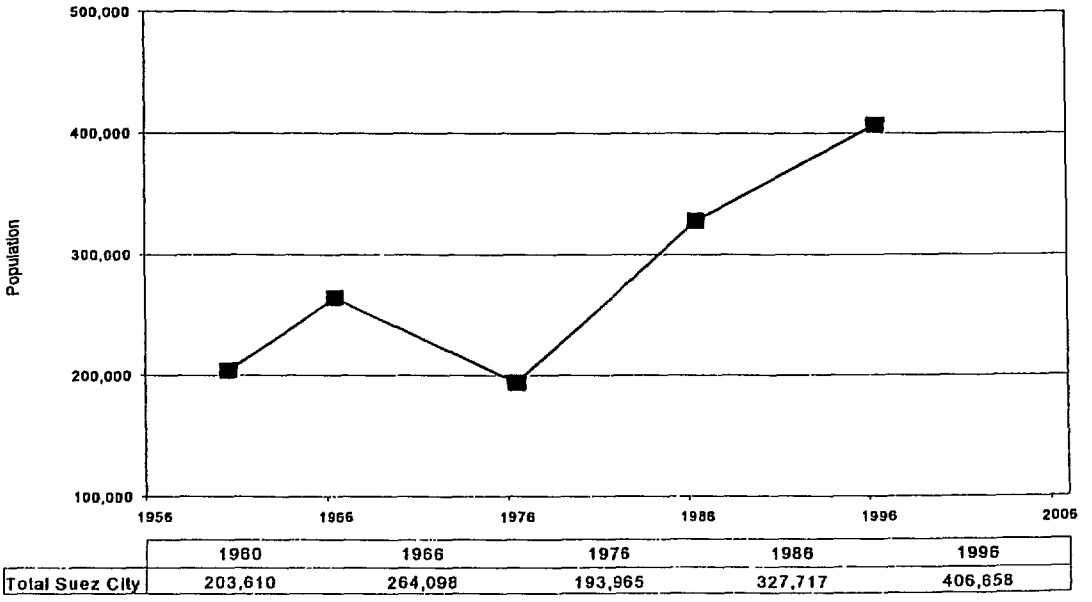
The Third Region Planning Department and GOPP have conducted comprehensive surveys to analyze the future economic development prospects of Suez and to project the number of new jobs that would be created in the City to the year 2015. The studies have assessed future employment opportunities in the areas of fisheries, industry, mining, services, port and transport, tourism and commercial activities. The results were first published by GOPP in 1995 in a report titled *Suez City Master Plan for the year 2015 – Part 2: Sectors Studies*. The GOPP report projected that in 2015, the total workforce in the City of Suez would reach 188,625, excluding the rural areas of the Govenorate.

Figure V2-2.5 CAPMAS Historical Population



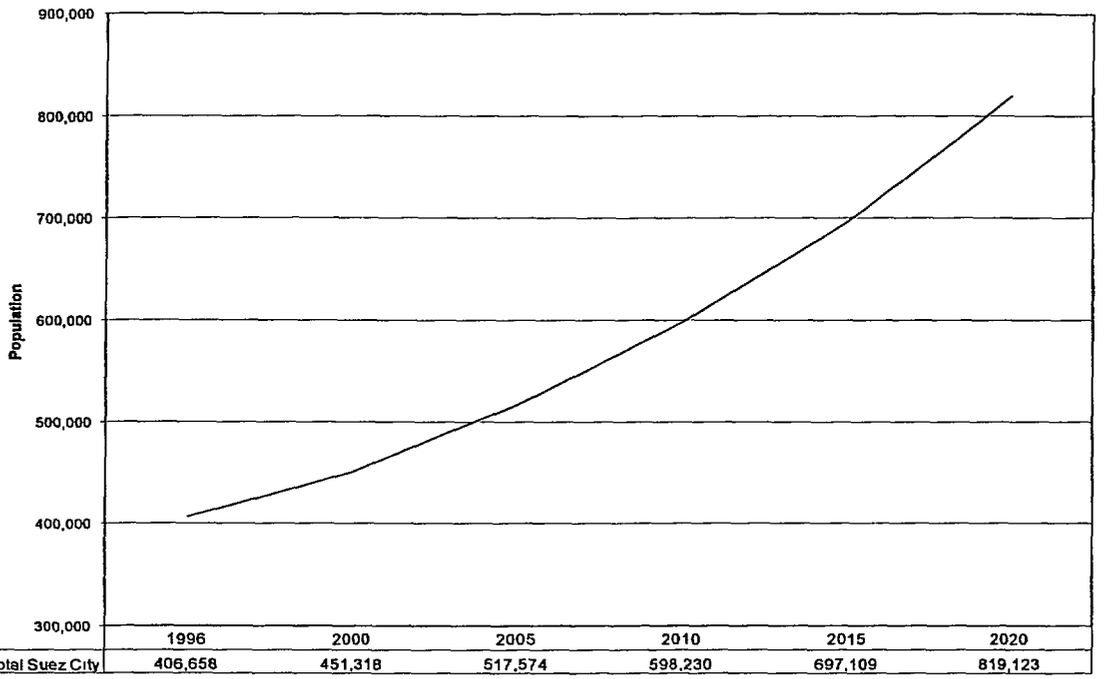
Source: 1960 – "Statistical Year Book", CAPMAS, June 1964; 1966 – "Statistical Year Book", CAPMAS, June 1970; 1976 "– "1976 General Census Final Results: Suez Govenorate," CAPMAS, September 1978; 1986 – "1986 Complete Population Census: Suez Govenorate," CAPMAS, June 1988; 1996 – "1996 Census Report for Suez Govenorate," CAPMAS, July 1997

Figure V2-2.6 Suez Govenorate Historical Population



Source: "Suez Govenorate Statistical Yearbook," Govenorate Information Center, November 1997. No data available for Shortat Mina Al Suez.

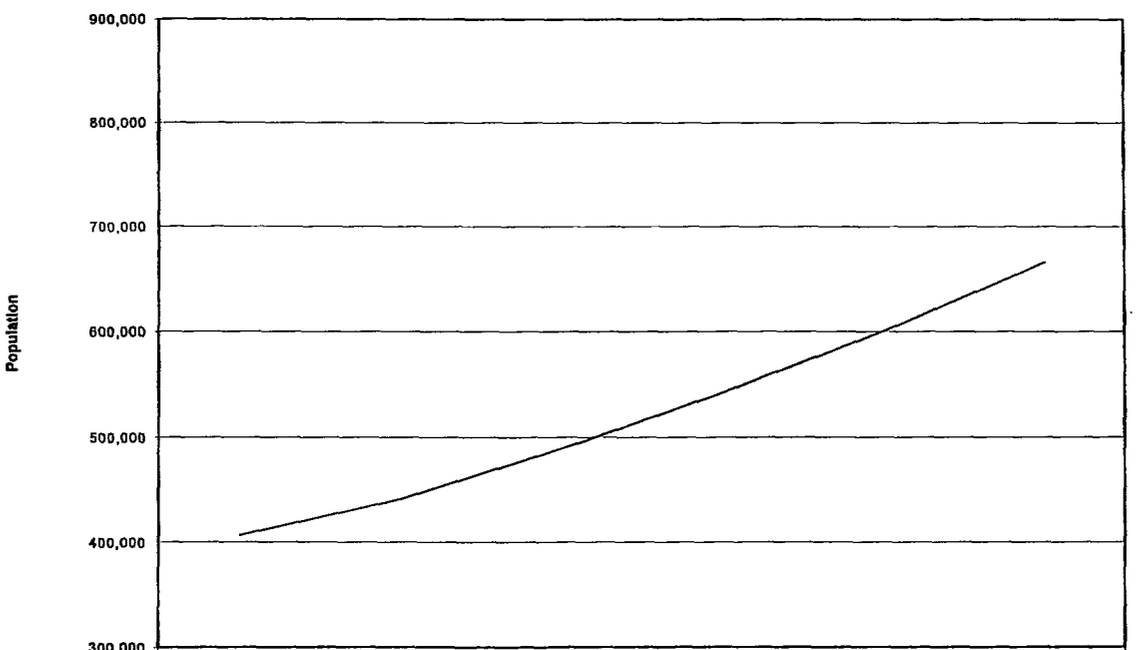
Figure V2-2.7 Population Projection, CAPMAS Average Growth Rate '86 and '96



	1996	2000	2005	2010	2015	2020
Total Suez City	406,658	451,318	517,574	598,230	697,109	819,123

Source: "1986 Complete Population Census: Suez Govenorate" CAPMAS, June 1988 and "Finalized Results of 1996 Census Report for Suez Govenorate", CAPMAS, July 1997

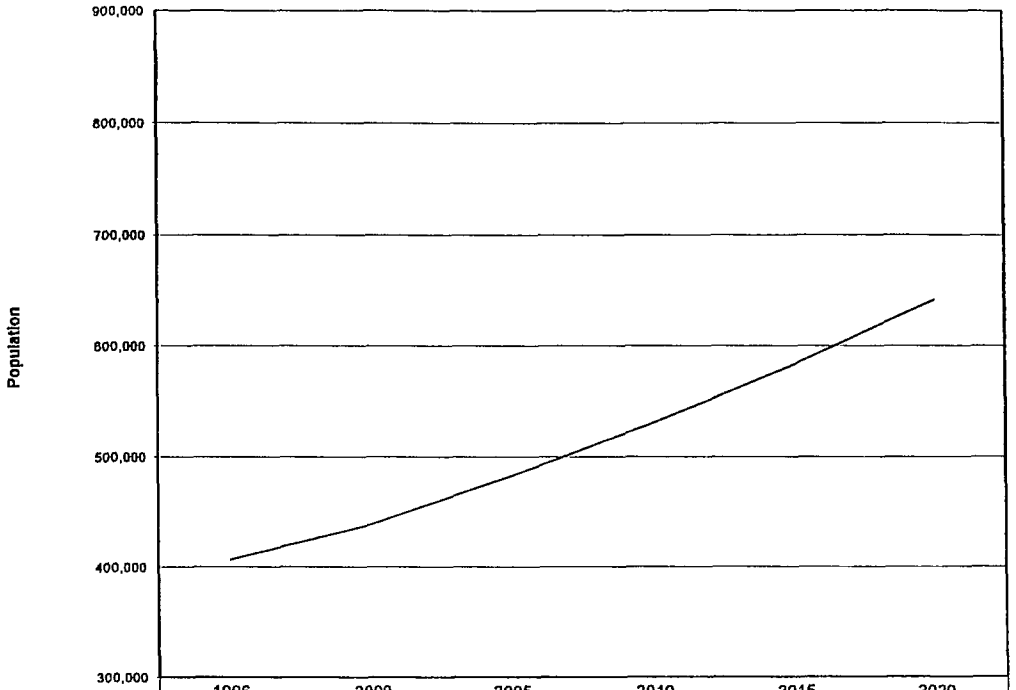
Figure V2-2.8 Population Projection with Suez '96 Annual Growth Rate



	1996	2000	2005	2010	2015	2020
Total Suez City	406,658	441,476	489,245	542,215	600,957	666,104

Source: CAPMAS "1996 Census Preliminary Report for Suez Govenorate"; 1996 Growth Rate – "Suez Govenorate Year Book," Suez Govenorate Information Center, November 1997.

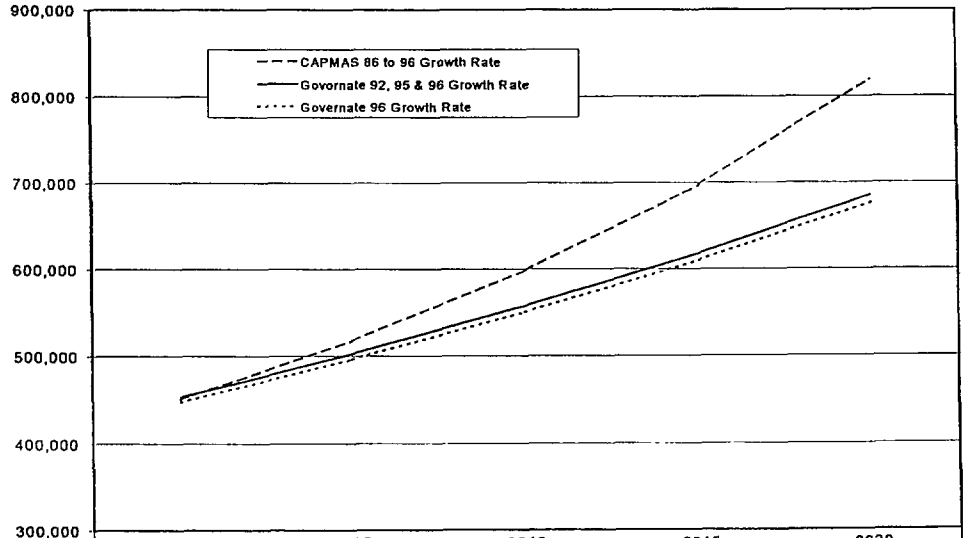
Figure V2-2.9 Population Projection with Suez 92, 95 & 96 Annual Growth Rate



	1996	2000	2005	2010	2015	2020
Total Suez City	406,658	438,662	482,281	530,296	583,159	641,367

Source: 1996 Base – "Finalized Results of 1996 Census Report for Suez Govenorate," CAPMAS, July 1997; Average Growth Rates – "Suez Govenorate Year Book," Govenorate Information Center, Nov. 1997.

Figure V2-2.10 Population Projections from Previous Studies



	2000	2005	2010	2015	2020
CAPMAS 86 to 96 Growth Rate	451,318	517,574	598,230	697,109	819,123
Govornate 92, 95 & 96 Growth Rate	453,508	502,750	557,338	617,854	684,941
Governate 96 Growth Rate	448,098	496,596	550,354	609,979	676,105

Source: GOPP – "Urban Boundaries of Suez City," Ministry of State for New Urban Communities, December 1995; Chemonics Consultants – "Suez Sewer Evaluation Report," May 1995; NOPWASD – "Updating the National Plan for Potable Water and Wastewater, Suez Govenorate," 1996.

This figure corresponds with the results of the CCMP population projection, taking into account the following considerations:

- In 1992, the average percentage of the Egyptian workforce, compared to the whole population, equaled approximately 30 percent.
- Taking into account technological progress and mechanization in Egypt, it is predicted that by the year 2015, the average percentage of the workforce compared to the whole population will have gradually increased to 33 percent.

This suggests that the total core population of Suez in 2015 would be about 571,621. Adding to this the projected year 2015 population of the Al Ganayin urban area of 44,626, the total population of the Study Area will be approximately 616,247. The GOPP total is compatible with CCMP figure for the year 2015, which is approximately 633,346, or about 616,000, plus additional available residential areas for about 17,000 people.

2.5.4 Reconciliation of Future Development Plans

The urban growth of Suez follows a Master Plan prepared in 1995 by the Third Region Planning Department and GOPP, with the assistance of an independent consultant team.

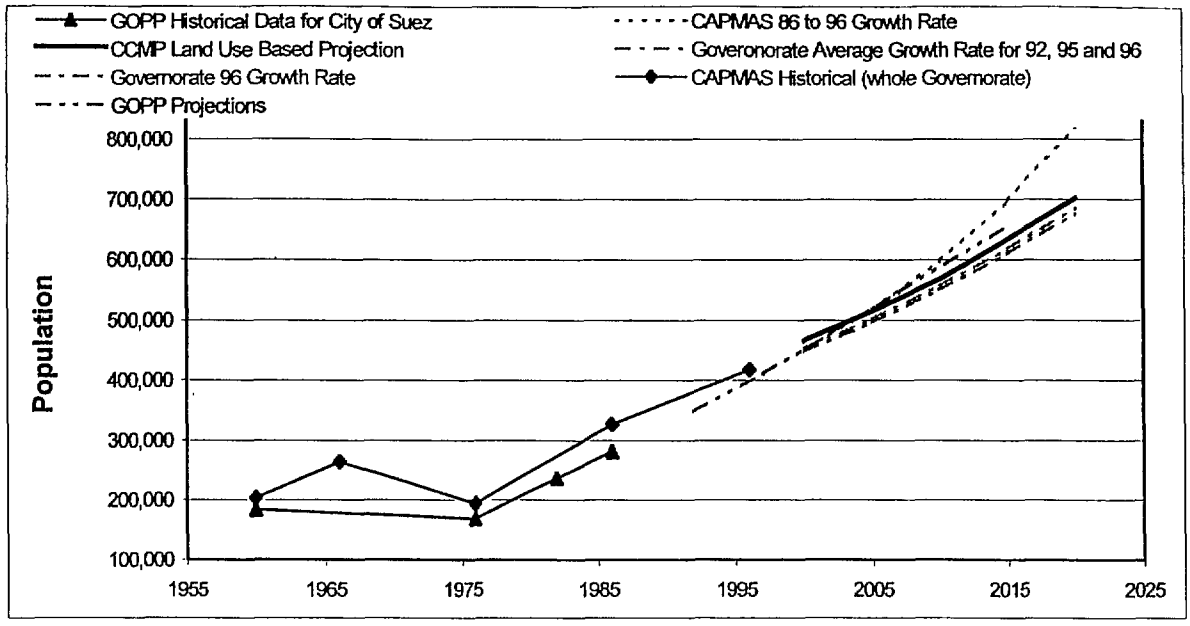
The planning period of the Suez City 1995 Master Plan extends to the year 2015. The Plan suggests that by the year 2015, the population of Suez City, excluding the population of Qism Al Ganayin, would reach 656,000, compared to 600,957 by 2015 and 666,104 by 2020 as projected by CCMP. The Plan does not give any specific recommendations concerning development of the existing urban areas of Suez City.

The current growth of Suez City follows the overall land use recommendations of the Suez City 1995 Master Plan concerning new growth urban areas. The growth areas, aside from the existing urban areas, are identified graphically on the map titled *Urban Limits of Suez City: The Approbation of Suez Build-out Area*, issued in January 1994 by the Third Region Planning Department of GOPP. This is the same document that identifies the Study Area Boundary as discussed in Section 2.1.1.

Current development status was evaluated for the overall feasibility of the land use categorizations allocated and assigned for future development by the Suez City 1995 Master Plan. Subdivisions on which construction work is progressing, as well as subdivisions that are unequivocally allocated for future development, were integrated into the CCMP future Land Use Plans. Including these areas, the land currently being developed or allocated for future residential use would accommodate all the 666,104 people projected by CCMP for the year 2020, as well as an additional 35,330 people.

Recommendations to exclude land assigned for urban growth in the Suez City 1995 Master Plan, but not yet allocated for residential use, are discussed further in Section 2.6.

Figure V2-2.11 CCMP Population Projection



2.6 Land Use Projections

2.6.1 Variations to Residential Area Population Distribution

Through analysis of overall existing urban conditions, urban development trends, current net residential densities, and experience in similar municipal areas, projections were made to determine the following:

- Future Net Residential Densities of existing residential areas.
- Future Net Residential Densities of future development areas.
- Ultimate rate of housing occupancy, or the highest Net Residential Density, in future development areas.

The future land use plan presents the land use and residential densities in year 2020 based on low housing occupancy rates. The low occupancy housing rate methodology assumes that new housing developments would have occupancy rates equivalent to 70 percent of their maximum capacity. Ultimate condition assumes new housing developments would have a maximum occupancy rate equivalent to 100 percent of their capacity.

Ultimate conditions in the study area will occur after 2020 (or before, if there is a variation to the projected population due to unforeseen factors such as gain in employment rates or change in the prevailing rate of housing occupancy).

The low occupancy rate rationale for new housing developments reflects the following considerations:

- Low housing occupancy rate is generated by widespread real estate speculation. Speculators purchase apartments or individual residences and keep them vacant, assuming their market value will increase. Some may refrain from renting them to

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avoid leasing regulations that give near-ownership rights to the tenants. Others would buy apartments or houses for their young children and keep them unused for many years until the beneficiary son or daughter marries and becomes the occupant.

- Low housing occupancy rate reflects high market demand for affordable housing. In other terms, it reflects an excess supply of unaffordable housing produced by developers in both private and public sectors. They cater mainly to high revenue clientele in the formal housing sector. The high sale price of the residential units remains out of reach for the majority of low-income Egyptians. Therefore, the newly built residential units may remain vacant or unfinished for long periods before being sold.
- Low housing occupancy rate is encouraged by the low property taxes imposed on housing in Egypt.

Working with Governorate officials, an evaluation was conducted according to the following steps:

1. Review and make recommendations regarding approved urban and economic development plans undertaken by central and local governmental authorities.
2. Select the most appropriate location and calculate the land area needed to accommodate additional population until the year 2020.
3. Distribute the additional population projected for the year 2020 among existing urban areas and selected future development land.
4. Stage population increases in five-year increments (2000, 2005, 2010, and 2020) as required.

Figure V2-2.12, Projected Population by Qism presents in bar graph form the projected population by Qism. Figure V2-2.13, Suez 2020 Land Use, presents the projected land use in the year 2020, and Figure V2-2.14, Suez Ultimate Land Use, presents the land use for ultimate conditions.

The CCMP land use is based on these projections and should be reviewed periodically for any changes in the projections, staging, or distribution.

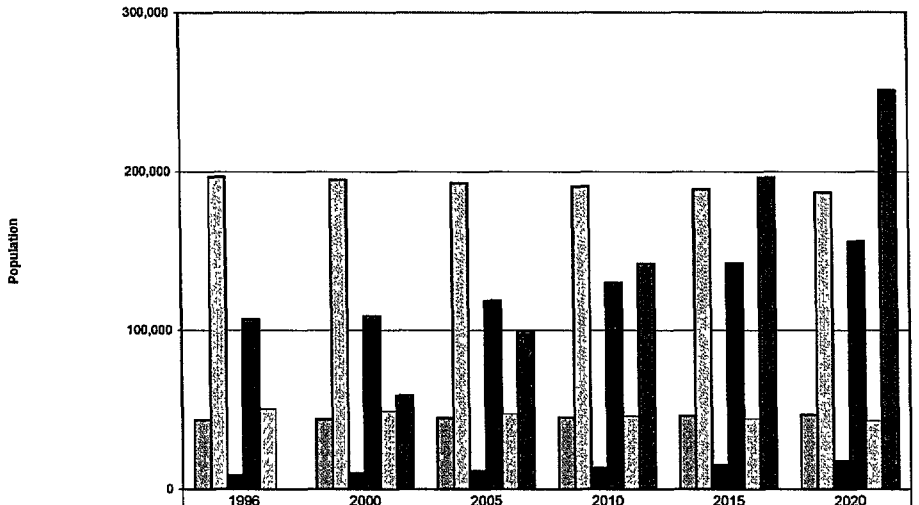
2.6.2 Variations to Other Land Use Area

Planning for all other land use categories is assumed to remain approximately the same as at present or to follow the current growth and development trends.

2.6.3 Development of Water and Wastewater Planning

With the creation of land use areas for existing conditions, and the projections and staging of population growth, future land use areas could be developed to coincide with the projected development. This information was entered into computer databases developed for electronic mapping of the study area.

Figure V2-2.12 Population by Qism



	1996	2000	2005	2010	2015	2020
Al Suweis	43,590	44,124	44,807	45,511	46,234	46,977
Al Arbaein	196,770	194,997	192,847	190,767	188,756	186,811
Ataqa	8,875	9,962	11,509	13,297	15,363	17,750
Faysal	106,755	108,904	118,723	129,739	142,098	155,964
Al Ganayin	50,666	49,330	47,709	46,142	44,626	43,160
Future Development		59,057	99,442	141,934	196,268	250,772

MapInfo, a Geographic Information System (GIS) software program, was selected for this work because it can accommodate multiple layers of information on one base map. Utilizing GIS, water and wastewater planning can be developed for the CCMP project and added to the same database of information.

2.6.4 Proposed Modifications to Development Plans

Previous master plans or land use plans have allocated more land than needed to meet the anticipated population. As noted in Section 2.5, most of the subdivisions programmed in the Governorate's expansion scheme have been integrated into CCMP future land use plans. Some subdivisions have not been incorporated into CCMP plans and they are identified in Table V2-2.9, Suez Subdivisions Recommended for Relocation. Although these proposed changes have little or no impact on water and wastewater capacity needs they should be evaluated to preserve and foster green areas, agricultural areas and recreational areas.

Table V2-2.9 Suez Subdivisions Recommended for Relocation

District	Sub-divisions	Location Proposed by Suez City Master Plan	Recommended Reallocation or Use
1	1, 2 and 3	Along the Suez Canal	Cultivated area
1	4	Along the Suez Canal	Recreational green area
1	5 and 6	East of Suez along the Suez Canal	Low density development after 2020
6	1	Eastern part of subdivision 1, Qism Faysal	Recreational green area
7	5	Western part of subdivision 5, Qism Faysal	Recreational green area

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Industrial Road
Cairo - Suez Road
Suez - Ismailia Road
Suez Sweetwater Canal
WTP
Gulf of Suez
Port Tawfik
Suez Canal
Sinai
WWTP
LEGEND
Study Area Boundary
WWTP- Wastewater Treatment Plant
WTP- Water Treatment Plant
SUEZ 2020 LAND USE
Agricultural Land
Beach Setback
Cemetery
Commercial - Office & Gov't
Commercial - Tourism
Educational Facilities
Future Development
Industrial - Low Water Use
Industrial - Moderate Water Use
Irrigated Parks & Open Spaces
Military Camps
Residential - High Density
Residential - Low Density
Residential - Very Low Density
NOTE Land use categories shown represent average densities derived from GOPP land use maps
N
ARAB REPUBLIC OF
EGYPT
USAID
SUEZ 2020 LAND USE
MONTGOMERY WATSON
SANDER OR ASSOCIATES
DATE: AUGUST 1999
FIGURE. V2-2 13

LEGEND

Study Area Boundary

WWTP- Wastewater Treatment Plant

WTP- Water Treatment Plant

SUEZ ULTIMATE LAND USE

- Agricultural Land
- Beach Setback
- Cemetery
- Commercial - Office & Gov't
- Commercial - Tourism
- Educational Facilities
- Industrial - Low Water Use
- Industrial - Moderate Water Use
- Irrigated Parks & Open Spaces
- Military Camps
- Residential - High Density
- Residential - Low Density
- Residential - Very Low Density

NOTE: Land use categories shown represent average densities derived from GOPP land use maps

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ARAB REPUBLIC OF
EGYPT

USAID

SUEZ ULTIMATE LAND USE

DATE: AUGUST 1999 FIGURE V2-2.14

2.7 General Recommendations

The following recommendations are suggestions to improve and, whenever judge feasible, to modify the provisions of the Govenorate development plans:

1. The Suez land use plan used for this master plan should be used by Govenorate Authorities. If deviations from the land use plan occur appropriate measures should be taken by the utilities to modify infrastructure to meet the revised development needs.
2. Other land use principles that are anticipated in this master plan are listed below. Changes to this land use approach would result in changes to infrastructure needs and should be dealt with by utility planners.
   - The amount of land assigned for development in the 1995 Suez City Master Plan exceeds the amount of land required to accommodate the projected year 2020 population in CCMP land use plan. As noted in section 2.6.4 Proposed Modifications to Development Plans and as reflected in Table V2-2.9, Suez Subdivision Recommended for Relocation this excess land should be preserved as recreational, green or agricultural land.
   - Urban growth in Ataqa and Faysal should continue westward, away from agricultural land. The strip of land along the Suez Canal should continue to be cultivated or used as public recreational area.
   - The growth of Suez should be oriented toward the Gulf of Suez waterfront. The Land Use Plan proposes the creation of a public recreational area that would end the long-standing practice of using the land along the Gulf's shores exclusively for industrial purposes. The City could border the waterfront with much-needed landscaped recreational grounds and lagoons. The environmentally friendly and construction-free Corniche and beaches would extend south along the coastal road leading to Al Adabiyya. This would reverse the City's image as an industrial, gloomy center and would help promote it as destination for local tourism.
   - To further enhance the City's image and to compensate for the lack of public areas in Qisms Al Arbaein and Suez, the conversion of several ponds near Port Tawfik low-density residential zones into lagoons surrounded by public playgrounds is also recommended.
3. Population growth should be monitored regularly and utility development adjusted accordingly.
4. Utilities and government agencies should form joint committees to monitor land development and communicate regularly on changing utility needs.

End of Chapter 2: Physical Conditions, Land Use and Population

3.0 Wastewater Flows

This section describes how wastewater flows were determined for existing conditions and estimated for future conditions in Suez. Determination of existing and expected flow rates is a critical consideration in planning and design of all wastewater infrastructure.

3.1 Introduction

The analysis of the wastewater collection system and the recommended improvements to transport existing and future flows is based on the wastewater flow projections. Flows from all existing drainage basins were established to the level of detail appropriate for hydraulic modeling.

A land use based approach was used to derive wastewater flows. The land use approach started with the development of existing and future land uses as shown on Figures V2-2.4, Suez Existing Land Use; V2-2.13, Suez 2020 Land Use; and V2-2.14, Suez Ultimate Land Use. Land use categories were identified which reflect differing water consumption and wastewater flow patterns. For example, the different residential land use categories have various ranges of population density and wastewater flow. A wastewater contribution was developed for each of the existing land use categories using a unit of cubic meters per day per square kilometer ($m^3/d/km^2$). The wastewater contributions for various land uses were initially based on measured flows to the existing wastewater treatment plant compared to existing water demand factors. Flows were then adjusted to match total flows received at the wastewater treatment plant.

A land use based approach, rather than a flow per capita approach, was chosen as the method for determining wastewater flows. This approach was chosen because it provides accuracy and because the hydraulic model can be easily updated in the future.

3.2 Determination of Existing Wastewater Flows

The wastewater flow projections were based on land use maps developed as part of this study. In addition, adjustments were made for infiltration. This Master Plan integrates the future water and wastewater projections and coordinates the implementation programs for both.

The study area was divided into a number of polygons, each of which contributes flows to a given node in the hydraulic model. MapInfo Geographic Information System (GIS) was used to determine the area of each land use category within each polygon. The wastewater factors were then applied according to the land use category to determine wastewater flow from each polygon. An infiltration allowance is included, based on the findings of the Infiltration/Salinity Survey.

Theoretical wastewater flow for the existing system was compared with measured flow into the wastewater treatment plant. A wastewater return factor was derived by matching

calculated flows with plant records. The return factor was then used to determine current and future wastewater contributions in each polygon. The calculated wastewater contributions for each polygon were added to the hydraulic model at the appropriate entry node (manhole).

3.2.1 Existing Land Use Evaluation

A list of land use categories was prepared to reflect typical land use patterns within the study area boundaries. The land use categories are listed in Table V2-2.8, Land Use Categories. Section 2.4 describes how they were established. Areas of similar wastewater contributions were grouped and assigned to the appropriate category. To maintain consistency, the same categories were used for both water and wastewater modeling. Some categories which receive no water or wastewater service are included to ensure that the entire study area is accounted for.

The digitized land use maps were used as base maps for existing and future wastewater system overlays. The wastewater drainage basins are individually outlined as wastewater polygons. By overlaying a polygon on the land use base map, the GIS program was used to delineate and extract the land use entities associated with each wastewater polygon. The individual land use entities were sorted and accumulated to provide a cumulative area, by land use, tributary to a given node in the hydraulic model.

3.2.2 Existing Wastewater Return Factors

Recognizing that not all the water supplied to customers returns as wastewater, wastewater return factors were established according to the existing water use characteristics of Suez. The percentage return factor allows for both losses from and additions to the wastewater collection systems.

Losses from the system flow can be attributed to the following causes:

- Water system leakage.
- Washing of vehicles.
- Washing sidewalks and streets.
- Watering lawns and gardens.
- Dust abatement on streets.
- Incorporating water into commercial products or construction materials (such as concrete, mortar, or grout).
- Cooling or process water evaporation.
- Makeup water for evaporation from fountains and pools.
- Water supplied to communal standpipes or areas without wastewater collection.
- Water supplied to industries or organizations, which operate their own independent wastewater collection and treatment facilities.
- Leakage from wastewater pipes above groundwater level.

Additions to the system flow come from the following sources:

- Groundwater infiltration through defective joints, pipes, and manholes.
- Groundwater pumped into the wastewater system (construction dewatering).
- Independent water production facilities which discharge into the wastewater system.
- Discharges of irrigation drainage to the wastewater system.

Since many such losses and additions occur simultaneously, the only practical way to obtain an estimate is to use a net percentage return factor which takes into account the difference (positive or negative) between the amount of water supplied and the amount of wastewater returned to the collection system. The return factor for Suez was calculated to be 95 percent based on the current water supply and wastewater collection records in Suez. The estimated contributions to the existing wastewater flows in Suez and the resulting wastewater return factor are presented in Table V2-3.1, Suez Wastewater Return Factor.

Table V2-3.1 Suez Wastewater Return Factor

Estimated Infiltration as a Percent of Water Supplied (1)	Wastewater Derived From Water Supplied	Net Wastewater Return Factor
29%	66%	95%

(1) As measured and reported in Phase III Infiltration/Salinity Survey Report, ABB

The wastewater return rate was applied to existing water use factors for each land use category to develop wastewater factors. The resulting wastewater contribution factors are presented in Table V2-3.2, Suez Existing Wastewater Contributions by Land Use. Factors for year 2020 and for ultimate conditions are presented later in this section. Increased population density and increased affluence may contribute to increases in the wastewater factors in year 2020 and ultimate conditions. The area of each existing land use polygon was calculated using GIS. Wastewater factors were then multiplied by the land use areas and accumulated over the wastewater service areas to determine total system flows. The resulting derived flows were calibrated with plant flow records.

Table V2-3.2 Suez Existing Wastewater Contributions by Land Use

Land Use Category	Contribution Factors ($m^3/d/km^2$)
Commercial – Office & Government	2,660
Commercial – Tourism	1,140
Educational Facilities	665
Industrial – Low Water Use	95
Industrial – Moderate Water Use	475
Military Camps	0
Residential – Very Low Density	4,465
Residential – Low Density	5,605
Residential – Medium Density	7,600
Residential – High Density	9,500
Residential – Very High Density	0

3.2.3 Existing Wastewater Flow Peaking Factors

Peaking factors represent the increase above the average daily flow (ADF) experienced during a specified time period. The various peaking conditions are numerical values obtained from historical data and at times, adjusted based on engineering judgment. The peak flows in the wastewater collection system reflect the water supply system's Peak Hour Demand (PHD) of 2.0 times Average Day Demand (ADD). However, the gravity system includes storage capacity, resistance to excessive flow velocities, and a wide range of transmission distances and times from various parts of the system, all of which tend to mitigate the downstream effect of peaks. In addition, infiltration will not increase as the user flow increases; rather, it will probably decrease as the water level and pressure in the pipe increase. To the extent that infiltration constitutes a significant portion of the average daily flow in Suez, it reduces the amplitude of peak and low flows. Peaking conditions that are of particular significance to hydraulic analysis of the wastewater system include the following:

- Peak hourly flow (PHF) is used for sizing collector pipes, lift stations, and force mains. PHF reflects the simultaneous peaks in seasonal and diurnal fluctuations in water use patterns, plus infiltration.
- Average, maximum, and minimum hourly flows are used in determining wetwell sizes and pump configurations at lift stations.

Peaking factors, expressed as a multiple of the ADF, have been developed based on the existing WWTP records and existing water demand patterns. Table V2-3.3, Historical Flows and Peaking Factors, presents a summary of the historical peaking factors.

Table V2-3.3 Suez Historical Flows and Peaking Factors

	Rate (m^3/d)	Peaking Factor
Annual Average Daily Flow (ADF) (1)	95,000	1.00
Maximum Monthly Flow(2)	101,600	1.09
WWTP Minimum Day(2)	61,500	0.66
WWTP Minimum Nighttime Flow (MNF)(3)	38,800	0.63 x Min. day = 0.42
WWTP Maximum Day MDF(2)	116,200	1.24
WWTP Peak Hour PHF(4)	133,600	1.15 x MDF = 1.43

1) The annual average daily wastewater flow to WWTP.
2) Based on treatment plant records.
3) Minimum day on record multiplied by diurnal nighttime minimum hour.
4) Maximum day on record multiplied by diurnal daytime maximum hour.

The maximum hourly peaking factor at the plant was 1.43. To account for the higher peaking factors farther upstream from the wastewater treatment plant, a peaking factor of 2.50 was used for the collection system. This collection system peaking factor appears realistic when compared to the WWTP peak flows derived from operating records.

The peaking factors derived for this project were based on detailed flow records recorded at the Suez WWTP for two weeks (one week in winter and one week in summer). If flows are recorded on an hourly basis then plotted against time of day a pattern can be observed. This pattern is referred to as a Diurnal pattern. It is typical to observe higher flow during daylight

hours and the lowest flow during the hours just after midnight. The diurnal pattern for each wastewater treatment plant will vary and generally plants serving large populations will have less variation than plants serving small populations. Data collected from the Suez wastewater treatment plant was used to generate Table V2-3.4, Diurnal Flow, and this data was used to assist in the determination of peaking factors. The data is not centered around "1" due to uniform addition of infiltration.

Table V2-3.4 Diurnal Flow

Hour	Peak/Average Ratio	Hour	Peak/Average Ratio
1:00	1.080	13:00	1.340
2:00	1.080	14:00	1.450
3:00	0.980	15:00	1.560
4:00	0.840	16:00	1.450
5:00	0.840	17:00	1.620
6:00	0.840	18:00	1.500
7:00	0.890	19:00	1.450
8:00	1.340	20:00	2.100
9:00	1.390	21:00	1.340
10:00	1.500	22:00	1.450
11:00	1.230	23:00	1.340
Noon	1.340	Midnight	1.340

Data from the Suez WWTP indicates a diurnal fluctuation, and a definite seasonal variation in average daily flows, although the timing varies slightly from year to year. The summer average flows are about 5 percent higher than the annual average flows, and generally last from July through October. The winter average flows are about 5 percent lower than the annual average, and generally last from February through May.

Since the Suez wastewater system experiences very little rainfall induced infiltration and inflow, no wet weather flow analysis was conducted.

Minimum hourly and daily flows are important for sizing pipes, lift stations, pump configurations, and force mains. The same factors that mitigate the peaking factors also reduce the fluctuations to less than the average. The minimum nighttime flow is generally considered to be the result of infiltration plus fixture leakage, with minimal user contribution. In new development areas, the minimum flow may be extremely low. This may necessitate provisions for flushing gravity systems and either parallel pipes or 'pigging' facilities to regularly clean sediment from force mains.

Research conducted in North America and Europe indicates that the smaller the population served, or the ADF, the lower the minimum flow. The recommended range of minimum flows for analyzing lift stations would be 0.3 to 0.5 of average. However, operating records for the existing system indicate a much wider range of minimum flows, from 0.0 to 0.8. Analysis indicates that lift stations serving relatively small commercial and industrial areas in Suez receive extremely low minimum nighttime flows and correspondingly high

peaks during working hours. At the other extreme are pump stations that serve large residential areas, which have minimum flows up to 80 percent of ADF. These high minimums indicate hydraulic problems, which include the following:

- Existing pipelines with extremely flat slopes.
- Inadequately sized pipes resulting in backups and surcharging.
- Blockage, sedimentation, and surcharging of pipelines and manholes.
- Excessive leakage from toilets and other fixtures.
- Unacceptably high infiltration.

Survey records indicate that many of these conditions are widespread in Suez. The modeling highlights some of these hydraulic deficiencies, and recommendations are made for their correction.

For analyzing the system and making recommendations for the future, the minimum flow will be in the range of 0.3 for the smallest lift stations, and 0.5 for the largest, but 0.4 will generally be used unless otherwise indicated. When making recommendations for future system development, consideration will be given to the dominant land use and historical trends in wastewater peaks and minimum flows.

The summary of wastewater peaking and minimum flow factors used for this study is listed in Table V2-3.5, Peaking and Minimum Flow Factors.

Table V2-3.5 Peaking and Minimum Flow Factors

Peak Hourly Flow (PHF)	2.50
Minimum Night-time Flow (MNF)	0.40

3.3 Development of Future Wastewater Flows

Future wastewater flows were calculated using a process similar to that used to calculate existing flows. Development of future wastewater flow rates relies on identification of future land uses, which will receive water and wastewater service. Appropriate return factors were applied to the projected water demand for each of these future land uses to determine the future wastewater contribution. The area of each future land use was calculated for each polygon and wastewater contributions were applied to each land use to determine wastewater flows for entry into the hydraulic model. Future flows for the year 2020 and for ultimate conditions were developed.

3.3.1 Future Land Use

For both the water and wastewater master plans, future developments are based on the same land use base maps and projected population densities. Areas with development plans or development potential within the study area boundaries were identified, categorized and mapped. This includes extending the wastewater collection system to areas which currently receive water, but no wastewater collection. It also includes anticipating increases in density and occupancy rates within the existing developed areas, projections of growth in areas on the

fringe of existing urban areas, and projections of development on tracts of undeveloped land surrounded by urban uses.

Future land uses were identified using the previously established land use categories. The projected population increases were first distributed to fully utilize dwelling units, followed by allocating the remaining population increase to new developments. Therefore, residential densities in some sections of the city are anticipated to be higher in the future, which results in existing drainage basin polygons being upgraded to higher density land use categories by year 2020 and at ultimate development.

The life expectancy of most facilities recommended in this master plan will extend well beyond the 20 year planning horizon. To avoid premature obsolescence of permanent utilities, it is important to consider the ultimate development potential and population density of an area. Many newly developed residential areas are not expected to be fully occupied by year 2020. It is assumed that they would be 70 percent occupied by year 2020 and an "ultimate" or "build-out" horizon has been defined to reflect 100 percent occupancy. This ultimate condition may not be reached until the year 2025 or later.

3.3.2 Future Wastewater Return Factors

The wastewater return rate for existing conditions and existing wastewater contribution factors are presented in Tables V2-3.1, Suez Wastewater Return Factor and V2-3.2, Suez Existing Wastewater Contributions by Land Use, respectively, were reviewed for use in evaluating year 2020 and Ultimate conditions. It was decided that the net effect of increased return percentage and decreased infiltration would balance each other. Therefore, the return rate of 95% derived for the existing system was used for projecting future contributions.

Table V2-3.6, Future Wastewater Contribution Factors, presents the future wastewater contributions used for the analysis of future collection system performance. The sole reason for an increase in future wastewater contribution from a land use category is the assumed increase in water demand resulting from increased water supply, economic improvements and increased industrial activities.

Table V2-3.6 Future Wastewater Contribution Factors (2020 and Ultimate)

Land Use Category	Contribution Factors ($m^3/d/km^2$)
Commercial – Office & Government	2,660
Commercial – Tourism	1,368
Educational Facilities	665
Industrial – Low Water Use	190
Industrial – Moderate Water Use	2,375
Military Camps	NA
Residential – Very Low Density	4,912
Residential – Low Density	6,166
Residential – Medium Density	9,120
Residential – High Density	10,925
Residential – Very High Density	NA

3.3.3 Future Wastewater Flow Peaking Factors

The peaking factors used for analyzing the existing systems were used in the analyses of the future systems. Although reductions in infiltration rates may increase peak fluctuations, the longer average travel distances from developing areas to the treatment plant will attenuate fluctuations. The net effect will probably be about the same as existing conditions. The existing peaking factors are based on actual data, while the magnitude of future changes could only be estimated. Existing peaking factors as presented in Table V2-3.5, Peaking and Minimum Flow Factors, were used when calculating future peak flows, since the future variations will be small compared to the natural differences between drainage basins.

3.3.4 Phasing of Future Wastewater Collection Flows

The increase in future wastewater collection flows can be attributed to the following three causes: (1) extending wastewater collection to all existing water service areas, (2) population growth within existing service areas and (3) new development.

Currently, various areas of developed land in Suez do not have wastewater collection. It is assumed that the initial five-year construction program will focus on extending wastewater collection to all existing residential and commercial areas. The additional flows from these areas have been added to the first five-year incremental flow increase. After year 2005, the increases in flows reflect only population growth and increases per capita consumption. If the expansion of the wastewater collection system into existing water service areas is not completed by year 2005, the incremental increase will shift from year 2005 to the year the extensions are completed.

It is assumed that the non-residential growth rate would parallel the population growth rate through year 2020. Applying this growth rate to wastewater contributions produces five-year incremental wastewater collection volumes presented in Table V2-3.7, Projected Interim Wastewater Flows.

Table V2-3.7 Projected Interim Wastewater Flows

Year	Average Daily Flows (m^3/day)	Peak Flows[5] (m^3/ day)
Current [1]	95,400	133,600
2000 [1]	96,000	135,800
2005 [2]	195,000	278,800
2010 [3]	228,700	327,000
2015 [3]	262,400	375,200
2020 [4]	296,100	423,400
Ultimate [4]	310,900	444,600

1) Current based on 1998 WWTP data – 2000 based on recent trends
2) Based on addition of wastewater collection in areas with current water service plus population growth.
3) Based on population growth.
4) Based on future land, water and wastewater factors.
5) 1.43 peaking factor at the WWTP.

The estimates of future flows in this master plan are based on today's conditions, anticipated population growth, and anticipated future development of the water supply system. Conditions which could delay the projected growth in wastewater flow include slower than anticipated expansion of wastewater collection service into developed areas and slow development of water system improvements to meet the projected water demands. Conditions which could accelerate the growth in wastewater flows include higher than anticipated growth rates, intensification of land use beyond that estimated, or development beyond the study area boundaries.

Based on derived wastewater flow factors and associated land use categories, flows have been calculated for existing and future conditions. Total wastewater flows by land use category are presented in Table V2-3.8, Projected Average Daily Wastewater Flows. Flow projections will vary if the growth of any of the land uses vary. It is very important that land use and flow projections be updated regularly.

3.4 Distribution of Wastewater Flows

As a part of developing the hydraulic network model, wastewater collection system contribution nodes and nodal polygons were identified, reflecting wastewater flows and tributary boundaries, respectively. Model nodes and their respective nodal polygons were defined by system characteristics such as piping configurations, topography, minimum grade for various diameters of pipe and proximity to other existing nodal polygons. Once established, nodal polygons and land use polygons were given various attributes to reflect their state of development at various time frames: existing, 2020, and ultimate development.

The nodal polygons were overlaid on the land use polygons for the time frames of interest to calculate the area of each land use within each drainage basin polygon. Wastewater contributions were applied to the land use areas to determine the average daily flow (ADF) associated with each wastewater drainage polygon. The ADFs were the basic nodal input to

the hydraulic model. Diurnal curves were then used in the hydraulic model to obtain peak flows.

Table V2-3.8 Projected Average Daily Wastewater Flows

Land Use Category	Existing	2020	Ultimate
Commercial – Office & Government	4,561	14,481	14,253
Commercial – Tourism	92	971	1,140
Educational Facilities	462	571	582
Industrial – Low Water Use	138	3,281	3,277
Industrial – Moderate Water Use	0	15,822	15,865
Military Camps	NA	NA	NA
Residential – Very Low Density	0	118,097	81,091
Residential – Low Density	45,518	80,584	132,344
Residential – Medium Density	NA	NA	NA
Residential – High Density	41,804	62,312	62,330
Residential – Very High Density	NA	NA	NA
Total Average Daily Flow	92,574	296,119	310,884

End of Chapter 3: Wastewater Flows

4.0 Existing Wastewater Collection System

This section contains a description of the existing wastewater collection system in Suez. The majority of the wastewater system in Suez is owned, operated and maintained by the Governorate. Additionally, small portions of the system may be owned and/or controlled by the military, other government agencies or by private industry.

The existing Suez wastewater service area covers approximately 12 square kilometers, the existing water service area covers approximately 43 square kilometers and both are expected to expand to over 90 square kilometers at ultimate build-out.

The community of Suez has its origins in the construction of the Suez Canal. In the 1950s and 1960s the General Organization for Sewerage and Sanitary Drainage (GOSSD) supervised the design and construction of infrastructure in Suez, including much of the current wastewater system. During 1967-1973 war, while, Suez was evacuated, the wastewater facilities, particularly treatment facilities, were damaged. Major reconstruction was needed after the residents returned to Suez.

The collection system continues to expand and now consists of more than 230 kilometers of 175 mm to 1200 mm wastewater lines, excluding service laterals. A new wastewater treatment plant with a hydraulic capacity of 130,000 m^3/day was constructed in 1995.

4.1 Wastewater Collection Facilities (Pipes)

The Suez wastewater system includes over 230 kilometers of wastewater collection pipe. Figure V2-4.1, Suez Wastewater Existing Pipe Network and Table V2-4.1, Inventory of Suez Wastewater Collection Pipes, provide an approximate inventory of collection system pipe as recorded in the survey report prepared in 1995 by ABB Susa / Dillingham (ABB) for the Canal Cites Phase II project.

Table V2-4.1 Inventory of Suez Wastewater Collection Pipes

Total Length (meters) of Wastewater Pipe by Diameter (milimeters)								
175mm	200mm	225mm	250mm	300mm	350mm	375mm	400mm	450mm
165,586	261	31.664	2,912	13.657	502	4,580	720	1,412
500mm	550mm	600mm	750mm	800mm	900mm	1000mm	1200mm	Total
2,143	100	2.480	20	2,750	341	991	803	230,921

4.2 Wastewater Collection Facilities (Lift Stations)

The wastewater collection system of Suez consists of gravity collector and interceptor lines, which transport flow to 15 major lift stations. The Atakka station is the main lift station for the city and occupies a site approximately halfway between the old wastewater treatment plant and the new wastewater treatment plant. Table V2-4.2, Lift Stations Inventory, provides information on the lift stations.

Table V2-4.2 Lift Stations Inventory

Lift Station	No of Pumps	Lift Station Firm Capacity (m^3/day)	Force Main Diameter (mm)	Force Main Length (m)
24 October	2	6,650	300	1,500
Arab El-Mamel	4	36,000	400	2,000
Ataqa	5	207,360	1,400	1,900
El-Omda	2	2,810	300	800
El-Arbein	2	15,550	300	3,000
El-Herafien	2	25,920 [1]	800	800
Faisal	3	12,960	300	1,600
Gabalaya	4	64,800	800	6,600
Kafr Hoda	4	12,960 [1]	300	2,000
Manshia	2	4,320 [1]	200	1,000
Port Tawfik	2	16,400 [1]	250	4,000
Sawahel	2	8,640	200	1,500
Tal. El-Qalzam	3	5,760	400	5,000
Zaraier	3	39,750	800	2,500
Zareb	4	46,650 [1]	700	5,250

1) lift station capacity based on anticipated upgrade during CMC Phase II rehabilitation

4.3 Existing Areas Without Wastewater Collection

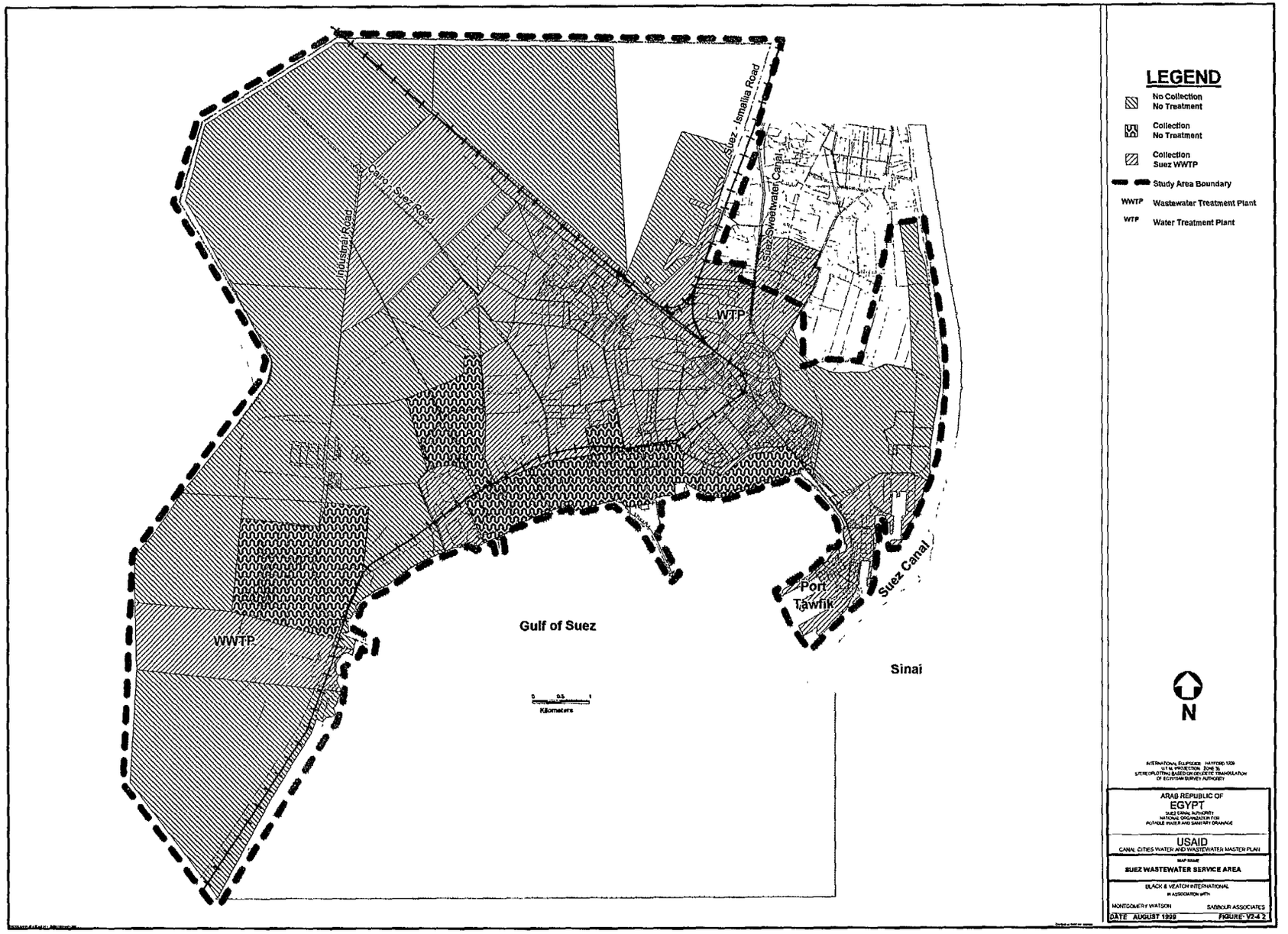
Eliminating of the discharge of untreated wastewater and extending service to areas currently without wastewater collection are high priorities for the Suez Govenorate and NOPWASD. Suez includes neighborhoods which have water service, but no wastewater collection, or which have wastewater collection but no wastewater treatment. This report identifies these areas and provides information for prioritizing the construction of wastewater facilities. Table V2-4.3, Wastewater Service Areas, lists information on areas without wastewater collection or treatment. Figure V2-4.2, Suez Wastewater Service Area, shows the areas that generate wastewater that is currently not collected or is collected but not treated.

Table V2-4.3 Suez Wastewater Service Areas

Area with Water Service (1)	43	km^2
Area with Wastewater Collection (1)	12.5	km^2
Water Service Area without Wastewater Collection and/or Treatment	30.5	km^2
Percentage of Area with Water but without Wastewater Service	71	%
Estimated Population without Wastewater Collection and/or Treatment.	165,000	
Percentage of City Population	41	%
Potential Additional Wastewater	75,000	M^3/d
Percent Increase at WWTP	80	%

1) Includes flows from areas without collection and those without treatment.

End of Chapter 4: Existing Wastewater Collection System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Cairo Suez Road
Industrial Road
Suez Sweatwater Canal
WTP
WWTP
Gulf of Suez
Port Tawfik
Suez Canal
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STEREOPLOTTING BASED ON DELUXE TO TRIANGULATION OF EGYPTIAN SURVEY AUTHORITY
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EGYPT
SUEZ CANAL AUTHORITY
NATIONAL ORGANIZATION FOR POTABLE WATER AND SANITARY DRAINAGE
USAID
CANAL CITIES WATER AND WASTEWATER MASTER PLAN
MAP NAME
SUEZ WASTEWATER SERVICE AREA
BLACK & VEATCH INTERNATIONAL
IN ASSOCIATION WITH
MONTGOMERY WATSON
SABBOUR ASSOCIATES
DATE AUGUST 1998
FIGURE V2-4.2

5.0 Suez Wastewater Treatment Plant

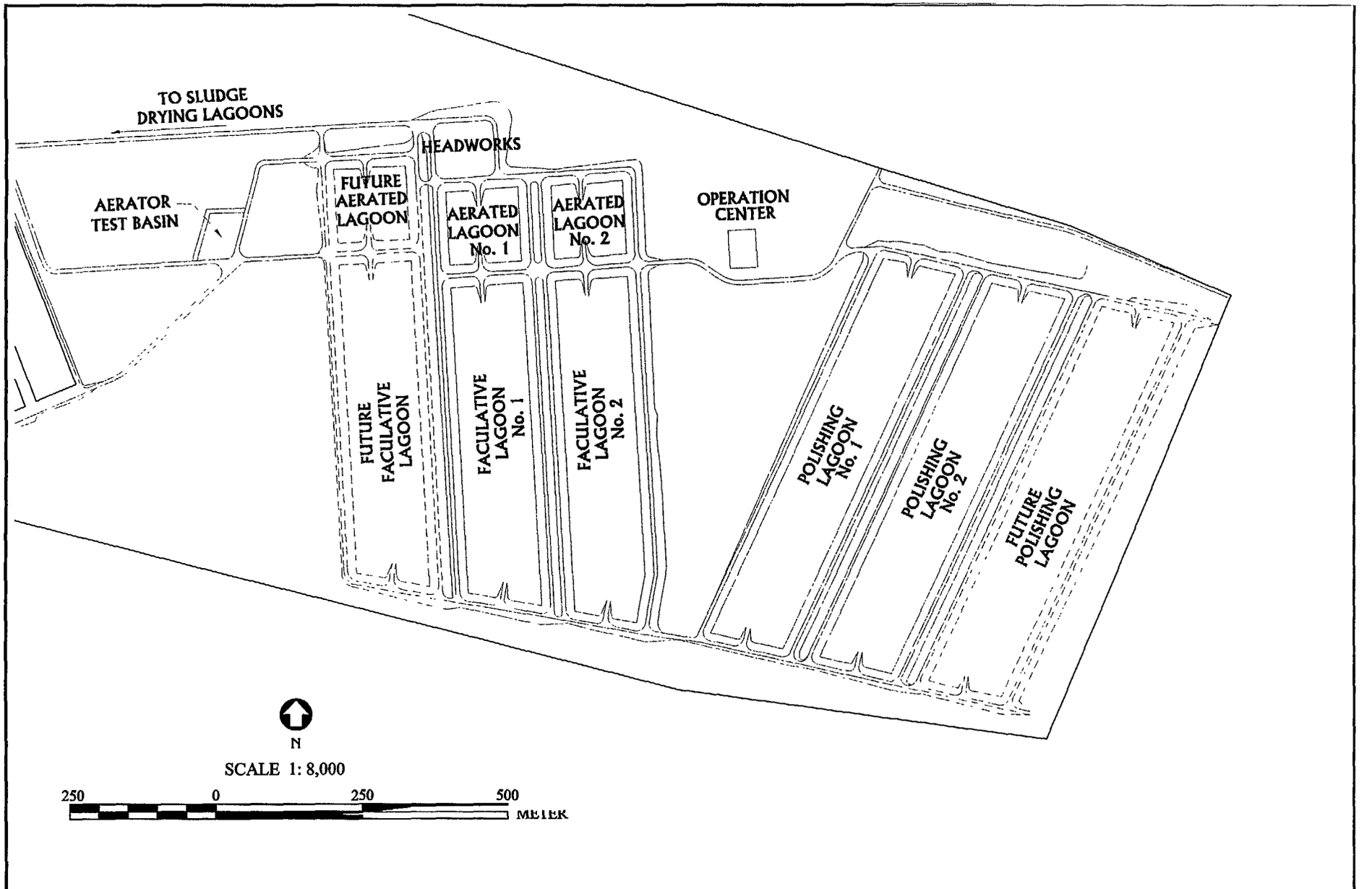
This section presents an overview of the background and the general condition of the existing wastewater treatment system in Suez.

5.1 General Description

The existing Suez Wastewater Treatment Plant has been in operation since August 1995. A plant layout and schematic are shown on Figure V2-5.1, Suez Wastewater Treatment Plant Site Layout, and Figure V2-5.2, Suez Wastewater Treatment Plant Process Flow Diagram. The plant is approximately 8 km to the southwest of Suez on a site inland from the coastal road between Suez and Ain El-Sokhna. It has two treatment trains each designed for 65,000 m^3/d. During the 12-month period ending in January 1999, the average plant flow was approximately 95,400 m^3/d. A summary of influent flow, TSS and BOD_5 for these months is found in the Appendix. Trial operations immediately after startup, using differing operating procedures determined that the most cost-effective procedure that consistently achieved the required effluent quality was to use only one of the two treatment trains. With this mode of operation, the total detention time in the lagoon treatment process is just over 7-1/2 days compared to the design detention time of 11 days. During the same period average TSS and BOD_5 loads were 194 mg/l and 169 mg/l respectively. This represents approximately 50% of the TSS capacity and approximately 60% of the BOD_5 capacity. Since start up the plant has consistently met or exceeded the required effluent standards.

5.1.1 Headworks

The new Ataka Station pumps wastewater to the site through approximately 1.9 km of 1400 mm diameter force main. The force main discharges to one of two adjacent influent boxes at the beginning of the headworks structure. The second influent box has a plugged stub-out for a future force main connection. From the influent box, the flow is discharged to one of two Parshall flume channels. Only one channel is equipped with a Parshall flume; the other is used as a bypass channel. In the future, a second Parshall flume can be installed in the bypass channel. The installed Parshall flume has a throat width of 2.1 m and can accurately measure flows up to 260,000 m^3/d. A sluice gate controlling the opening between the two influent boxes and slide gates on each end of the flume channels are used to direct the flow to the preferred channel. A staff gage is laminated on the wall of the Parshall flume channel to determine the depth of flow through the Parshall flume. The depth of flow can be converted to a flow rate using a flow chart developed specifically for this Parshall flume. Each channel is sized to pass a future peak flow of 400,000 m^3/d without overflowing.



ARAB REPUBLIC OF EGYPT SUEZ CANAL AUTHORITY NATIONAL ORGANIZATION FOR POTABLE WATER AND SANITARY DRAINAGE	USAID CANAL CITIES WATER AND WASTEWATER MASTER PLAN	BLACK & VEATCH INTERNATIONAL IN ASSOCIATION WITH MONTGOMERY WATSON SABBOUR ASSOCIATES	SUEZ WASTEWATER TREATMENT PLANT SITE LAYOUT DATE: AUGUST 1999 FIGURE: V2-5.1

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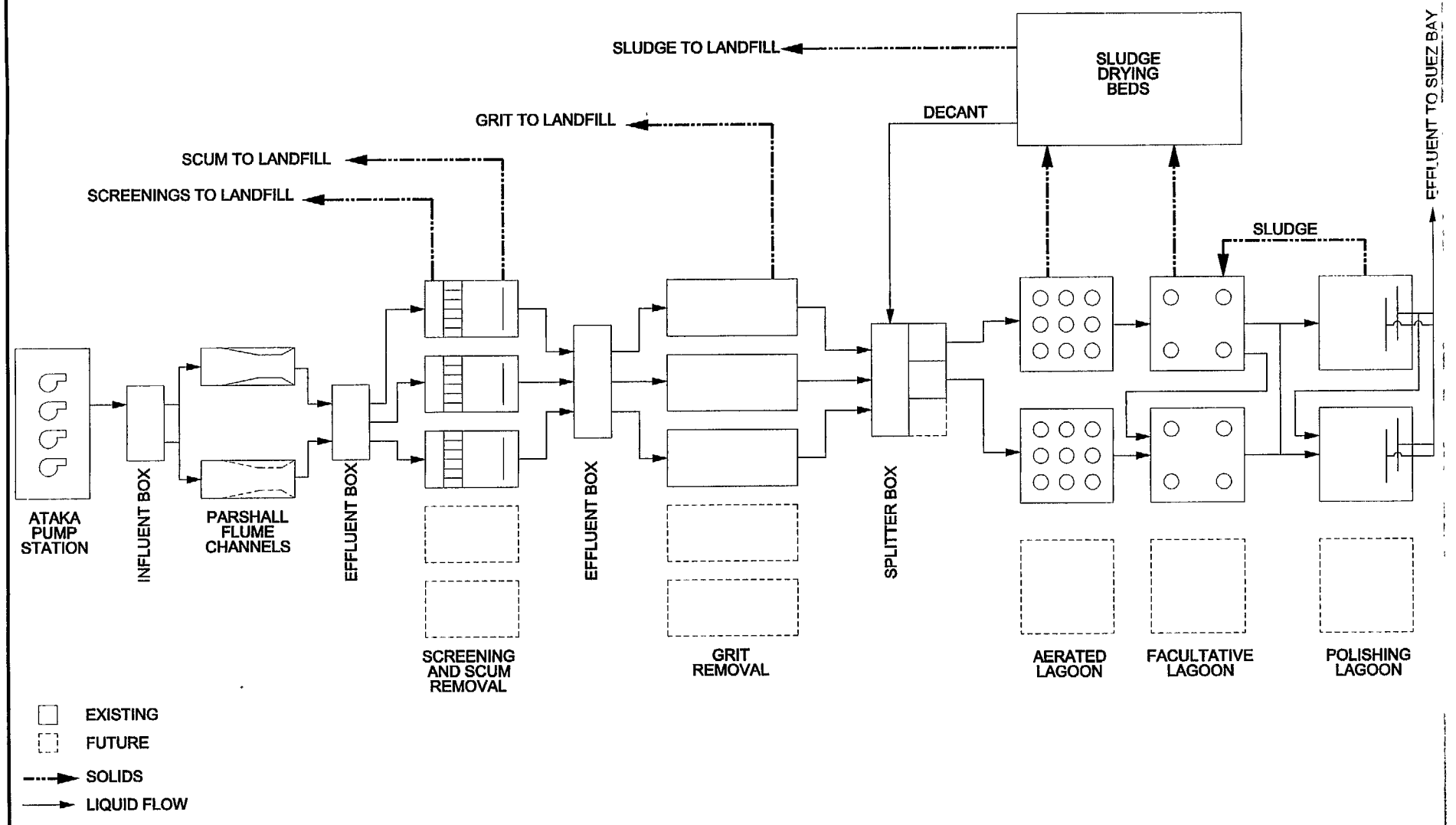

ARAB REPUBLIC OF EGYPT SUEZ CANAL AUTHORITY NATIONAL ORGANIZATION FOR POTABLE WATER AND SANITARY DRAINAGE	USAID CANAL CITIES WATER AND WASTEWATER MASTER PLAN	BLACK & VEATCH INTERNATIONAL IN ASSOCIATION WITH MONTGOMERY WATSON SABBOUR ASSOCIATES	SUEZ WASTEWATER TREATMENT PLANT PROCESS FLOW DIAGRAM DATE: AUGUST 1999 FIGURE: V2-5.2

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Flow from the flume channels passes through an effluent channel and is divided equally to three screening and scum removal channels. Each channel is equipped with a mechanically cleaned bar screen for removal of large solids and a scum barrier to collect floating material. The climber-type front cleaned bar screens have clear openings of 25 mm between the bars. Screenings are raked to a discharge chute that discharges to a 1.5 m^3 screenings receptacle, and are eventually hauled to an on-site landfill.

Downstream from the bar screen, a concrete scum barrier captures the floating material, which is removed by raking and also hauled to on-site disposal. Slide gates on each end of the channels allow one or more of the channels to be taken out of service for maintenance. Provisions have been made to add two screening and scum removal channels in the future and for the bypass channel to discharge to these future channels.

Flows from the three screening and scum removal channels are collected in an effluent channel located at the end of the three channels. The effluent channel can discharge the flow equally to three grit removal basins. The grit removal basins are velocity-controlled to allow the grit to settle to the grit storage areas on the bottom of the basins. When sufficient quantities of grit have settled out of the flow and are ready for removal from the storage area, the basin is taken out of service by closing slide gates at each end of the basin, dewatering the basin, and grit is removed with a front end loader. The grit is loaded on trucks for disposal at an on-site landfill. The basins are sized to allow one basin to be taken out of service during peak flows.

A splitter box receives the flow from the grit removal basins. Sharp-crested weirs on one side of the splitter box evenly split the flow to two concrete boxes. Each box feeds one train of the lagoon treatment system. Each train of the treatment system consists of an aerated lagoon, a facultative lagoon, and a polishing lagoon. Earthen berms form the walls of the lagoons and a synthetic lagoon liner inhibits migration of wastewater to the groundwater. The aerated lagoons and facultative lagoons are separated by earthen berms. The polishing lagoons are adjacent to each other, with a common earth berm between them, but are located away from the facultative lagoons. Each lagoon in each train has an earthen access ramp that extends from the top of the berm to the lagoon bottom.

5.1.2 Treatment Process

The flow is delivered from one of the boxes to one of the aerated lagoons through a combination of 1500 mm transmission pipe and two 1400 mm diameter pipes extending from the transmission pipe into the aerated lagoon. Flow to the other aerated lagoon is through a combination of 1400 mm transmission pipe and two 1200 mm pipes from the transmission pipe.

Flow is discharged to the bottom of an aerated lagoon in two locations at the base of the side berm. Thirty dual-speed floating mechanical aerators with draft tubes, designed to satisfy the biochemical oxygen demand of the wastewater, are installed in each aerated lagoon. The

aerators are held in position by cables attached to mooring posts in the lagoon. Each aerator has three mooring cables for stabilization. Plant operators cycle aerators to supply the adequate dissolved oxygen (DO) for treatment. In addition to supplying dissolved oxygen, the aerators also serve to mix the wastewater to keep the solids in suspension.

From the aerated lagoon, wastewater is transferred to the facultative lagoon located through two 750 mm effluent pipes opposite the influent pipes. Each effluent pipe discharges to an effluent control box and a 750 mm diameter pipe transfers flow from the control box to the facultative lagoon. A sluice gate in the control box controls the flow from the aerated lagoon and a sharp-crested weir in the box controls the liquid level in the aerated lagoon. A transfer structure located in the berm between the two aerated lagoons can be used in the event that a facultative lagoon is taken out of service. The transfer structure consists of a 1500 mm pipe and a concrete control box. A slide gate in the control box is used to control the flow from one aerated lagoon to the other.

Each facultative lagoon is equipped with 40 single-speed floating mechanical aerators with draft tubes. The aerators are similar to those in the aerated lagoon, and are turned on and off by plant operators to control DO in the lagoons. In the recent past, the DO demand has been met with approximately 10 aerators. As designed, solids settle to the bottom of the facultative lagoon and undergo anaerobic decomposition. Effluent from the west facultative lagoon flows to a concrete effluent structure. A sharp-crested overflow weir in the effluent structure controls the liquid level in the facultative lagoon. The flow is directed through slide gates to either the polishing lagoons or to the east facultative lagoon for series operation. Effluent flow from the east facultative lagoon flows to a concrete effluent structure and then to the polishing lagoons.

In the polishing lagoons, additional solids settle out. Algae growths in the lagoons occasionally increase the concentration of suspended solids, but when corrected for the algae, the solids concentrations are well within the allowable limits.

5.1.3 Effluent Discharge

Each polishing lagoon has two effluent control structures, each equipped with two 1050 mm collector pipes and two 1200 mm discharge pipes. A weir in the effluent box between the collector pipes and the discharge pipes controls the elevation of the liquid surface in the polishing lagoon. Each collector pipe extends from the structure out into the lagoon to a tee and then parallels the berm in each direction for 18 m. Each section paralleling the berm has 26 ports located on the centerline and top and bottom of the pipe. Lagoon effluent enters the pipe through these ports and is transported to the effluent structure. Slide gates in the structure control which pipe is used to withdraw effluent from the lagoon, depending on the quality of the treated wastewater. Effluent from the west polishing lagoon can be directed to the influent end of the east polishing lagoon for series operation or to a 1200 mm diameter effluent pipe discharging to the wetwell for the non-potable water pumping station. Effluent

from the east polishing lagoon discharges to the same effluent pipe. An overflow weir maintains the liquid level in the non-potable pumping station wetwell. Treatment plant effluent that overflows the weir is transported to Suez Bay by a 1500 mm diameter buried marine outfall and discharged through 20 riser pipes. The riser pipes are 300 mm in diameter and extend from the top of the marine outfall to above the bay floor. A tee on the end of each riser discharges horizontally into Suez Bay.

5.1.4 Solids Management

Solids that settle to the bottom of the lagoons undergo anaerobic decomposition. Stabilized sludge is removed from the lagoons by dredging and transferred to drying lagoons. After the sludge has been dewatered to approximately 40 percent solids, it is removed from the drying lagoons with front-end loaders and hauled to the on-site sludge disposal area. Sludge that settles out in the polishing lagoons is returned to the facultative lagoons.

5.1.5 Support Facilities

An operations center is located near the plant access road. The operations building has four major areas: the administrative quadrant, the personnel quadrant, the warehouse quadrant, and the maintenance quadrant. The administrative quadrant houses the following:

- Lobby and visitors reception area
- Public restrooms
- Conference room
- Central control room
- Laboratory
- Plant Manager's office
- Chief Operator's office
- Central clerical services and records storage

The personnel quadrant has a separate entrance and houses the following:

- Locker rooms and restrooms
- Meeting/Training rooms
- Staff lunchroom
- General storage

The warehouse quadrant contains:

- Storage for maintenance supplies
- Storage for spare parts for plant equipment
- Storage for parts and accessories for vehicles

The maintenance quadrant contains:

- Vehicle maintenance area
- Parking area for some plant vehicles
- Maintenance area for plant process equipment.

Access to the site is controlled by a perimeter fence with a manually operated gate and guardhouse manned by security personnel.

5.1.6 Treatment Plant Summary

Table V2-5.1, Suez Treatment Plant Design Parameters, presents a summary of treatment plant design parameters. The operating records for 1998 indicate that the actual pollutant concentration in the wastewater is lower than the values used in design. As a result, the plant may successfully treat a much larger volume of wastewater than initially thought. To better predict when the treatment plant will reach its capacity, additional testing will be necessary. The testing should include influent and effluent BOD_5, soluble BOD_5, total suspended solids (TSS), and volatile suspended solids in each of the three lagoon areas and a dissolved oxygen profile in the aerated lagoon area. The results of these additional tests could be used to determine the need for future treatment plant modifications and expansions.

Table V2-5.2, Suez Treatment Plant Components, presents the treatment plant components.

Table V2-5.1 Suez Treatment Plant Design Parameters

Flow Characteristics	**Units**	**Design**	**1998 Data**
Average Plant Flow	m^3/d	130,000	93,400
Peak Plant Flow *	m^3/d	260,000	113,200
Influent Characteristics	**Units**	**Design**	**1998 Data**
Total Suspended Solids (TSS)			
Concentration	mg/L	400	203
Mass Loading	kg/d	52,000	19,000
Biochemical Oxygen Demand (BOD_5)			
Concentration	mg/L	280	168
Mass Loading	kg/d	36,400	15,700
Effluent Characteristics	**Units**	**Design**	**1998 Data**
Total Suspended Solids (TSS)			
Concentration	mg/L	50	26
Mass Loading	kg/d	6,500	2,430
Biochemical Oxygen Demand (BOD_5)			
Concentration	mg/L	60	19
Mass Loading	kg/d	7,800	1,770

* peak observed September 1998

Table V2-5.2 Suez Treatment Plant Treatment Components

Treatment Unit	Description	Design
Headworks Facility		
Parshall Flume	Number	1
	Throat Width, mm	2,100
Bar Screen	Number	3
	Type	Climber
	Channel Width, mm	1,500
	Clear Opening Between Bars, mm	25
Grit Basins	Number	3
	Basin Width, m	3.5
	Basin Length, m	18
Process		
Aerated Lagoon	Number	2
	Width, m	100
	Length, m	125
	Side Water Depth (m)	4.3
	Retention Time @ Design Flow (d)	1
Facultative Lagoon	Number	2
	Width, m	125
	Length, m	535
	Side Water Depth, m	4.3
	Retention Time at Design Flow, d	5
Polishing Lagoon	Number	2
	Width, m	125
	Length, m	700
	Side Water Depth, m	3.5
	Retention Time at Design Flow d	5
Solids Management		
Sludge Drying Lagoon	Number	18
	Width, m	78
	Length, m	156

End of Chapter 5: Suez Wastewater Treatment Plant

6.0 Regulations, Laws and Treatment Criteria

This section presents a review of the institutional and legal impacts on improvements or changes in the environment related to the protection of the Nile River and other waterways. The ability of a waterway to receive a treated wastewater effluent can be a significant factor in the siting of a wastewater system, its points of collection and discharge, and the selection of an appropriate level of treatment.

Responsibility for environmental protection of Egypt is dispersed among many ministries and government agencies. Recent interest in the protection of the environment has led to the formation of the Ministry of State for Environmental Affairs and the Egyptian Environmental Affairs Agency (EEAA) which is empowered to monitor and maintain the laws and decrees associated with the environment. These are the two central institutions concerned with environmental protection in Egypt. However, other ministries, including the Ministry of Health & Population and the Ministry of Public Works & Water Resources, play an important role in the protection of the environment when the discharge of liquid wastes is involved.

6.1 1962 - Law No. 93

Law No. 93 for 1962 was established for the development of public wastewater systems and regulation of the wastes draining into it. Details were provided through the Minister of Housing and Utilities Decree No. 649 of 1962. The Law and its subsequent decree identified requirements for permitting, treating wastes, and establishing collection networks. The main provisions of Law No. 93 and its Executive Regulations can be summarized as follows:

- Defines what constitutes a public wastewater system and establishes who would have authority over the system.
- Establishes criteria for connections to the network, including requirements for permits, applications to connect, and penalties to be applied to violations.
- Establishes criteria and specifications for all liquid wastes discharged into public wastewater collection system.
- Establishes methods and timing for sampling and analyzing liquid waste specimens.

Laws in following years, particularly Law No. 48 for the Year 1982, have superseded or modified some of the treatment standards and criteria.

6.2 1982 - Law No. 48

Law No. 48 for 1982 was established to protect the Nile River and its waterways from pollution. Details were provided through the Ministry of Irrigation Decree No. 8 of 1983. The Law is particularly focused on protecting freshwater resources for both potable and non-potable agricultural uses. Table V2-6.1, Waterways Protected by Law No. 48 provides a summary of waterways and sources of pollution defined by the Law and its Executive Regulations.

Table V2-6.1 Waterways Protected by Law No. 48

Waterway	Description
Nile River and its Two Branches	The main course of the Nile starting from the international border with Sudan to the mouth of Damietta and Rozetta branches in the Mediterranean Sea.
Bays	Side branches of the Nile, inside islands.
Feeders and Main Canals	Large canals conveying water from the downstream side of the Delta Barrage and feeding canal networks in Northern Egypt.
Canals	Large and small canals, with all their branches, up to field irrigation canals.
Side Channels	Parallel or adjacent distribution canals fed by main connecting canals carrying irrigation water.
Drainage and Drains	Large and small drainage canals, with all their branches, up to field drainage and covered drainage canals.
Lakes	Lakes connected with seas or closed.
Ponds	Closed water surfaces into which waterways discharge.
Closed Water Surfaces	Depressions filled with water and connected with waterways.
Oozes and Swamps	Low ground around lakes in which drainage channels discharge.
Underground Water Reservoirs	Underground water reservoirs inside Egypt's borders.
Solid Wastes	All solid materials, whether they are resulting from refuse, garbage, sweepings, dry rubbish, stone fractures, building and workshop scraps, or any solid material left by persons, housing buildings, and non-housing buildings – governmental or private, whether they were commercial, industrial, tourist, or public, as well as means of transportation.
Fluid Wastes	Wastes resulting from industrial shops and on which the standard measures regarding the industrial liquid wastes are applicable.
Human or Animal Waste	Waste resulting from wastewater purifying operations or from their networks, or from real estate or other establishments, such as public, trading, industrial, and tourist shops, whether immovable, moveable, or floating.
Animal Fluid Wastes	Wastes resulting from slaughtering operations, abattoirs, slaughterhouses, poultry farms, hangers, and the like.
Establishment	All real estate shops, trading, industrial, or tourist structures – whether governmental or non-governmental.

The main provisions of Law No. 48 and its Executive Regulations can be summarized as follows:

- Defines waterway and pollutant sources.
- Establishes standard for treatment prior to discharge of marine vehicles in potable and non-potable water sources.
- Establishes standards for treatment prior to discharge of industrial wastes into potable and non-potable water sources.
- Establishes standards for wastewater discharge.

6.3 1994 - Law No. 4

Environmental Law No. 4 of 1994 and the Prime Minister's Decree No. 338 of 1995 established the mandate of EEAA and provided clarification to discharge limits. Law No. 4 is the outcome of a long process that started with the formation in 1981 of ministerial and technical environmental committees reporting to the Prime Minister. These early initiatives led to the issuance of Presidential Decree No. 631 of 1982 establishing the formation of an Environmental Affairs Authority. The mandate of the Authority was limited; nevertheless, it issued Law No. 102 of 1983 for the protection of natural resources. In 1985, the Authority was reorganized by adding specialized divisions and technical staff positions. Its restricted operating scope led to the realization that there was a need for a much stronger authority with a clear mandate to protect the environment and with effective enforcement backing. This need was further recognized with the issuing of Ministerial Decrees Nos. 30 and 31 of 1991 to restructure and strengthen the Environmental Affairs Authority and with preparation of the Environmental Action Plan (EAP) in 1992. In 1994, Law No. 4 was authorized to deal with major environmental policy issues. Although this law does not address all aspects of environmental protection, it covers the areas of greatest concern including air, land, and marine environment. Details were left to be worked out by executive regulations and ministerial decrees. Decree of the Prime Minister No. 338 of 1995 Promulgating the Executive Statutes of the Law on Environment provided the details. The main provisions of Law No. 4 and its Executive Regulations can be summarized as follows:

- Founding an agency with a clear mandate to protect the environment.
- Establishing and operating environmental information and monitoring networks to guarantee efficient implementation of the Agency's mandate. EEAA becomes the coordinating body responsible for the collection and dissemination of information.
- Establishment of an Environmental Protection Fund with sufficient resources and well-defined expenditure items. The Fund's resources are devoted to research and technical analysis of the environment; environmental assessment studies; establishment of environmental networks; the removal of pollutants; and other activities aiming at environmental protection.
- Establishment of the principles and procedures to be followed in the preparation of environmental impact assessments on new projects and extensions to existing projects which have the potential to adversely affect the environment.
- Establishment of an Environmental Affairs Department (EAD) in each Governorate to help coordinate and implement EEAA's mandate at the local level.

An important provision of Law No. 4 is Article 1, which indicates that the new law does not detract or weaken the provisions of Law No. 48 for the Year 1982 concerning the protection of the Nile River and the watercourses from pollution.

Annex No. 1 of Prime Minister Decree No. 338 of 1995 sets forth the criteria and specifications for certain materials when drained and disposed of in a marine environment. Reference is made in the Annex to the fact that the criteria and specifications also remain subject to the provisions of Law No. 48 of the Year 1982.

Annex No. 2 of Prime Minister Decree No. 338 of 1995 defines installations subject to the provisions of evaluation of environmental impact. Item 6, under the heading "Installations Subject to Environmental Assessment Based on Site Activities," includes all infrastructure projects, including stations for wastewater treatment and reuse of their waters.

6.4 Discharge Limits

The applicable discharge limits set under Law No. 48 and enhanced by Law No. 4 for discharges of treated wastewater effluent are summarized in Table V2-6.2, Wastewater Effluent Limits. There are no specific guidelines in either law indicating how the wastewater specifications are to be measured and to what distance from the point of discharge.

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Table V2-6.2 Wastewater Effluent Limits

Description	Ceiling Criteria and Specifications Law No. 48 (mg/L), unless noted	Ceiling Criteria and Specifications Law No. 4 (mg/L), unless noted
Temperature	35 C	≤ 10 C over prevailing
pH	6-9	6-9
Biological Oxygen Demand (BOD_5)	60	60
Chemical Oxygen Demand (Dichromate)	-	100
Chemical Oxygen Demand (Michromate)	80	-
Chemical Oxygen Demand (Permanganate)	40	-
Dissolved Oxygen (DO)	Not Less Than 4	-
Oils and Greases	10	15
Hydrocarbons of Oil Origin	-	0.5
Dissolved Substances	2,000	2,000
Ashes of Solute Solid Materials	-	1,800
Total Suspended Substances (TSS)	50	60
Color	Free of Color	Free of Color
Lees and Dregs	-	NTU 50
Sulfides	1	1
Cyanide	-	0.1
Phosphate	-	5
Nitrates	50	40
Fluorides	-	1
Phenols	-	1
Total of Heavy Metals	1	-
Aluminum	-	3
Ammonia (Nitrogen)	-	3
Mercury	-	0.005
Lead	-	0.5
Cadmium	-	0.05
Arsenic	-	0.05
Chromium	-	1
Copper	-	1.5
Nickel	-	0.1
Iron	-	1.5
Manganese	-	1
Zinc	-	5
Silver	-	0.1
Barium	-	2
Cobalt	-	2
Pesticides of All Types	Non-existent	0.2
Coliform Bacteria (probable count in 100 cm^3)	5,000	5,000

NOTE: Law No. 48 limits as defined in Article 66 of Decree No. 8 of Year 1983; Law No 4 limits as defined in Annex 1 of Decree No. 338 of Year 1995.

While they are not specified as applying to wastewater, Table V2-6.3, Discharge Standards for Non-Potable Water Sources, shows standards from Law No. 48 that apply to industrial fluid wastes and may also apply to wastewater.

Table V2-6.3 Discharge Standards for Non-Potable Water Sorces

Description	Standard Measures and Specifications
Temperature	Not more than 5 C over prevailing rate
Dissolved Oxygen (DO)	Not less than 4 mg/L at any time
Hydrogen Exponent (pH)	Not less than 7 and not more than 8.5
Industrial Detergents	Not more than 0.5 mg/L
Phenol	Not more than 0.005 mg/L
Sediment	Not more than 50 units
Dissolved Solid Substances	Not more than 650 mg/L
Coliform Bacteria (Probable count in 100 cm^3)	Not more than 5,000
NOTE: Law No. 48 limits as defined in Article 68 of Decree No. 8 of the Year 1983.	

6.5 General Water Quality Considerations

Oxygen is a key element in the growth of microorganisms and the subsequent stabilization of waste materials in aerobic processes. It is also essential for the survival of fish and other aquatic life. Therefore, when considering a wastewater discharge, it is important to ensure that the oxygen depletion caused by waste assimilation does not result in conditions, which are unfavorable to life.

Oxygen demands are created by the absorption of carbonaceous materials (carbonaceous biochemical oxygen demand or CBOD) and by nitrification of ammonia to the nitrate form (nitrogenous biochemical oxygen demand). Both of these demands need to be considered and weighed against the natural reaeration capacity of the water body, whether by mixing, wind action, photosynthesis by plankton, or other processes.

Eutrophication is the enrichment of water bodies by nutrients (primarily nitrogen and phosphorus). It is usually a major cause of pollution in lakes and other water bodies with poor mixing and circulation. When conditions are suitable, this enrichment increases the growth rate of phytoplankton which are the basic building blocks of the marine ecosystems food chain. The rate of algal biomass growth is dependent on temperature and on the availability of a carbon source and light. Algal biomass is quantified by chlorophylla, a photosynthetic pigment found in algae.

Algae produce oxygen when adequate light is available, but also have a constant oxygen requirement for respiration. In the presence of large algal populations or blooms, oxygen concentrations can be seriously depressed during the night when oxygen production halts, but algal respiration continues. The worst situation occurs when the bloom suddenly collapses, resulting in a tremendous oxygen demand from the decomposition of the dead algal cells. The decline in oxygen concentration can make conditions unsuitable for fish and other aquatic life, impart disagreeable color and odor to the water, and produce substances which are toxic to fish and shellfish.

While such stimulation of the ecosystem can sometimes produce desirable results, the blue-green algae which usually predominate in phytoplankton populations, have poor food characteristics for higher tropic levels, and can create nuisance conditions.

Sustained anoxic (inadequate oxygen concentration) conditions can create a reductive environment which can lead to the formation of hydrogen sulfide and ammonia, both of which are toxic to fish and other marine life, and place stresses on the aquatic ecosystem. These stresses reduce the diversity of the aquatic community, impede growth rates, and contribute to the incidence of diseases.

Heavy metals and pesticides are also toxic and tend to accumulate and concentrate in the higher trophic levels, which include fish and, ultimately, man. Areas that are highly productive are particularly sensitive to these materials. Every effort must be made to prevent toxic materials from entering the environment.

The aquatic, estuarine, or marine environment will respond to changes in waste and nutrient loadings. The more the system is impacted, the worse water quality will become and the less suitable for certain uses. For example, odors and profileration of weeds make the environment less suitable for recreation purposes, fish spawning grounds may disappear, human diseases may increase, and so on. Therefore, the use values and requirements of the proposed receiving water body need to be considered in determining the acceptable level of impact.

Each of the receiving water bodies associated with Port Said, Ismailia, or Suez has certain beneficial uses such as fisheries, water-based recreation, and wildlife habitat. These uses need to be preserved through maintaining adequate water quality.

End of Chapter 6: Regulations, Laws and Treatment Criteria

7.0 Wastewater Collection System Design Criteria

This section presents the methodology for evaluating the Suez wastewater collection system. It presents information on how the wastewater collection system inventory was prepared, the design criteria used in evaluation of the system, and information on the modeling process.

7.1 Preparation of Wastewater System Inventory Database

The inventory contains information on wastewater collection lines 300 mm and larger and on the manholes connected to them. All inventory information is maintained in Mapinfo database files. ABB Susa Dillingham (ABB) and Chemonics Egypt, in cooperation with the Construction Management Consultants (CMC a joint venture of Black & Veatch International and Montgomery Watson) provided copies of wastewater system maps prepared for CMC projects. Manholes and pipelines shown on drawings for CMC projects have been assigned ID tags, which were used, when possible, in the CCMP work. When available construction contract submittal drawings were also obtained from construction contractors and as-built drawings for existing lines were obtained from NOPWASD and the Govenorate. Data from all these sources varied in accuracy and completeness. Limited information was available for some portions of the system; and elevation data was not available for approximately 40 percent of the manholes.

Information compiled in the Mapinfo database was transferred into Black & Veatch's Sanitary Sewer Management System (SSMS). This program was used to perform a number of checks on the integrity of the data. Negative slopes, inconsistent diameters, inconsistent manhole elevations and other features were flagged for checking and correction.

7.1.1 Use of Available Wastewater System Data

To evaluate hydraulic capacity throughout the wastewater system, key physical data must be known for each segment. Such information includes pipe diameter, pipe length, manhole invert elevations, and the like. For this project, all available data were entered into a MapInfo, GIS database and later into the SSMS program. Inspection of this data revealed that not all manholes included elevation data and those that did were not to a common datum. To produce a functional computer model, the 11,000 plus manholes of the system were simplified to approximately 320 nodes (manholes). The model simplification involves grouping together the pipes with the similar diameter and relatively same slopes and omitting intermediate manhole information. The nodes were included in the hydraulic model at changes of direction for headloss considerations.

In order to produce the SSMS database required for the hydraulic modeling, the following procedures were followed:

- Where no as-built drawings were provided, elevations were interpolated or extrapolated using the line length in the MapInfo database. Missing invert elevations were interpolated between the nearest known manholes with available elevations. Where no levels were available, minimum pipe slopes from the adjacent manholes were assumed. Minimum pipe slopes were considered a realistic estimate due to the relatively flat terrain throughout the Suez study area.
- When it was determined that adjacent wastewater network data was not collected to a common datum, available topographic information was used to assist in the estimation of a common datum. Caution was exercised to ensure that the relative invert elevations were adequate for modeling purposes. At a minimum, the invert elevations of wastewater lines discharging to a common pumping station were all to the same datum. The model accuracy is likely to be affected by this estimation, in direct proportion to the amount of information that was not available.
- Where ground elevation was missing, it was generally assumed to be 3.0 m above the pipe invert elevation. Ground elevation values are not needed for the hydraulic program and are not critical to the analysis, except in the case of excessive surcharging.
- Coordinate data, although not vital for the hydraulic modeling, are required for production of maps. This information was obtained from the MapInfo database and used to build system maps.

7.1.2 Data Input and Checking

A series of data queries were conducted to identify wastewater lines for which input data was not reasonable. The data queries include the following:

- Invert elevation – to identify lines with negative slope. Invert elevations for lines connected to each manhole were also compared.
- Rim elevation – rim elevations were checked against invert elevations.
- Coordinates – Plots of the wastewater system, which depend on the input coordinates, were reviewed for relative accuracy.
- Connectivity – Wastewater line reaches that were not connected to downstream lines in the model were identified, investigated, and where appropriate, corrected.

7.2 Collection System Design Criteria

The improvement criteria described in this section pertain to design of relief lines, lift stations, and force mains. Operating criteria are established for assessing the performance of the wastewater systems, as simulated by the computer hydraulic models, and for sizing future facilities. The recommended criteria consider specific guidelines recommended by the Egyptian Code for Water and Wastewater Networks; NOPWASD adopted operations; and

accepted industry standards for design and operation of efficient and reliable wastewater collection systems. The intent of these criteria is to develop a recommended wastewater system with sufficient capacity to accommodate future peak flows in the collection system and to satisfy maximum month loads at the treatment plant.

Computer models developed for Suez identify existing deficiencies as well as the improvements needed to accommodate future growth. Facility deficiencies were identified by comparing the performance of various elements of the wastewater system to the recommended operating criteria under various scenarios. Specific wastewater collection system components that influence system operation include the following:

- Wastewater pipe size, grade, material, and condition.
- Wastewater line depth of installation.
- Pump station and force main capacity.
- Available amount of wetwell and upstream storage.

7.2.1 Gravity Wastewater Line Design Criteria

The total peak flow determined by the model for each line segment is compared with the full pipe capacity. Parallel relief lines are sized, and costs are assigned for any pipe with a peak flow greater than 100 percent of pipe capacity. All improvements are sized as parallel relief lines. The wastewater line improvement criteria are summarized below:

- Upgrading of pipelines is not considered if projected peak flows are less than 100 percent of capacity.
- Where total flow exceeds 100 percent of pipe capacity, parallel relief lines are sized to transport the peak flow downstream.
- Relief and extension lines are sized for a design flow-to-capacity ratio of 0.75 using Manning's 'n' of 0.013.
- Minimum recommended pipe diameter is 175 mm.
- For gravity pipes smaller than 700 mm, a minimum velocity of 0.5 m/s and maximum velocity of 0.75 m/s at minimum flows is provided.
- For gravity pipes larger than 700 mm and smaller than 2000 mm, a minimum velocity of 0.6 m/s and maximum velocity of 1.0 m/s at minimum flows is provided.

7.2.2 Lift Station and Force Main Evaluation Criteria

The firm capacity of the lift station is assumed as the flow the station can convey with the largest pump out of service. The following criteria are used in evaluating the lift stations:

- Station expansion is recommended when ratio of flow to capacity is between 1.0 and 1.2.
- Station replacement is recommended when flow to capacity ratio is more than 1.2.

Replacement force mains are assumed for all force main improvements. The following criteria are used in evaluating the force mains:

- Force main is recommended for parallel or replacement when maximum velocity at peak flow exceeds 1.8 m/sec.
- Recommended parallel or replacement force mains have design velocity equal to 1.5 m/sec, at maximum capacity of the lift station.

7.2.3 Design Criteria Summary

Table V2-7.1, Recommended System Design and Operating Criteria, presents a summary of the design criteria.

Table V2-7.1 Recommended System Design and Operating Criteria

System Segment	System Operating Conditions	
Gravity Wastewater Collection System Design	Total peak flow determined by model for each segment is compared to full pipe capacity.	
	Parallel relief pipes are sized for any segment with a peak flow greater than 100% of pipe capacity.	
	All improvements are sized as parallel relief pipes	
	Wastewater Collection Improvement Criteria	Pipe upgrading is not considered if projected flows are less than 100% of capacity.
		Where total flow exceeds 100% of pipe capacity, parallel relief pipes are sized and simulated to transport peak flow.
		Relief and extension pipes are sized for a design-to-flow ratio of 0.75 using Manning's "n" of 0.013.
		Minimum recommended pipe diameter is 175 mm.
		For pipes smaller than 700 mm, provide minimum velocity of 0.5 m/s and maximum velocity of 0.75 m/s at minimum flows.
		For pipes larger than 700 mm and smaller than 2,000 mm, provide minimum velocity of 0.6 m/s and maximum velocity of 1.0 m/s at minimum flows.
Lift Station Design	Pump stations will be sized to handle the peak flow with the largest pump out of service.	
	Lift Station Criteria	Station expansion is recommended when ratio of peak flow/capacity is between 1.0 and 1.2.
		Station replacement is recommended when ratio of peak flow/capacity is greater than 1.2.
Force Main Design	Parallel force mains are assumed for all force main improvements	
	Force Main Criteria	Force main replaced when maximum velocity at peak flow exceeds 1.8 m/s.
		Design velocity for new force mains at peak flow is 1.5 m/s.

7.3 Collection System Modeling

7.3.1 Hydraulic Model

The hydraulic model of the wastewater system was developed utilizing wastewater network data, flow data, and a flow routing program. Modeling for this Master Plan included only 300 mm and larger trunk lines. The model was developed using HYDRA software

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(developed by Pizer, Inc., United States), as the hydraulic engine. The data was processed using Black & Veatch's Sanitary Sewer Management System (SSMS) support modules developed to write to and read from HYDRA.

The Average Daily Flow (ADF) determined from the flow monitoring program and land use data was used as the "base" flow component and was input into the model. The monitored diurnal, seasonal, and daily flow variations observed at Suez WWTP were input into the hydraulic model to obtain peak flows. Infiltration was considered a constant flow during high groundwater conditions, as observed infiltration flows were relatively constant over several days. The system was not influenced by rainfall; therefore, no stormwater inflow was modeled.

7.3.2 Model Calibration

A series of analyses were performed to calibrate the model flow data against actual treatment plant flow data to ensure accurate simulation. The collection system peaking factors farther upstream were adjusted to make the simulated hydraulic peak at the treatment plant match the measured peaks. Attempts were made to match flows predicted by the model with monitored or recorded flows at specific points in the collection system, such as at lift stations. However, due to the limited nature of monitored flow data, only general comparisons were made. Detailed model calibration was not conducted, a thorough flow monitoring program was outside the scope of this project.

7.3.3 Planning Horizon

For purposes of this study, the planning period for the Suez Wastewater Master Plan is through year 2020; however, hydraulic evaluations were also carried out for ultimate development. Ultimate development was considered full occupancy of developed areas.

7.3.4 Existing System Analysis for Peak Flow Conditions

The purpose of modeling the existing system was to determine how the system would respond to peak dry weather flows.

7.3.4.1 Existing Modeled Flow Rate

The average daily flow (ADF) rates and infiltration rates used in the model were determined from the flow projections. The average flow rates were distributed in the model at selected node points. In most cases, the ADF rates were applied to individual manholes receiving flows from the contributing polygon or contributory area.

7.3.4.2 Peak Wastewater Flow Analysis

The peak wastewater flow analysis simulated the dry weather condition, using peak wastewater production plus infiltration to determine whether any of the existing trunk lines

are undersized for current peak wastewater flow. The model indicated that a number of pipes are overloaded during existing peak dry weather conditions.

Following the hydraulic analyses, parallel relief lines were sized and costs were developed for all lines which currently receive peak flows exceeding 100 percent of their existing capacity. Analyses and results of hydraulic modeling are presented in chapter 8.

End of Chapter 7: Wastewater Collection System Design Criteria

8.0 Current and Future Wastewater Needs

This section provides a description of current and future expansion, upgrading, and extensions that will be needed for the Suez wastewater collection and treatment system.

8.1 Wastewater Collection System Analysis

The existing collection system model developed for Suez consists of approximately 230 manholes (nodes) and approximately 23,600 m of 300 mm to 1200 mm wastewater pipes. Some pipes smaller than 300 mm were included in the model if required to reach individual subbasins. The model includes all lift stations which form part of the existing trunk system. Table V2-8.1, Modeled Gravity Trunk Wastewater Line Inventory, shows a breakdown of the wastewater lines modeled by diameter. The trunk lines were identified through review of maps and drawings provided by NOPWASD, SCA, the Govenorate, CMC, and other consultants. Other relevant information not provided on the as-built drawings was obtained through interviews with Suez Govenorate personnel. The locations of the existing 300 mm and larger trunk lines and lift stations are shown on Figure V2-8.1, Suez Modeled Wastewater System.

Table V2-8.1 Modeled Wastewater Pipes Inventory

Diameter (mm)	Length (m)
225	302
300	9,373
375	4,568
450	6,256
500	1,142
600	94
800	1,177
1,000	713
1,400	1,900
2,000	4,900
Total	23,625

Table V2-8.2, Lift Stations, includes lift stations in the study area that were analyzed in the hydraulic model.

Table V2-8.2 Lift Stations

Lift Station	No of Pumps	Lift Station Firm Capacity (m^3/day)	Force Main Diameter (mm)	Force Main Length (m)
24 October	2	6,650	300	1,500
Arab El-Mamel	4	36,000	400	2,000
Ataqa	5	207,360	1,400	1,900
El-Omda	2	2,810	300	800
El-Arbein	2	15,550	300	3,000
El-Herafien	2	25,920	800	800
Faisal	3	12,960	300	1,600
Gabalaya	4	64,800	800	6,600
Kafr Hoda	4	12,960	300	2,000
Manshia	2	4,320	200	1,000
Port Tawfik	2	8,210	250	4,000
Sawahel	2	8,640	200	1,500
Tal. El-Qalzam	3	5,760	400	5,000
Zaraier	3	39,750	800	2,500
Zareb	4	46,650	700	5,250

8.1.1 Hydraulic Capacity Evaluation for Existing Peak Flow Conditions

A summary of the recommended relief lines presented in Table V2-8.3, Relief Lines Existing Conditions.

Table V2-8.3 Relief Lines Existing Conditions

Length of Overloaded Pipes (m)	Total Length of Pipes (m)	Overloaded Pipes Based on Length (%)
3,521	30,310	11.6

Results of the analysis show that parts of the system may already be overloaded. For the existing conditions approximately 11.6 percent of the modeled wastewater collection system is overloaded under peak dry weather conditions. Table V2-8.4, Overloaded Pipes Existing Conditions, presents a summary of the overloaded lines according to percent utilization.

Table V2-8.4 Overloaded Pipes Existing Conditions

Percent Utilization (%)	Overloaded Pipes Peak Conditions Total Length (m)
100-125	1,726
125-150	135
> 150	1,660
Total	3,521

Lift stations were evaluated based on flow conditions and the station's firm capacity For the purposes of this report "Firm Capacity" is defined as the capacity of the station with the largest pump out of service. Two examples, below illustrate this concept.

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Firm Capacity - Example 1

Lift station with four pumps. Two pumps have 500 m^3/day capacity and two pumps have 750 m^3/day capacity.

Station Firm Capacity = 500 + 500 + 750 + ~~750~~
= 500 + 500 + 750
= 1,750 m^3/day

Firm Capacity - Example 2

Lift station with three pumps each with 500 m^3/day capacity.

Station Firm Capacity = 500 + 500 + ~~500~~
= 500 + 500
= 1,000 m^3/day

Force mains were evaluated based on flow velocity not exceeding 1.8 m/s. Table V2-8.5, Lift Stations/Force Mains Existing Conditions, shows a summary of the pumping station and force main capacities and the existing peak flows at each station.

Table V2-8.5 Lift Stations/Force Mains Existing Conditions

Lift Station	Station Firm Capacity (m^3/day)	Force Main Capacity (m^3/day)	Station Modeled Peak Flow[1] (m^3/day)	Recommendations
24 October	6,650	10,964	4,673	
Arab El-Mamel	36,000			
Ataqa	207,360	239,435	140,744	
El-Omda	2,810			
El-Arbein	15,550	10,964	22,652	Replace LS & Parallel FM
El-Herafien	25,920	78,183	22,268	
Faisal	12,960	10,964	21,671	Replace LS & Parallel FM
Gabalaya	64,800			
Kafr Hoda	12,960	10,964	8,751	
Manshia	4,320			
Port Tawfik	8,210			
Sawahel	8,640	14,923	5,960	
Tal. El-Qalzam	5,760	19,492	6,329	Replace LS
Zaraier	39,750	77,967	37,568	
Zareb	46,650	59,694	41,849	

1) Existing, Peak, Dry Weather Flow Conditions.
LS= Lift Station
FM= Force Main

As seen in Table V2-8.5, three lift stations (El-Arbein, Faisal and Tal El-Qalzam) have reached their design capacity and should be enlarged or replaced. Additionally two force mains (El-Arbein and Faisal) are inadequate for current peak conditions. It should be noted that the lift stations' rated capacities are greater than the firm capacities used in the analysis;

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therefore, the stations could periodically handle more flow, provided that all pumps are in service.

8.1.2 Year 2020 Hydraulic Peak Flow Capacity Evaluation

This section describes the hydraulic capacity evaluation of the Suez collection system for year 2020 growth conditions. The collection system was evaluated with projected year 2020 flows.

8.1.2.1 Year 2020 Peak Wastewater Flow Analysis

The initial peak wastewater flow analysis simulated dry weather conditions, using peak wastewater production and high groundwater infiltration. Inflow was not included. Dry weather flow was simulated to determine whether any of the existing pipes are undersized for future peak wastewater flow. Results of the analysis show that parts of the system will become overloaded during year 2020. For the year 2020 peak dry weather flow approximately 5,562 meters of pipe are overloaded and this represents approximately 18.3 percent of the modeled pipe.

Table V2-8.6 Relief Lines Year 2020 Conditions

Length of Overloaded Pipes (m)	Total Length of Pipes (m)	Overloaded Pipes Based on Length (%)
5,562	30,310	18.3

Table V2-8.7, Summary of Overloaded Lines 2020 Conditions, presents a summary of the overloaded lines according to percent utilization.

Table V2-8.7 Summary of Overloaded Lines 2020 Conditions

Percent Utilization (%)	Overloaded Lines Peak Conditions Total Length (m)
100-125	3,216
125-150	355
> 150	1,991
Total	5,562

Lift station capacities were evaluated based on projected peak flows and the present firm capacity. Four lift stations (El-Arbein, Faisal, Tal El-Qalzam and Ataka) and two force mains (El-Arbein and Faisal) were found to have inadequate capacity and will require expansion or replacement to convey future peak dry weather flows. The Ataka station was built with facilities for one additional pump and it should be added at this time. The lift stations and force mains with recommendations for expansion or improvements to convey future flow conditions are listed in Table V2-8.8, Lift Stations / Force Mains 2020 Conditions. The force mains were evaluated based on flow velocities not exceeding 1.8 m/s.

Table V2-8.8 Lift Stations/Force Mains 2020 Conditions

Lift Station	Station Firm Capacity (m^3/day)	Force Main Capacity (m^3/day)	Station Modeled Peak Flow(1) (m^3/day)	Recommendations
24 October	6,650	10,964	6,239	
Arab El-Mamel	36,000			
Ataqa	207,360	239,435	235,000	Expand LS
El-Omda	2,810			
El-Arbein	15,550	10,964	25,404	
El-Herafien	25,920	78,183	29,793	Replace LS & Parallel FM
Faisal	12,960	10,964	28,433	Replace LS & Parallel FM
Gabalaya	64,800			
Kafr Hoda	12,960	10,964	9,436	
Manshia	4,320			
Port Tawfik	8,210			
Sawahel	8,640	14,923	7,425	
Tal. El-Qalzam	5,760	19,492	8,154	Replace LS
Zaraier	39,750	77,967	44,658	
Zareb	46,650	59,694	47,467	

1) Existing, Peak, Dry Weather Flow Conditions

(1) This information was obtained from May 1996 Infiltration/Salinity Report, Page 2/2 Volume 1.
(2) This assumes no upgrade in current conditions.
LS= Lift Station
FM= Force Main

8.1.3 Ultimate Hydraulic Capacity Evaluation for Peak Flow Conditions

Hydraulic modeling of the ultimate growth analysis on the existing system produced almost identical system overloading as the year 2020 analysis. This is as a result of minimal growth within the existing system drainage boundary during this period. The growth that will occur in the Suez system between the year 2020 and ultimate growth is projected to be outside the existing system boundaries and will be served by new extension lines as discussed later.

8.2 Wastewater Treatment Plant Analysis

A study of alternative treatment processes for Suez was conducted during the latter part of 1989 as part of the Canal Cities Water and Wastewater Phase II Project, USAID Contract 263-0174. The final report presenting the results of the study was submitted in October 1989.

First, a review of a rapid infiltration (RI) process, recommended by others in earlier studies, was conducted. A site visit was made to the area selected for the RI treatment. It was subsequently decided that this site was not acceptable because of the shallow groundwater table, steep relief, an active sand dune area, and inadequate space. Two additional sites were investigated and rejected for the same reasons. A general review of the entire surroundings of the City revealed no suitable, cost-effective site. After further study, the following liquid treatment alternatives were considered:

- Deep shaft activated sludge process with and without primary settling.
- Complete mix activated sludge process with and without primary settling.

- Aerated lagoons.
- Trickling filters.

Solids treatment alternatives were also evaluated during the 1989 study. Table V2-8.9, Solids Treatment Alternatives, presents a summary of the solids treatment alternatives considered for each liquid treatment process.

Table V2-8.9 Solids Treatment Alterntatives

Treatment Process	Alternatives
Thickening	Gravity Belt Filter Thickening Gravity Thickening
Stabilization	Anaerobic Digestion Aerobic Digestion Facultative Lagoons
Dewatering	Belt Filter Press Sludge Drying Beds Sludge Drying Lagoons
Dry Sludge Storage	Land Application on Dedicated Land Land Application on Agricultural Fields Landfilling

In the aerated lagoon process, solids in the wastewater settle to the bottom of the lagoons and are stabilized. Unlike the other processes considered, the aerated lagoons require no additional sludge thickening and stabilization facilities.

The study recommended the aerated lagoon process followed by sludge drying lagoons and landfilling of the dried solids. This recommendation was based on least cost, high treatment reliability, and ease of operation. These reasons are still valid. The aerated lagoon process is highly reliable and is easy to operate. Adequate space is available and, during construction of the plant, provisions were made for installing an additional process train when it becomes necessary. It is recommended that the wastewater treatment process currently used in Suez be continued.

Further liquid treatment evaluation has not been conducted as part of this master plan study. However, the potential for effluent reuse and improvements to solids handling, including the use of composting, have been evaluated.

8.3 Wastewater Effluent Reuse

The acceptability of treated wastewater for reuse depends on a number of factors, including the physical, chemical, and microbiological quality of the water. Making wastewater suitable for reuse is achieved either by (1) removing or reducing the concentrations of microorganisms and chemical constituents of concern through wastewater treatment or (2) eliminating contact between reuse water and edible crops by design or by operational controls.

The constraints on reuse related to physical characteristics, such as pH, temperature, particulate matter, and chemical constituents (i.e., chlorides, sodium, heavy metals, and some trace organic compounds) are well known, and recommended limits have been established for

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many of these constituents. One chemical constituent for which recommended limits have been established and which is of concern to the Suez Wastewater Treatment Plant is total dissolved solids (TDS), which cannot be removed by conventional wastewater treatment. To remove the dissolved solids, desalination must be used. Desalination is a very costly method of treatment and makes the cost of reuse water prohibitive when compared to irrigation water obtained from other sources.

A few agricultural crops, such as the date palm and several varieties of grass, are salt tolerant and can survive TDS concentrations equal to 1,000 mg/L in the irrigation water. However, as the plants extract fresh water from the irrigation supply, the salt concentration in the soil will increase and must be leached out of the soil. The leaching process requires greater quantities of water, all of which will flow to waste.

The health risks associated with microorganisms are more difficult to assess. Epidemiological investigations directed at wastewater-contaminated drinking water supplies, the use of partially treated wastewater for food crop irrigation, the health effects of contact with such water on farm workers, and the infections carried by aerosols or windblown spray from spray irrigation sites, have provided considerable evidence of infectious disease transmission. In developing countries, the irrigation of market crops with that inadequately treated wastewater is a major source of enteric disease.

For these reasons, water reuse standards and guidelines are concerned principally with the protection of public health and with nonpotable uses such as agricultural irrigation, and are generally based on the control of pathogenic organisms.

Where public contact with reuse water is likely or where the water is used to irrigate edible crops, tertiary treatment is typically required to produce essentially pathogen-free finished water. Recommended guidelines published jointly by the United States Environmental Protection Agency (USEPA), United States Agency for International Development (USAID), and the World Health Organization (WHO) are presented below.

United States Environmental Protection Agency

The USEPA jointly with the USAID published "Guidelines for Water Reuse" in 1992. The primary purpose of the document is to provide guidelines for utilities and regulatory agencies in the U.S., particularly in states where standards do not exist or are being revised or expanded. The guidelines address water reuse for non-potable urban, industrial, and agricultural applications as well as indirect potable reuse by groundwater recharge and augmentation of surface water sources of supplies. The USEPA guidelines address important aspects of water reuse and include recommendations on treatment processes, water quality limits, monitoring frequencies, and other controls for various water reuse applications. The treatment processes and water quality limits recommended in the guidelines for various applications are given in Table V2-8.10, USEPA Recommended Guidelines for Reuse.

Both reuse water quality limits and wastewater treatment unit processes are recommended for the following reasons:

- Water quality criteria involving surrogate parameters do not adequately characterize reuse water quality.
- A combination of treatment and quality requirements known to produce reuse water of acceptable quality obviate the need to monitor the finished water for certain constituents.
- Expensive, time-consuming and, in some cases, questionable monitoring for pathogenic microorganisms is eliminated without compromising health protection; and treatment reliability is enhanced.

Total and fecal coliforms are the most commonly used indicator organisms in reuse water. The total coliform analysis includes organisms of both fecal and non-fecal origins.

Since fecal coliforms are better indicators of fecal contamination than total coliforms, the guidelines use fecal coliforms as the indicator organism.

The USEPA guidelines include limits on fecal coliforms, but not on parasites or viruses. In the U.S., the parasites have not been shown to be a problem at the treatment levels and reuse water quality limits recommended in the guidelines, although there has been considerable interest in recent years regarding the occurrence and significance of *giardia* and *cryptosporidium* in reuse water. Where USEPA recommends filtration and high levels of disinfection to produce reuse water that is essentially free of measurable pathogens, chemical addition prior to filtration may also be necessary.

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Table V2-8.10 USEPA Recommended Guidelines for Wastewater Reuse

Type of Use	Treatment	Reclaimed Water Quality
Urban Uses, Food Crops Eaten Raw, Recreational Impoundments	Secondary; Filtration; and Disinfection	pH = 6-9 ≤ 10 mg/L BOD ≤ 2 NTU No Detectable Fecal Coli/100 mL ≥ 1 mg/L Cl_2 Residual
Restricted Access Area of Irrigation, Processed Food Crops, Aesthetic Impoundments, Construction Uses, Industrial Cooling, Environmental Reuse	Secondary and Disinfection	pH = 6-9 ≤ 30 mg/L BOD ≤ 30 mg/L SS ≤ 200 Fecal Coli/100 mL ≥ 1 mg/L Cl_2 Residual
Groundwater Recharge of Nonpotable Aquifers by Spreading	Site Specific and Use Dependent, Primary (Minimum)	Site Specific and Use Dependent
Groundwater Recharge of Nonpotable Aquifers by Injection	Site Specific and Use Dependent, Secondary (Minimum)	Site Specific and Use Dependent
Groundwater Recharge of Potable Aquifers by Spreading	Site Specific, Secondary and Disinfection (Minimum)	Site Specific, Meet Drinking Water Standards After Percolation Through Vadose Zone
Groundwater Recharge of Potable Aquifers by Injection, Augmentation of Surface Supplies	Includes the Following: Secondary; Filtration; Disinfection; and Advanced Wastewater Treatment	Includes the Following: pH = 6.5-8.5 ≤ 2 NTU No Detectable Fecal Coli/100 mL ≥ 1 mg/L Cl_2 Residual Meet Drinking Water Standards

NOTE: NTU values based on 24-hour average value should not exceed 5 NTU at any time, should be met prior to disinfection; fecal coli counts for use categories 1 and 6 are based on a 7-day median value, should not exceed 14 fecal coli/100 ml in any sample; Cl_2 residual measured after a minimum contact time of 30 minutes; industrial cooling use based on recirculating cooling towers; fecal coli count for use category 2 based on a 7-day median value, should not exceed 800 fecal coli/100 ml in any sample.

While viruses are a concern in reuse water, the guidelines do not include virus limits for the following reasons:

- A significant body of information exists indicating that viruses are inactivated or removed to low levels by appropriate wastewater treatment.
- The identification and enumeration of viruses in wastewater are hampered by relative low virus recovery rates.
- There are a limited number of facilities having the equipment and personnel necessary to perform the analyses.
- The laboratory analyses can take as long as four weeks to complete.
- There is no consensus among public health officials regarding the health significance of low levels of viruses in reuse water.

World Health Organization

The World Health Organization (WHO) published guidelines in 1989 for the use of reclaimed water in agriculture and aquaculture. The WHO guidelines are directed mainly at reuse in countries where specific guidelines have not been developed, and are less restrictive than water reuse guidelines in the U.S. and in many other industrialized countries. The WHO guidelines are generally followed in Egypt.

The report of a WHO Scientific Group on Health Aspects of the Use of Treated Wastewater for Agriculture and Aquaculture that met in Geneva in 1987 was published by WHO as "*Health Guidelines for the Use of Wastewater for Agriculture and Aquaculture*". The recommended microbiological quality guidelines are summarized in Table V2-8.11, WHO Recommended Guidelines for Wastewater Reuse.

Table V2-8.11 WHO Recommended Guidelines for Wastewater Reuse

Category	Reuse Conditions	Exposed Group	Intestinal Nematodes (Arithmetic Mean No. Per 100 ml)	Fecal Coliforms (Geometric Mean No. Per 100 ml)	Wastewater Treatment to Achieve the Required Quality
A	Irrigation of: Crops Likely to be Eaten Uncooked; Sports Fields; Public Parks	Workers, Consumers, Public	< 1	≤ 1,000	Stabilization Ponds to Achieve the Micro-biological Quality Indicated, or Equivalent Treatment
B	Irrigation of: Cereal Crops; Industrial Crops; Fodder Crops; Pasture; and Trees	Workers	≤ 1	No Standards Recommended	Retention in Stabilization Ponds for 8-10 Days or Equivalent Helminth and Fecal Coliform Removal
C	Irrigation of: Crops in Category B if Exposure of the Workers and the Public Does Not Occur	None	Not Applicable	Not Applicable	Pretreatment as Required by the Irrigation Technology, But Not Less Than Primary Sedimentation

NOTE: In specific cases, local epidemiological, sociocultural, and environmental factors should be taken into account, and the guidelines modified accordingly; intestinal nematodes include Ascaris and Trichuris species and hookworms; nematode egg and fecal coliform count during irrigation period; for Category A reuse conditions a more stringent guideline (<200 fecal coliforms per 100 ml) is appropriate for public lawns such as hotel lawns, with which the public may come into direct contact; for Category B reuse conditions in the case of fruit trees, irrigation should cease two weeks before fruit is picked, and no fruit should be picked off the ground. Sprinkler irrigation should not be used.

The guidelines are based on the conclusion that the main health risks are associated with helminthic diseases and, therefore, a high degree of helminth removal is necessary for the safe reuse of wastewater. Intestinal nematodes serve as indicator organisms for large settleable pathogens. The guidelines indicate that other pathogens apparently become nonviable in long-retention pond systems, implying that helminth eggs and protozoan cysts will be

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removed to the same extent. The guidelines applicable to helminth eggs are intended as a design standard, not as a standard requiring routine testing of the effluent.

The Scientific Group concluded that where the only exposed populations are farm workers, no bacterial guidelines are necessary due to the lack of evidence indicating a health risk from bacteria. The recommended bacterial guideline of a geometric mean fecal coliform level of 1,000/100 ml is considered to be technically acceptable. The Scientific Group indicated that the potential health risks associated with the use of treated wastewater for lawn and park irrigation may be greater than those associated with the irrigation of vegetables and, therefore, recommended a fecal coliform limit of 200/100 ml for such urban irrigation.

The 1989 WHO guidelines identify waste stabilization ponds as the method of choice for meeting these guidelines in warm climates where land is available at reasonable cost. Based on helminth removal, the guidelines recommend a retention time of 8 to 10 days and at least twice that length of time to reduce the fecal coliforms to 1,000/100 ml.

The intent of international organizations such as the World Bank and the United Nations Development Program, who sponsored early work in this area, was to introduce at least some treatment of wastewater prior to crop irrigation in developing countries. The WHO guidelines satisfy this intent. The WHO guidelines are appropriate as an interim measure in developing countries until there is ability to produce reuse water of higher quality.

Stabilization pond systems have large land requirements and may be appropriate in warm climates. However, experience in the Middle East indicates that most existing stabilization pond systems are unable to consistently meet the WHO guidelines for the irrigation of food crops eaten raw.

8.3.1 Potential Reuse of Suez Wastewater Treatment Plant Effluent

The characteristics of the effluent from the Suez Wastewater Treatment Plant indicate that the effluent must have additional treatment before it is made available for reuse. Two of the most notable characteristics are the total dissolved solids and the coliform bacteria. The average TDS of the effluent for the 12-month period ending in October 1998 was approximately 2,645 mg/L. Because of this high concentration of TDS, the effluent will support only the most salt-tolerant crops if used as irrigation water without further treatment. These crops may be date palms or certain forage crops. Additional testing should be performed to determine soil conditions and drainage. It is recommended that desalination of the effluent be considered if the effluent is to be used for irrigation.

Another possibility for reuse would be as industrial process water. Normally, the high TDS concentration would preclude the use of the effluent as cooling water, even for one-pass cooling. If it is used for cooling water, recycling is not recommended. As for use as process water, a nearby industry has expressed interest in the wastewater plant effluent, and has collected samples for analysis. If the industry determines that it can use the effluent, either as

it is or with additional treatment, a contract between the industry and the Directorate should be established. In most industries, desalination would be recommended for reuse applications.

The coliform count in the effluent is another area of concern. The World Health Organization recommends a count not to exceed 1000/100ml for crops likely to be eaten uncooked, and a count not to exceed 200/100 ml for water that will be used for irrigation of parks and playing fields. The average coliform count in the wastewater treatment plant effluent has frequently been over 50,000/100 ml. For the effluent to be considered for any reuse, it must be disinfected to reduce the health hazards. The most common means of disinfection is chlorine. The effluent contains algae and other suspended solids that will consume chlorine before residual chlorine disinfection can take place. It is recommended that the treatment process be followed by filtration to remove the algae and other suspended solids before chlorine is added.

Other constituents of the wastewater that will cause problems when trying to reuse the wastewater for irrigation are the heavy metals, which can be toxic to plant growth even in minute concentrations. Presently, no testing is done for these metals. A complete testing program should be implemented to determine the concentrations of heavy metals in the effluent.

In addition to tertiary treatment before reuse can be considered, other facilities will be necessary. The costs of storage basins for the treated effluent, pump stations, and transmission lines to the point of use must be considered when comparing the cost of reuse against the cost of obtaining water from another source.

8.3.2 Disinfection Evaluation

It has been reported that the Egyptian Environmental Affairs Agency have expressed concern about the coliform bacteria being discharged in the wastewater treatment plant effluent. Fecal coliforms are generally used as indicator organisms for the presence of bacterial pathogens because their survival characteristics and rates of removal in treatment processes are similar to those of pathogens. The removal of bacterial pathogens is one of the objectives of wastewater treatment. A reduction in fecal coliforms is accepted as a reduction in pathogens.

In Suez wastewater treatment plant effluent is discharged to Suez Bay. To determine the effect of the discharge, samples of the water in the bay near the point of discharge should be collected and tested for fecal coliforms. Studies performed at the start of The Canal Cities Water and Wastewater Phase II Project (USAID Contract No. 263-0174) to determine that design requirements for the treatment plant determined the plant effluent would not require disinfection.

If new studies indicate the need for disinfection or if the effluent is reused for irrigation, industrial process water, etc. then disinfection should be considered. The most common method for reducing the coliform count in wastewater treatment plant effluents is by adding

chlorine. The existing wastewater treatment plant does not have facilities for disinfection, although the plant's hydraulic design includes provisions for adding disinfection in the future without the need for pumping. Facilities needed for adding chlorine include the following:

- Covered storage area for 30 one tonne containers.
- Chlorine feed building.
- Chlorine feed equipment.
- Chlorine contact basins.
- Instrumentation.

The amount of chlorine to be used daily will need to be determined. This can be done by conducting a series of tests using different concentrations of chlorine and determining the chlorine residual and the number of coliform organisms surviving after a period of time. In order to evaluate the cost to disinfect the effluent, it is assumed the chlorine concentration will be between 5 and 10 mg/L. For the average day flow experienced in 1998, the amount of chlorine required each day will be between 470 and 950 kg.

Chlorine is available in Alexandria. The cost to refill a one-tonne (1,000 kg) container in early 1999 was approximately $280 (980 LE). The cost of disinfecting with chlorine will be $130 to $270 (460 LE to 930 LE) per day. After adding transportation to and from Alexandria, it is estimated that the price would double. This would generate costs of up to $440 (1,500 LE) per day or nearly $162,000 (550,000 LE) per year. Costs would vary depending on the quality quantity of the effluent.

8.4 Biosolids

The 1989 treatment study recommended the aerated lagoon process followed by sludge drying lagoons and landfilling of the dried solids. This recommendation was based on least cost, high treatment reliability, and ease of operation. These reasons are still valid. The dredging and sludge drying process is highly reliable and is easy to operate. Adequate space is available in the existing drying lagoons to handle the amount of biosolids being produced. It is recommended that the biosolids handling process currently used in Suez be continued. Although the need for additional drying lagoons is not anticipated for at least 10-15 years or longer, records should be maintained regarding actual quantities of sludge being produced in order to project the need for additional facilities in the future.

Because biosolids are landfilled, testing for stabilization and metal content in the dried sludge has not been conducted routinely. In order to consider beneficial uses for the biosolids, a program for regular testing should be established to assess the suitability of the dried solids for reuse.

Although composting of biosolids has been implemented in Port Said, it has met with limited success. Much difficulty has been experienced with the quality of solid waste and the resulting compost material. Mechanical failures have also hampered the composting

operations. Test should be conducted to determine suitability of for the biosolids for composting and solid waste sorting capabilities in Suez should be evaluated. In light of the difficulties experienced with the composting program in Port Said it is recommended that composting of biosolids at the Suez plant not be implemented at this time.

8.5 Assessment of WWTP Capacity

The Suez WWTP has a design capacity of 130,000 m^3/day (average day) with BOD loading of 280 mg/L and TSS loading of 400. mg/L. The plant was constructed with two 65,000 m^3/day treatment trains, with provisions for expansion with addition of one additional 65,000 m^3/day train.

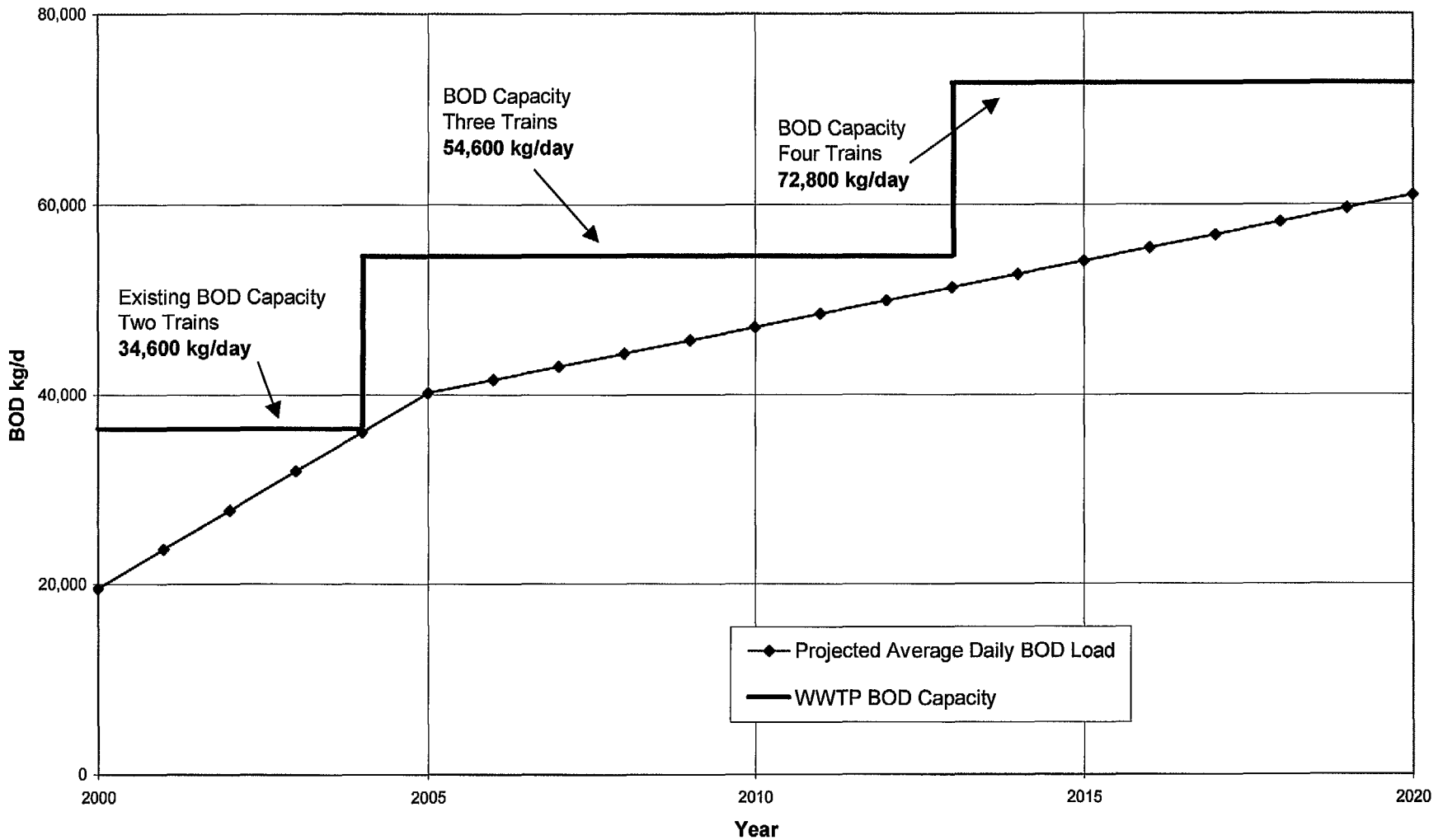
To date, the plant has not reached its design capacity of 130,000 m^3/day. The 1998 average was approximately 95,400 m^3/day. The average BOD and TSS concentrations have also not reached design values. Plant effluent has been of acceptable quality and well within the design effluent limits.

The flow and loads to the WWTP will increase as the population of Suez increases and as the number of persons served by the wastewater system increases. As noted above, wastewater treatment plant capacity is often expressed as a flow rate in m^3/day and as BOD and TSS concentration in mg/L. Another, often more useful, way to express treatment plant capacity is in terms of mass loading rate. Experience indicates that in many types of wastewater treatment plants, the BOD mass loading rate is one of the most, if not the most, critical measure of plant capacity and/or performance.

The design BOD mass loading rate for the Suez plant is 36,400 kg/day. According to 1998 operating data, the average BOD mass loading rate was approximately 16,000 kg/day or approximately half of the design rate.

In earlier chapters of this Master Plan, population projections for Suez were presented. By estimating future flows to the treatment plant as well as future BOD concentrations, a graph like Figure V2-8.2, Suez WWTP BOD Treatment Capacity vs. Projected BOD Mass Loading, was generated.

Figure V2-8.2, Suez WWTP BOD Treatment Capacity vs. Projected BOD Mass Loading, illustrates that using design BOD mass loading rate the BOD treatment capacity of the plant will be exceeded in 2004. This projection is dependent upon rate of growth in the number of persons and businesses connected to the wastewater system within the next five years. If growth of the wastewater system occurs at a lower rate BOD mass loading capacity will not be exceeded as soon.



ARAB REPUBLIC OF **EGYPT** SUEZ CANAL AUTHORITY NATIONAL ORGANIZATION FOR POTABLE WATER AND SANITARY DRAINAGE	**USAID** CANAL CITIES WATER AND WASTEWATER MASTER PLAN	**SUEZ WWTP BOD TREATMENT CAPACITY VS PROJECTED BOD MASS LOADING RATE**	BLACK & VEATCH INTERNATIONAL IN ASSOCIATION WITH MONTGOMERY WATSON SABBOUR ASSOCIATES DATE: AUGUST 1999 FIGURE: V2-8.2

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Figure V2-8.2 illustrates the effects of adding the third treatment train in year 2004 and a fourth treatment train about year 2014. These two additional treatment trains would be sufficient carry Suez BOD loads beyond 2020.

Chapter 9 of this Master Plan includes estimated CIP costs for these additional treatment trains.

9.0 Implementation Plan

This section presents the priced Implementation Plan, which includes recommendations for upgrading certain existing trunk sections, expansion of the system into currently unserved areas, and extension of the system to accommodate development along with added treatment facilities to treat the additional flows.

9.1 Introduction

The Implementation Plan was prepared using information from flow monitoring, wastewater line inventory, growth and development projections, and computer modeling described in Chapter 8 of this report. The implementation plan prioritizes improvements into two major construction phases following the criteria given below.

9.1.1 Phase 1

- Construction of relief lines to eliminate existing hydraulic deficiencies identified by the model under current peak flow conditions.
- Upgrading of lift stations to eliminate hydraulic deficiencies identified by the model under current peak flow conditions.
- Construction of extension wastewater lines to serve areas currently served by water system, which do not have wastewater facilities.
- Construction of new lift stations to serve areas currently served by water system, which do not have wastewater facilities.
- Wastewater System Management Plan to include an annual program of wastewater line inspection, maintenance, and rehabilitation.
- Wastewater treatment plant expansion to accommodate the increased flows projected to be collected by the other Phase 1 facilities and population growth.

9.1.2 Phase 2

- Construction of extension lines to serve future development areas currently without water or wastewater service.
- Construction of new lift stations to serve future development areas currently without water or wastewater service.
- Wastewater treatment plant expansion to accommodate the increased flows projected to be collected by the other Phase 2 facilities and population growth to the ultimate development conditions.

The capital improvements recommended in the Implementation Plan are based on the following criteria:

- Wastewater line capacity and flow containment for peak wet weather conditions.
- No significant future infiltration removal (the system is not influenced by rainfall).

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Figure V2-9.1, Suez Wastewater System Recommended Improvements and Figure V2-9.2, Suez Existing Wastewater System Improvements, show the facilities included in the implementation plan. The recommended improvements are grouped into two phases. Phase 1 improvements are needed to address immediate or near-term deficiencies and should be constructed within the next 5 years. Phase 2 improvements are additional facilities needed by year 2020. Phase 2 improvements should be reviewed prior to implementation based on the actual growth and water demand patterns.

9.1.3 Wastewater Collection System Extensions

New interceptor lines, lift stations, and force mains will be required to serve portions of the study area which are currently served with water, but not by wastewater collection, and areas of future development. Currently all wastewater collected is tributary to the Atakka Lift Station. This lift station was built specifically to convey wastewater from the old treatment plant to the new treatment plant. The peak flow projections indicate the Atakka Lift Station is fairly well matched to the ultimate peak flow projected from currently connected tributary area. Most of the lift stations and force mains within the existing collection system are in a similar situation.

The new extension lines are indicated on Figure V2-9.1, Suez Wastewater System Recommended Improvements. The recommended interceptors, lift stations, and force mains were sized to serve ultimate development. The indicated locations are preliminary and should be used only as a guide for planning purposes.

More precise alignments and pump station locations must be defined after a detailed topographic and land availability survey along the proposed routes performed alignments has been conducted, under a design contract.

The construction of wastewater collection system extensions is dependent on development within the study area. Phase 1 capital improvement projects focus on serving areas which are currently served with water but do not have wastewater collection or areas currently under development. These Phase 1 interceptors, lift stations, and force mains are sized to accommodate the peak flow under ultimate development conditions.

Some economy may be provided in lift stations by constructing the building to handle the ultimate peak flow, but installing only the number of pumps needed for the Phase 1 expansions cumulative peak flows. Additional pumps can be installed when the Phase 2 extensions are constructed to collect additional flows. Phase 2 extension lines are planned assuming balanced development throughout the study area. Therefore, proposed new interceptors are evaluated as future improvements with construction periods depending on actual extension of the water system into new development areas. It is recommended that utility authorities maintain regular communication with the planning agencies and periodically reassess wastewater facility needs to accommodate development.

9.1.4 Recommended Pipe Materials

Selection of pipe material is based on local manufacturing and soil conditions. The Infiltration and Salinity Study documented that the soil in Suez ranges from moderately corrosive to highly corrosive. The salinity and potential for generation of hydrogen sulfide gas inside the pipes dictates the need for protective measures there also.

The roughness of the inside surface of the pipe has a large impact on velocity and, therefore, on the recommended grade to avoid sedimentation of solids. Using pipes with smooth surfaces, longer pipe lengths, and fewer joints will significantly decrease the number of pump stations needed in flat areas. Recommended pipe materials are based upon comparisons of costs and performance characteristics.

Pipe materials recommended for gravity wastewater lines in are listed below.

- PVC is recommended for pipes 175 mm and 300 mm diameter
- Rigid fiberglass reinforced plastic is recommended for pipes 300 mm to 700 mm diameter;
- Rigid fiberglass reinforced plastic pipe is available in sizes larger than 800 mm and is preferred because of its longer service life if the cost is not considered prohibitive; or
- Reinforced concrete pipe produced locally is an acceptable material for pipes larger than 800 mm diameter.

Pipe materials recommended for force mains in Suez are listed below.

- PVC pressure pipe is recommended for 75 mm to 300 mm diameter force mains;
- Ductile iron pipe is recommended for 350 mm to 1000 mm force mains, and
- Prestressed concrete cylinder pipe is recommended for force mains larger than 1000 mm in diameter.

Reinforced concrete pipe should be protected on the inside by an embedded PVC liner similar to T-lock and coated on the outside with coal tar epoxy against corrosion from the brackish groundwater throughout the Suez area. Special consideration must be given to protection at the joints, which are particularly vulnerable to corrosion. It may also be prudent to wrap the reinforced concrete pipe in an inexpensive taped polyethylene sleeve, as is done with ductile iron pipes, to reduce exterior corrosion.

As always, the installation inspection is as at least as critical as the actual choice of materials. In the case of PVC or rigid fiberglass reinforced plastic, damage during handling and jointing can affect the positive attributes. Although these materials are light and easy to handle, they are also easily damaged if handled roughly. In the case of reinforced concrete pipe, damage to the interior or exterior coatings frequently occur by mishandling during installation and must be repaired before backfilling or commissioning. Even a pinhole in the coal tar epoxy coating will allow corrosion of the reinforcement or prestressing steel leading to corrosion expansion which will crack the cover concrete exposing the pipe to massive

corrosion. Pinhole detectors are available and recommended for inspection of both the coal tar epoxy and PVC linings. Backfilling must be complete before dewatering is stopped to prevent misalignment by floatation.

9.1.5 Recommended Pipe Slopes and Peak Flow Rates

For designing the wastewater system extensions, certain criteria were established. The wastewater collection system was designed to carry the ultimate peak flow at a velocity of at least 1.0 m/s and minimum flows at 0.6 m/s to minimize sedimentation. In general, the slopes are slightly steeper than those previously implemented in Suez, but experience with the existing system and sedimentation problems found during the Canal Cities Phase II work indicate this approach is needed. Table V2-9.1, Recommended Slopes and Design Peak Flow Rates for Various Pipes, presents these recommended criteria, based on the Manning's Equation, for both conventional pipe and smooth bore PVC and GRP pipes.

Table V2-9.1 Recommended Slopes and Flow Rates for Various Pipes

	Concrete, VCP or DIP Pipe (N=0.013)				PVC or GRP Pipe (N=0.010)			
Nominal Size (mm)	ID (mm)	Slope for Velocity of 1 m/sec (m/1000m)	100% Dia. Gravity Flow (m3/d)	Flow Rate as Force Main V=1.5 m/s (m3/d)	ID (mm)	Slope for Velocity of 1 m/s (m/1000m)	100% Dai Gravity Flow (m3/d)	Flow Rate as Force Main V=1.5 m/s (m3/d)
75					70	22.00	347	575
100	100	22.70	702	1,000				
110					103	13.00	744	1,080
150	150	13.20	1,577	2,290				
175	175	10.80	2,152	3,117				
200	200	9.00	2,805	4,072	190	5.70	2,531	3,675
225	225	7.70	3,552	5,153				
250	250	6.70	4,388	6,362	238	4.22	3,971	5,766
300	300	5.25	6,316	9,161				
315					300	3.10	6,310	9,161
350	350			13,000				
375	375	3.90	9,871	14,314				
400	400			16,800	380	2.26	10,119	14,698
450	450	3.10	14,310	20,612				
500	500	2.65	17,523	25,447	500	1.57	17,534	25,447
600	600	2.10	25,366	36,644	600	1.23	25,237	36,644
700	700	1.70	34,426	49,876	700	1.00	34,325	49,876
800	800	1.42	44,921	65,144	800	0.84	44,915	65,144
900	900	1.22	57,003	82,448	900	0.72	56,928	82,448
1000	1000	1.05	70,038	101,788	1000	0.62	69,965	101,788
1200	1200	0.83	101,258	146,574	1200	0.49	101,143	146,574
1300	1300	0.74	118,361	172,021				
1400					1400	0.40	137846	199,504
1500	1500	0.61	157,394	229,022				
1600					1600	0.34	181447	260,576

When reviewing the existing Suez system and proposed expansion designs available from NOPWASD, there appears to be a general trend to utilize gravity pipes significantly larger than are necessary to carry projected peak flows. In theory, larger pipes can be installed on flatter slopes than smaller pipes to obtain the same velocity, if the depth of flow in each is the same percentage of pipe diameter. It appears oversized pipes are being installed mainly to utilize the flatter recommended slopes, thus requiring fewer lift stations. Unfortunately, the installed pipes will have a serious sedimentation problem unless peak flow depth is 75%-80% of the pipe diameter and minimum flow depth is at least 30% of the pipe diameter. Installing oversized pipes should be avoided. It is unnecessarily expensive during construction, and creates a costly sediment cleaning maintenance problem which will last as long as the oversized system is in place.

9.1.6 Improvement Costs

For purposes of economic evaluation and budget estimates, cost data for construction of wastewater facilities such as lines, lift stations and force mains were compiled from recent construction costs from the CMC, Phase II. The basis of construction costs used in preparing budget cost estimates for capital improvement projects is presented in tables below. The construction costs represent average planning level costs based on mobilization/demobilization, shoring, dewatering, surface restoration and construction costs. Additionally these costs are based on use of international contractors, management and inspection. These costs should be updated during detailed design to represent current costs based on the inflation index and method of contracting.

9.1.6.1 Gravity line construction

Table V2-9.2, Wastewater Gravity Line Construction Costs, presents the estimated cost of gravity line construction for relief and extension wastewater lines. The cost per meter of trench, including manhole costs, is presented for representative invert depths.

Table V2-9.2 Wastewater Gravity Line Construction Costs

Nominal Diameter (mm)	Depth of Wastewater Line			
	Up to 3.0m ($/m)	Up to 4.5m ($/m)	Up to 6.0 m ($/m)	Up to 7.5 m ($/m)
200 uPVC	460	560	670	770
250 uPVC	580	680	790	890
300 uPVC	700	800	910	1010
400 GRP	930	1040	1150	1270
500 GRP	1060	1260	1370	1470
600 GRP	1400	1500	1610	1720
700 GRP	1630	1740	1850	1970
800 RCP	1860	1980	2100	2220
1000 RCP	2320	2430	2550	2660
1200 RCP	2790	2910	3030	3150
1300 RCP	3020	3140	3260	3380
1500 RCP	3490	3610	3740	3870

UPVC = unplasticized poly vinylchloride pipe
GRP = glas reinforced plastic pipe (fiberglass pipe)
RCP = reinforced concrete pipe

9.1.6.2 Force Main Construction

Table V2-9.3, Force Main Unit Construction Costs, shows the basis of costs for force main construction. The force main improvement costs are based on average costs per meter and an average depth between 1 to 2 m, and do not take into consideration valve chambers and fittings or air valves. These appurtenances should be priced individually based upon the detailed design and vertical alignment.

Table V2-9.3 Force Main Unit Construction Costs

Nominal Diameter (mm)	Cost per meter length ($)
75 uPVC	150
100 uPVC	160
125 uPVC	180
150 uPVC	190
200 uPVC	200
250 uPVC	250
300 uPVC	300
350 DI	350
400 DI	410
500 DI	520
600 DI	620
700 DI	720
800 DI	820
900 DI	930
1,000 DI	1030
1,200 PCCP	1240
1,300 PCCP	1340
1,500 PCCP	1550

uPVC = unplasticized poly vinylchloride pipe
DI = ductile iron pipe
PCCP = prestressed concrete cylinder pipe

9.1.6.3 Lift Station Construction

Table V2-9.4, Lift Station Construction Cost, presents the lift station construction costs, based on the capacity of the station. Expansion or replacement of the lift station is considered based on the flow to capacity ratio. These costs represent planning level costs and should be updated during detailed design. The decision whether to expand or to replace a pumping station will be made at detailed design stage, based on the condition and physical configuration of the station.

Table V2-9.4 Lift Station Construction Costs
(Cost per Unit Pump Discharge (m^3/s)

Lift Station Capacity (m^3/day)	Expansion Costs ($)	Replacement Costs ($)
250	40,000	90,000
500	70,000	150,000
1,000	110,000	220,000
2,500	150,000	310,000
5,000	250,000	490,000
10,000	430,000	860,000
20,000	690,000	1,370,000
25,000	770,000	1,530,000
30,000	830,000	1,670,000
50,000	1,290,000	2,580,000
75,000	1,660,000	3,310,000
125,000	2,390,000	4,780,000
250,000	3,800,000	7,600,000

9.1.7 Contracting Procedures

The following sections present a breakdown of the critical capital improvements identified in Chapter 8 into separate capital improvement projects (CIP). The components of each CIP intended to be implemented at the same time, although components requiring different construction capabilities may be contracted separately. Capital improvement projects to be implemented by foreign contractors may be grouped to make a more attractive package and to reduce the necessary mobilization and overhead costs as a proportion of the work to be accomplished. On the other hand, if the work is to be performed by local contractors, the components may be divided among several contracts to accommodate different capabilities and smaller firms.

Wherever a capital improvement project is dependent on another project located downstream, those CIPs are identified. The contracting agency must pay special attention to scheduling, monitoring, and funding of contracts to ensure that the downstream projects are completed first.

Except for the relief line construction, all capital improvement projects will require some degree of detailed design and site surveying. This can be done under a single contract for all Phase 1 projects or with a separate design team for each project. Detailed design for Phase 1 should begin immediately, and sufficient time should be allocated before construction bidding is scheduled.

9.2 Phase 1 - Recommended Capital Improvement Projects

9.2.1 CIP 1 - Upgrading of Existing System to Handle Current Peak Flows

9.2.1.1 Relief Wastewater Line Improvements

For existing (year 1999) conditions, the model indicates that a total of approximately 3,500 meters of wastewater lines are overloaded during peak dry weather conditions. The overloaded lines are detailed in the CIP1 cost summary below. The capital improvement projects for relief wastewater lines required to meet existing system needs are shown on Figure V2-9.1, Suez Wastewater System Recommended Improvements, and are identified by the prefix "CIP1."

For planning purposes, relief lines are sized to parallel existing wastewater lines at the slopes as the existing lines. It is recommended that the upstream invert of the relief line be set above the invert of the existing pipe by approximately 60-75% of the diameter of the existing pipe. This configuration will allow the relief line to begin carrying peak flow before the manhole surcharges, but will maintain minimum flows in the existing pipe to avoid sedimentation in both pipes during low flows.

9.2.1.2 Lift Station Improvements

Lift station and force main capacities were evaluated based on existing and projected peak flow conditions and the existing firm capacity for each lift station. When the ratio of expected peak flow to firm capacity (peak flow/firm capacity) is less than 1.0, the station appears to be adequate and no improvement is recommended. Expansion is recommended when the ratio of peak flow to firm capacity exceeds 1.0, but is less than 1.2. Lift station expansion is defined as increasing the capacity by replacing pumps or modifying the impellers of existing pumps to obtain additional capacity within the space constraints of the existing pump station and wetwell configuration. A 20% increase in capacity was considered a practical limit without causing operational or maintenance problems. Lift station replacement is recommended when the ratio of peak flow to firm capacity is higher than 1.2.

Detailed review of whether to expand or to replace each lift station should be carried out before or during detailed design. Of the 15 lift stations investigated, three are recommended for improvement during Phase 1: Feisal, El-Arbien, and Tal. El-Qalzam. The recommended firm capacities of Phase 1 lift station improvements are listed in the CIP detail table below. The recommended firm capacities resulting from Phase 1 improvements are estimated to accommodate peak flows up to ultimate development.

9.2.1.3 Force Main Improvements

Force main capacities were evaluated based on existing and projected peak flow conditions and the existing firm lift station capacity. Proposed force main improvements are

assumed to be constructed in parallel; however, whether the existing force mains are paralleled or replaced with larger pipe should be determined during detailed design, considering the physical condition of the existing pipe and available space or alternate alignment for parallel force mains. Feissal and El-Arbien force mains will require improvements during Phase 1.

Many of the force mains from the existing lift stations discharge into the reception basin of the old wastewater treatment plant. As future connections are made to this basin it should be inspected and evaluated for structural and hydraulic integrity.

9.2.1.4 Cost Summary

CIP 1 – Existing System Critical Improvements

Facility	Size	Length	Estimated Cost
Feisal LS Replacement	28,500 m^3/d	NA	1,600,000
El-Arbien LS Replacement	25,500 m^3/d	NA	1,550,000
Tal. El-Qalzam LS Replacement	8,200 m^3/d	NA	740,000
Feisal Parallel FM	400 mm	1,600 m	656,000
El-Arbien Parallel FM	400 mm	3,000 m	1,230,000
CIP1-P1 Parallel Relief Line	500 mm	80 m	85,000
CIP1-P2 Parallel Relief Line	450 mm	110 m	110,000
CIP1-P3 Parallel Relief Line	400 mm	120 m	115,000
CIP1-P4 Parallel Relief Line	375 mm	90 m	80,000
CIP1-P5 Parallel Relief Line	450 mm	125 m	125,000
CIP1-P6 Parallel Relief Line	300 mm	585 m	410,000
CIP1-P7 Parallel Relief Line	375 mm	180 m	160,000
CIP1-P8 Parallel Relief Line	600 mm	80 m	110,000
CIP1-P9 Parallel Relief Line	450 mm	56 m	55,000
CIP1-P10 Parallel Relief Line	700 mm	385 m	630,000
CIP1-P11 Parallel Relief Line	500 mm	40 m	60,000
CIP1-P12 Parallel Relief Line	800 mm	450 m	1,000,000
CIP1-P13 Parallel Relief Line	450 mm	281 m	280,000
CIP1-P14 Parallel Relief Line	450 mm	750 m	745,000
CIP1-P15 Parallel Relief Line	450 mm	100 m	100,000
CIP1-P16 Parallel Relief Line	800 mm	66 m	125,000
CIP1-P17 Parallel Relief Line	450 mm	110 m	95,000
		Construction Cost Subtotal	$10,061,000
		Construction Contingency 20%	2,012,000
		Subtotal	$12,073,000
		Engineering and Administration Cost 20%	2,415,000
		Total Capital Improvement Cost	**$14,488,000**

9.2.2 CIP 2 – Port Tawfik Dock Area Collection System

The information gathered indicates the dock area south of the Port Tawfik collection system has no wastewater collection and is currently discharging directly to the Gulf of Suez.

Although the flow is small, to eliminate the pollution, a collection system with one or more small lift stations should be constructed with a force main to the Port Tawfik LS.

The components and cost of CIP 2 are detailed below.

CIP 2 – Port Tawfik Dock Area Collection System

Facility	Size	Length	Estimated Cost
CIP 2 – LS	1000 m3/d	NA	220,000
CIP 2 – FM to Port Tawfik LS	100 mm (1)	250 m	40,000
		Construction Cost Subtotal	$260,000
		Construction Contingency 20%	52,000
		Subtotal	$312,000
		Engineering and Administration Cost 20%	62,000
		Total Capital Improvement Cost	**$374,000**
1) 100mm pipe is shown based on flow requirements at time of design this should be evaluated further based on flow, possible sedimentation and expected O&M.			

In addition to the lift station and force main, CIP 2 serves an area of 63 hectares currently developed for light industrial use, which will drain to it by gravity. This area will be served by collectors and laterals smaller than 300 mm, which are not included in the scope of this report or the costs above.

To function properly, CIP 2 depends upon the Tawfik LS being connected to the Zarab LS by a functioning force main, this may not be the case now.

9.2.3 CIP 3 – Westside Lower Trunk

CIP 3 is planned to serve the existing development along both sides of the road on the west side of town and draining to the Atakka lift station. These developments are owned and operated by private industries. Recent information indicates that there may be wastewater collection systems within these residential complexes but they do not appear to be connected to the municipal wastewater collection and treatment system. The Westside Lower Trunk is intended to provide a conduit to connect these existing private developments to the WWTP. Once built, the Suez Govenorate must enforce regulations prohibiting private developments discharging untreated wastewater to the environment.

The components and cost of CIP 3 are detailed below.

CIP 3 – Westside Lower Trunk

Facility	Size	Length	Estimated Cost
Gravity Trunk	1500 mm	3650 m	13,000,000
		Construction Cost Subtotal	$13,000,000
		Construction Contingency 20%	2,600,000
		Subtotal	$15,600,000
		Engineering and Administration Cost 20%	3,120,000
		Total Capital Improvement Cost	**$18,720,000**

In addition to carrying the flow from existing developments, CIP 3 serves an area of 500 hectares currently developed or projected for development as residential and light industrial, which drain by gravity. This area will be served by collectors and laterals smaller than 300 mm, which are not included in the scope of this report or the costs above.

To function properly, CIP 3 depends upon CIP 6 being complete.

9.2.4 CIP 4 – Old Drainage Channel Interceptor

CIP 4 is planned to serve a strip of developed land along the south and east bank of the old drainage canal north of the Old WWTP. Based on recent information, it appears this area is draining to a canal instead of being collected and conveyed to the WWTP.

The components and cost of CIP 4 are detailed below.

CIP 4 – Old Drainage Channel Interceptor

Facility	Size	Length	Estimated Cost
Gravity Interceptor	300 mm	1620 m	1,200,000
Gravity Interceptor	380 mm	800 m	750,000
		Construction Cost Subtotal	$1,950,000
		Construction Contingency 20%	390,000
		Subtotal	$2,340,000
		Engineering and Administration Cost 20%	468,000
		Total Capital Improvement Cost	**$2,808,000**

In addition to intercepting the flow to the Old Drainage Canal, CIP 4 serves 55 hectares currently developed or projected for development, which drain to it by gravity. This area will be served by collectors and laterals, smaller than 300 mm, which are not included in the scope of this report or the costs above.

9.2.5 CIP 5 - West Gabalaya Collector

The information collected indicates there is an isolated development area west of the Gabalaya Lift Station, which has no organized wastewater collection but should be drained to the Gabalaya Station. CIP 5 is planned to provide this collection.

The components and cost of CIP 5 are detailed below.

CIP 5 – West Gabalaya Collector

Facility	Size	Length	Estimated Cost
Gravity Collector	300 mm	120 m	100,000
Gravity Collector	400 mm	1260 m	1,300,000
		Construction Cost Subtotal	$1,400,000
		Construction Contingency 20%	280,000
		Subtotal	$1,680,000
		Engineering and Administration Cost 20%	336,000
		Total Capital Improvement Cost	**$2,016,000**

In addition to intercepting the existing flow going to the Old Drainage Canal, CIP 5 serves 30 hectares currently developed and projected for development as low density residential, which drain to it by gravity. This area will be served by collectors and laterals smaller than 300 mm, which are not included in the scope of this report or the costs above.

9.2.6 CIP 6 - Coastal Interceptor, Lift Station, and Force Main

CIP 6 is planned to serve coastal areas which are below the old WWTP and 2000 mm gravity main to the Atakka Lift Station. The CIP 6 lift station and force main will convey the wastewater intercepted along the coast of the Gulf of Suez up to the inlet works of the new WWTP. In addition, it will receive the flow from CIP 3. During Phase 2, when CIP 15 is constructed, additional pumps will need to be added to this lift station along with a second force main.

The components and cost of CIP 6 are detailed below.

CIP 6 – Coastal Interceptor, Lift Station, and Force Main

Facility	Size	Length	Estimated Cost
CIP 6 – LS	268,000 m3/d (114,000 m3/d pumping added in Phase 2)	NA	6,000,000
CIP 6 - FM to WWTP	1300 mm	2,500 m	3,350,000
Gravity Interceptor	1300 mm	400 m	1,300,000
Gravity Interceptor	1200 mm	1810 m	5,300,000
Collector	380 mm	250 m	250,000
Collector	300 mm	2450 m	1,700,000
		Construction Cost Subtotal	$17,900,000
		Construction Contingency 20%	3,580,000
		Subtotal	$21,480,000
		Engineering and Administration Cost 20%	4,296,000
		Total Capital Improvement Cost	**$25,776,000**

In addition to intercepting existing industrial and residential discharges to the Gulf of Suez, CIP 6 serves 420 hectares projected for residential and industrial development, which drain to it by gravity. This area will be served by collectors and laterals smaller than 300 mm which are not included in the scope of this report or the costs above.

9.2.7 CIP 7 – Industrial Zone Collection System

CIP 7 is planned to serve the existing heavy and petrochemical industries located in the center of the Suez waterfront. Each of these major industrial complexes is responsible for collecting the wastewater generated within the complex. The information gathered indicates this wastewater is currently discharged directly to the Gulf of Suez with little pretreatment.

Figure V2-9.1, Suez, Wastewater System Recommended Improvements. identifies local developments LD-7, LD-8, and LD-9 to be implemented by various industrial complexes. These systems will also require pretreatment before discharging to the municipal collection

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system. CIP7 lift station will act as a receiving and testing point for the pretreated industrial waste.

In addition, CIP7 lift station and force main act as a link in forwarding intercepted wastewater along the coast from the Canal end (east) of Suez.

The components and cost of CIP 7 are detailed below.

CIP 7 – Industrial Zone Collection System

Facility	Size	Length	Estimated Cost
CIP 7 – LS	80,000 m3/d	NA	3,500,000
CIP 7 – FM to CIP 6P	800 mm	3,000 m	2.500,000
Gravity Interceptor	1000 mm	800 m	1,860,000
Receiving & Testing Basin on south side of highway plus crossing	NA	NA	140,000
		Construction Cost Subtotal	$5,500,000
		Construction Contingency 20%	1,100,000
		Subtotal	$6,600,000
		Engineering and Administration Cost 20%	1,320,000
		Total Capital Improvement Cost	**$7,920,000**

In addition to serving as an industrial wastewater receiver and a link in the coastal interceptor, CIP 7 serves an area of 90 hectares, currently under development and projected for future development, which drains by gravity. This area will require collectors and laterals smaller than 300 mm, not included in the scope of this report or the costs above.

To function properly, CIP 7 depends upon CIP 6 being complete.

9.2.8 CIP 8 – SCA Zone Interceptor System

CIP 8 is planned to serve the existing SCA Zone along the Canal north of the dock areas. According to available information SCA has constructed a collection system and possibly a lift station serving the residential area just east of the Suez Sweetwater Canal. It is believed that the lift station is pumping untreated wastewater into the Canal. Officials advised that SCA is negotiating with NOPWASD to transfer the infrastructure and operations of the system to NOPWASD, but no details were available.

This area is particularly important, because it is currently isolated from the municipal system, but projected for significant future growth. CIP 8 forms the upstream end of the coastal interceptor. Because of the developing nature of CIP 8, it is recommended that the lift stations be built for the stated capacity, but that the firm pumping capacity be installed for only the existing demand. The remaining pumps will be installed during Phase 2 CIP 14. To prevent sedimentation, the force mains should be installed as two parallel pipes. In the case of CIP 8-FM, twin 350 mm lines will allow proper velocity. In the case of CIP 8/1-FM, a 350 mm to carry the existing flow and a 700 mm line for future expansion are recommended. Both of these force mains should be installed now, to ensure that there is adequate space and

to obtain large savings by installing both pipes in a single trench. Postponing the installation of the second pipe may reduce the cost by only 25% now, but will more than double the cost in the long term, not to mention disrupting more services and traffic in the future. A single 350 mm force main should join CIP 8LS all the way through to CIP 7P, while the future 350 mm and 700 mm force mains should be blocked off in the vicinity of the Phase 2 CIP 14LS.

The components and cost of CIP 8 are detailed below.

CIP 8 – SCA Zone Interceptor System

Facility	Size	Length	Estimated Cost
CIP 8 – LS	27,000 m3/d (12,000 m3/d pumps to be installed in Phase 2)	NA	1,300,000
CIP 8 - FM to CIP 8 LS	2 x 350 mm	1200 m	700,000
CIP 8/1 - FM to CIP 7P	350 mm 700 mm	4700 m	4,700,000
		Construction Cost Subtotal	$6,700,000
		Construction Contingency 20%	1,340,000
		Subtotal	$8,040,000
		Engineering and Administration Cost 20%	1,608,000
		Total Capital Improvement Cost	**$9,648,000**

CIP 8 serves 160 hectares, currently under development as very low density residential and light industrial, which drain to it by gravity. This area will be served by collectors and laterals, smaller than 300 mm, which are not included in the scope of this report or the costs above.

To function properly, CIP 8 depends upon CIPs 7, and 6 being complete.

9.2.9 CIP 9 – Phase 1 Wastewater Treatment Plant Expansion

CIP 9 is planned to expand the existing treatment plant to carry the increased flows anticipated by year 2004 from expansion of the collection system into currently unserved areas, population expansion, and industrial expansion. Expansion of the WWTP includes minor upgrading of the inlet works by adding a new flume and a third treatment lagoon train with connecting piping. No additional drying beds or solids handling areas are considered necessary at this stage. To have these additional facilities on line by 2004, the design and construction should be carried out in parallel with the Phase 1 collectors and pump stations.

The components and cost of CIP 9 are detailed below.

CIP 9 – Phase 1 Wastewater Treatment Plant Expansion

Facility	Size	Length	Estimated Cost
Mobilization @10%	NA	NA	2,031,000
Headworks	Lump Sum	NA	715,000
Sitework and Treatment Lagoons	65,000 m^3/d	NA	19,594,000
		Construction Cost Subtotal	22,340,000
		Construction Contingency 20%	4,468,000
		Subtotal	$26,808,000
		Engineering and Administration Cost 20%	5,362,000
		Total Capital Improvement Cost	**32,170,000**

9.3 Phase 2 Recommended Capital Improvement Projects

9.3.1 CIP 10 - Upgrading of Existing System to Handle Ultimate Peak Flows

9.3.1.1 Relief Wastewater Line Improvements

Additional Phase 2 relief wastewater lines required for future conditions are shown in green on Figure V2-9.1, Suez Wastewater System Recommended Improvements. The additional lines will be needed to convey additional peak flow due to growth by year 2020. These relief lines were sized to carry the projected peak flow under ultimate development conditions. These additional Phase 2 lines should be constructed before year 2020.

9.3.1.2 Lift Station Improvements

Phase 2 lift station recommended improvements are to accommodate peak flows up to ultimate development conditions. One additional lift station, Herafien LS, must be replaced in Phase 3. In addition, pump No. 6 must be added to the existing Atakka Lift Station, bringing the capacity to 311,000 m^3/day and firm capacity to 259,200 m^3/day. If the full complement of pumps was not installed in all Phase 1 replacement lift stations, they must be installed under Phase 2.

9.3.1.3 Force Main Improvements

Phase 2 force main recommended improvements are to accommodate peak flows up to ultimate development conditions. If the recommended parallel force mains were added in Phase 1, no additional force main improvements will be required in Phase 2.

9.3.1.4 Summary

The components and cost of CIP 10 are detailed below.

CIP 10 – Existing System Phase 2 Improvements

Facility	Size	Length	Estimated Cost
El-Herafien LS Replacement	30,000 m^3/d	NA	1,670,000
Atakka LS Expansion (52,000 expansion)	311,000 m^3/d	NA	1,340,000
CIP10-P18 Parallel Relief Line	450 mm	135 m	135,000
CIP10-P19 Parallel Relief Line	375 mm	365 m	320,000
CIP10-P20 Parallel Relief Line	300 mm	200 m	140,000
CIP10-P21 Parallel Relief Line	450 mm	35 m	35,000
CIP10-P22 Parallel Relief Line	375 mm	25 m	22,000
CIP10-P23 Parallel Relief Line	300 mm	115 m	80,000
CIP10-P24 Parallel Relief Line	700 mm	465 m	760,000
CIP10-P25 Parallel Relief Line	450 mm	220 m	260,000
CIP10-P26 Parallel Relief Line	300 mm	80 m	55,000
CIP10-P27 Parallel Relief Line	250 mm	267 m	155,000
CIP10-P28 Parallel Relief Line	300 mm	55 m	40,000
		Construction Cost Subtotal	$5,012,000
		Construction Contingency 20%	1,002,000
		Subtotal	$6,014,000
		Engineering and Administration Cost 20%	1,203,000
		Total Capital Improvement Cost	**$7,217,000**

9.3.2 CIP 11 – Local Development Interceptor

CIP-11 is planned to intercept wastewater from industrial and residential developments east and north of the organized private development. Recent information indicates these areas are discharging wastewater to the environment untreated. The proposed interceptor drains to the residential area's lift station. Some arrangement may need to be made to compensate the private owner of the lift station for the extra pumping required. On the other hand, once CIP 6 is built, this private facility can pump to the CIP 6 interceptor, instead of pumping to the Old WWTP; this will lower power costs.

The components and cost of CIP 11 are detailed below.

CIP 11 – Local Development Interceptor

Facility	Size	Length	Estimated Cost
Gravity Interceptor	300 mm	950 m	700,000
		Construction Cost Subtotal	$700,000
		Construction Contingency 20%	140,000
		Subtotal	$840,000
		Engineering and Administration Cost 20%	168,000
		Total Capital Improvement Cost	**$1,008,000**

CIP 11 serves an area of 65 hectares projected for development as low density residential and light industrial, which will drain to it by gravity. This area will be served collectors and

laterals smaller than 300 mm which are not included in the scope of this report or the costs above.

9.3.3 CIP 12 – Isolated Development Interceptor

CIP-12 is planned to intercept wastewater from a developing residential area north of the existing 2000 mm gravity main between the Old WWTP and the new Atakka Lift Station. Recent information indicates this area is discharging wastewater to the environment untreated. The proposed interceptor will drain to the existing 2000 mm gravity main, which will require a connection chamber.

The components and cost of CIP 12 are detailed below.

CIP 12 – Isolated Development Interceptor

Facility	Size	Length	Estimated Cost
Gravity Interceptor	300 mm	600 m	$420,000
Gravity Interceptor	400 mm	200 m	200,000
Gravity Interceptor	500 mm	450 m	480,000
		Construction Cost Subtotal	$1,100,000
		Construction Contingency 20%	220,000
		Subtotal	$1,320,000
		Engineering and Administration Cost 20%	264,000
		Total Capital Improvement Cost	**$1,584,000**

CIP 12 serves an area of 100 hectares, projected for development as low density residential, which will drain to it by gravity. This area will be served by collectors and laterals, smaller than 300 mm, which are not included in the scope of this report or the costs above.

9.3.4 CIP 13 – Cross Trunk Interceptors

CIP 13 is planned to serve the area on both sides of the 1200 mm gravity trunk currently under construction north of the 2000 mm gravity trunk from the Old WWTP and the new Atakka Lift Station.

The components and cost of CIP 13 are detailed below.

CIP 13 – Cross Trunk Interceptors

Facility	Size	Length	Estimated Cost
Gravity Collector	300 mm	700 m	50,000
Gravity Collector	400 mm	200 m	200,000
Gravity Collector	500 mm	1900 m	2,000,000
Gravity Collector	600 mm	500 m	840,000
		Construction Cost Subtotal	$3,090,000
		Construction Contingency 20%	618,000
		Subtotal	$3,708,000
		Engineering and Administration Cost 20%	742,000
		Total Capital Improvement Cost	**$4,450,000**

CIP 13 serves 320 hectares projected for development as low density residential, which drain to it by gravity. This area will be served by collectors and laterals smaller than 300 mm which are not included in the scope of this report or the costs above.

9.3.5 CIP 14 – East Lowlands Development Collector System

CIP-14 is planned to serve the projected development of the lowlands east of the Suez central district and the Suez Sweetwater Canal. At this time, the area is a low wetland but is projected for development into low and very low density residential. When this area is filled and developed, this CIP wastewater collection system should be built. This system will include both a new lift station and additional pumps in the Phase 1 CIP 8 lift station.

The components and cost of CIP 14 are detailed below.

CIP 14 – East Lowlands Development Collector Syst

Facility	Size	Length	Estimated Cost
CIP 14 / 1– LS	8,700 m^3/d	NA	$780,000
CIP 14 / 1 – FM	400 mm	800 m	330,000
CIP 14P Gravity Collector	300 mm	400 m	320,000
CIP 14 / 2– LS	11,800 m^3/d		1,000,000
CIP 14 / 2 – FM	350 mm	980 m	340,000
CIP 14LS	65,000 m^3/d	NA	3,000,000
CIP 8LS Expansion	27,000 m^3/d (12,000 m^3/d Expansion)	NA	450,000
Gravity Collector	600 mm	1495 m	2,240,000
Gravity Collector	700 mm	800 m	1,400,000
Gravity Collector	800 mm	500 m	1,000,000
		Construction Cost Subtotal	$10,860,000
		Construction Contingency 20%	2,172,000
		Subtotal	$13,032,000
		Engineering and Administration Cost 20%	2,606,000
		Total Capital Improvement Cost	**$15,638,000**

CIP 14 serves an area of 350 hectares, projected for development as residential, which drain to it by gravity. This area will be served by collectors and laterals smaller than 300 mm which are not included in the scope of this report or the costs above.

To function properly, CIP 14 depends upon CIP 8 being complete.

9.3.6 CIP 15 – Northwest Development Area Collection System

The area northwest of Suez is currently desert, but is projected for very low density residential development. CIP 15 is planned to serve this area and should be constructed when development begins. This collection system functions completely by gravity and discharges to the CIP-3 Westside Lower Trunk, which by this time may need cleaning to remove sedimentation accumulated during Phase 1 low flow. CIP 15 also includes upgrading to CIP

6 lift station by adding pumping capacity and another force main from CIP 6LS to the WWTP.

The components and cost of CIP 15 are detailed below.

CIP 15 – Northwest Development Area Collection System

Facility	Size	Length	Estimated Cost
CIP 6LS Expansion	268,000 m3/d (114,000 m3/d expansion)	NA	2,100,000
Additional FM	1000 mm	2500 m	2,600,000
Gravity Collector	300 mm	1300 m	$900,000
Gravity Collector	400 mm	2420 m	2,200,000
Gravity Collector	500 mm	3000 m	3,200,000
Gravity Collector	600 mm	2950 m	4,200,000
Gravity Collector	700 mm	1600 m	2,600,000
Gravity Collector	800 mm	600 m	1,100,000
Gravity Collector	1000 mm	650 m	1,500,000
Gravity Collector	1100 mm	500 m	1,300,000
Gravity Collector	1200 mm	750 m	2,100,000
Gravity Collector	1500 mm	2950 m	10,300,000
		Construction Cost Subtotal	$34,100,000
		Construction Contingency 20%	6,820,000
		Subtotal	$40,920,000
		Engineering and Administration Cost 20%	8,184,000
		Total Capital Improvement Cost	**$49,104,000**

CIP 15 serves an area of nearly 1,000 hectares projected for development as very low density residential, which drain to it by gravity. This area will be served by collectors and laterals, smaller than 300 mm which are not included in the scope of this report or the costs above.

To function properly, CIP 15 depends upon PH1 CIP 3 being completed.

9.3.7 CIP 16 - Southwest Suez Industrial Zone

The industrial area south of the WWTP on the west shore of the Gulf of Suez. Available information indicates that there is a proposal for the industrial developers to install and maintain a private collection system and treatment plant. To date this plan does not appear to have been implemented. If the industries in this area do not implement collection and treatment in a timely manner, CIP 16 should be implemented as part of Phase 2.

The components and cost of CIP 16 are detailed below.

CIP 16 – Southwest Suez Industrial Zone

Facility	Size	Length	Estimated Cost
Gravity Collector	300 mm	700 m	$500,000
Gravity Collector	400 mm	1100 m	1,000,000
Gravity Collector	500 mm	2000 m	2,500,000
Gravity Collector	600 mm	1000 m	1,500,000
Gravity Collector	700 mm	2250 m	4,200,000
		Construction Cost Subtotal	$9,700,000
		Construction Contingency 20%	1,940,000
		Subtotal	$11,640,000
		Engineering and Administration Cost 20%	2,328,000
		Total Capital Improvement Cost	**$13,968,000**

CIP 16 serves an area of nearly 750 hectares projected for development as industrial area, which drains by gravity. This area will be served by collectors and laterals smaller than 300 mm which are not included in the scope of this report or the costs above.

To function properly, CIP 16 depends upon PH1 CIP 6 being completed.

9.3.8 CIP 17 – Phase 2 Wastewater Treatment Plant Expansion

CIP 17 is planned to expand the existing treatment plant to carry the increased flows anticipated by year 2013 from extension of the collection system into future development areas and population expansion. This expansion of the WWTP includes construction of a major expansion of the headworks and adding a fourth treatment lagoon train with connecting piping. At this point some rehabilitation of existing works and additional sludge drying beds will be needed. To have these additional facilities on line by 2013, the design and construction should be initiated in 2010.

The components and cost of CIP 17 are detailed below.

CIP 17 – Phase 2 Wastewater Treatment Plant Expansion

Facility	Size	Length	Estimated Cost
Mobilization @ 10%	NA	NA	$2,830,000
Headworks	130,000 m^3/d	NA	1,430,000
Sitework and Treatment Lagoons	65,000 m^3/d	NA	19,595,000
Solids Handling Facilities	NA	NA	7,271,000
Upgrades and rehabilitation	NA	NA	5,659,000
		Construction Cost Subtotal	$36,785,000
		Construction Contingency 20%	7,357,000
		Subtotal	$44,142,000
		Engineering and Administration Cost 20%	8,828,000
		Total Capital Improvement Cost	**$52,970,000**

9.4 Wastewater System Management Plan

Wastewater system surveys for system maintenance and control of infiltration should be performed at least every 5 years. Before this Master Plan the Suez Infiltration/Salinity survey was conducted and most of the urgent and cost effective repairs have been implemented. Routine monitoring of infiltration should be conducted and if expected levels of infiltration removal are not achieved, additional studies and rehabilitation projects may be required.

To maintain the existing system and to prolong the life the facilities it is recommended that a wastewater system management plan be developed to improve the performance of the system as indicated in Table V2-9.5, Wastewater System Management Plan. These activities are necessary in order. Failure to implement a maintenance program results in deterioration of the facilities. The recommended wastewater system management plan should include the following components:

- An annual program of cleaning and inspection of wastewater lines by closed circuit television cameras and other inspections as needed.
- System inspections to identify areas in need of rehabilitation.
- Updating the hydraulic model at least every 5 years in order to ensure that the model reflects the current land use and demographic changes.

It is recommended that the model be updated with field survey data including manhole invert elevations. It should be noted that the system includes some negative pipe slopes. In constructing the hydraulic model for this project, all pipe segments were assumed to have positive slopes. If negative slopes were modeled, the hydraulic capacity evaluation would have produced different flow values due to the negative slopes acting as bottlenecks, and causing flows to back up. It is recommended that a complete inventory of the wastewater system be conducted to determine the pipe invert elevations and to identify negative pipe slopes which should be eliminated from the system in order to allow for flow by gravity. The cost of a complete survey of the approximately 8,500 manholes in the wastewater system is estimated at $1.1 million. However, the cost to survey only the 250 manholes used in preparing the hydraulic model for this study is estimated at approximately $35,000. The cost estimate listed in Table V2-9.5, Wastewater System Management Plan, does not include an allowance for local expatriate administrative support.

Table V2-9.5 Wastewater System Management Plan

Work Tasks[1]	Purpose/Benefit	Probable Construction Cost ($)
Planning Activities		
Wastewater System Inventory	The wastewater system inventory will consist of surveying all manholes in the study area to record, manhole invert level, in-coming and out-going pipe inverts and pipe diameters. [2].	$1,100,000
Flow Meters	Install flow-recording devices at the 15 major lift stations to record hourly flow data for future planning. The hourly data will provide information on diurnal patterns and any response of the system to rainfall or infiltration and changes in flow patterns over the years [2].	300,000
Hydraulic Modeling Training	Provide training of up to six months in use of hydraulic modeling. The purpose of the training will be to meet USAID's goal of providing a sustainable master plan that could be routinely and effectively updated by local utilities. This training will enable local staff to learn the model development process, make revisions to model input data, and use the model to develop capital improvement programs. A long-term training program allows time for involvement of personnel at all levels of the organization, including management. [2]	300,000
Land Use Map Update (Year 2005)	Land use update will reflect current land use data and include any changes in demographic data since the completion of this Master Plan.	150,000
Model Update (Year 2005)	Model update will reflect accurate surveyed data from manhole inventory work to be performed prior to the model. The updated model will have the accurate invert information and therefore will produce more accurate results than the current model. The updated model will also have current flow projections from the revisions to the land use data.	500,000
Sub-Total		$2,350,000
Inspection Activities		
Manhole Inspections	To identify infiltration sources and the structural condition of the manholes.[2]	1,000,000
Television Inspections	To identify infiltration sources and determine the condition of the wastewater lines, and sedimentation problems, which reduce the effective capacity of the system. [2]	800,000
Sub-Total		$1,800,000
Maintenance Activities		
Rehabilitation	To reduce infiltration and extend life of the wastewater system.	3,500,000
Sub-Total		$3,500,000
Total		$7,650,000

1) Individual projects will require prioritizing prior to implementation.
2) The cost estimate does not include an allowance for local expatriate administrative support.

9.5 Summary of Costs

The total projected capital cost of the Phase 1 Implementation Plan is $122 million. The current value of the Phase 2 Implementation Plan is $146 million. The recommended capital

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improvement projects are summarized in Table V2-9.6, Summary of Probable Capital Cost – Phase 1 and Table V2-9.7, Summary of Probable Capital Cost – Phase 2, and indicated on Figure V2-9.1, Suez Wastewater System Recommended Improvements. Construction costs include allowances for mobilization/demobilization, shoring, dewatering, and surface restoration. Costs will vary based on the actual surface and subsurface conditions. The projected capital costs listed for capital improvement projects include construction cost plus allowances of 20 percent for contingencies and 20 percent for engineering, legal, and administrative costs. No costs are included for land, rights-of-way, or rock excavation.

Table V2-9.6 Summary of Probable Capital Costs - Phase 1

CIP No.	Construction Cost IUS $ (1)	Total Capital Cost US (2)
CIP 1 – Existing System Critical Improvements	$12,073,000	$14,488,000
CIP 2 – Port Tawfik Dock Area Collection System	312,000	374,000
CIP 3 – Westside Lower Trunk	15,600,000	18,720,000
CIP 4 – Old Drainage Channel Interceptor	2,340,000	2,808,000
CIP 5 – West Gabalaya Collector	1,680,000	2,016,000
CIP 6 – Coastal Interceptor, Lift Station, and Force Main	21,480,000	25,776,000
CIP 7 – Industrial Zone Collection System	6,600,000	7,920,000
CIP 8 – SCA Zone Interceptor System	8,040,000	9,648,000
CIP 9 – Phase 1 Wastewater Treatment Plant Expansion	26,808,000	32,170,000
Wastewater System Management Plan	0	7,650,000
Phase 1 Totals	$94,933,000	$121,570,000

1) Construction cost includes 20 percent construction contingency
2) Capital cost includes construction cost and 20 percent engineering and administration cost

Table V2-9.7 Summary of Probable Capital costs - Phase 2

CIP No.	Construction Cost US ($)	Total Capital Cost US ($)
CIP 10 – Existing System Phase 2 Improvements	$6,014,000	$7,217,000
CIP 11 – Local Development Interceptor	840,000	1,008,000
CIP 12 – Isolated Development Interceptor	1,320,000	1,584,000
CIP 13 – Cross Trunk Interceptors	3,708,000	4,450,000
CIP 14 – East Lowlands Development Collector System	13,032,000	15,638,000
CIP 15 – Northwest Development Area Collection	40,920,000	49,104,000
CIP 16 – Southwest Suez industrial Zone	11,640,000	13,968,000
CIP 17 – Phase 2 Wastewater Treatment Plant Expansion	44,142,000	52,970,000
Phase 2 Totals	$121,616,000	$145,939,000

1) Construction cost includes 20 percent construction contingency
2) Capital cost includes construction cost and 20 percent engineering and administration cost

End of Chapter 9: Wastewater System Evaluation

APPENDIX A

1998 SUEZ WASTEWATER TREATMENT PLANT FLOW DATA

Suez WWTP Influent Data

	Plant Influent Flow Data			Plant Influent TSS Data			mass	Plant Influent BOD Data			mass
	Min	Max	Avg	Min	Max	Avg	Avg*Avg	Min	Max	Avg	Avg*Avg
	m^3/day	m^3/day	m^3/day	mg/l	mg/l	mg/l	kg/day (1)	mg/l	mg/l	mg/l	kg/day (1)
Feb-98	82,400	101,700	90,100	65	272	174	15,677	125	286	200	18,020
Mar-98	81,600	99,200	90,400	140	385	227	20,521	121	256	181	16,362
Apr-98	83,500	102,100	91,600	149	360	228	20,885	112	258	173	15,847
May-98	81,600	102,100	94,000	167	337	223	20,962	116	299	181	17,014
Jun-98	86,300	105,000	94,900	113	243	179	16,987	80	249	146	13,855
Jul-98	88,600	108,400	99,200	85	274	164	16,269	77	196	121	12,003
Aug-98	92,600	110,600	101,600	66	215	144	14,630	81	142	104	10,566
Sep-98	90,800	113,200	100,800	103	300	180	18,144	72	233	133	13,406
Oct-98	88,200	115,300	99,000	112	260	182	18,018	129	300	189	18,711
Nov-98	86,700	105,400	96,700	128	326	191	18,470	138	289	187	18,083
Dec-98	87,100	107,100	94,800	143	413	212	20,098	144	290	198	18,770
Jan-99	80,100	100,400	91,400	167	310	229	20,931	140	248	215	19,651
min	80,100	99,200	90,100	65	215	144	14,630	72	142	104	10,566
max	92,600	115,300	101,600	167	413	229	20,962	144	300	215	19,651
avg	85,792	105,875	95,375	120	308	194	18,466	111	254	169	16,024

Design Inflow (2 trains 65,000 each)	*130,000*	*Design TSS*	*400*	*52,000*	*Design BOD*	*280*	*36,400*

Average WWTP Influent Flow (m^3/day)	95,375
Daily TSS Mass Loading (kg/day)	20,962
Daily BOD Mass Loading (kg/day)	19,651
TSS Concentration (mg/l) - based on Daily TSS/Average Influent Flow	220
BOD Concentration (mg/l) - based on Daily BOD/Average Influent Flow	206

(1) based on Average Daily Flow multiplied by Average Daily TSS or BOD

APPENDIX B

LIST OF OVERLOADED PIPES

CIP - 1
Overloaded Pipes -- Existing Conditions

Pipes shown on Figure V2-9.2, Suez Existing Wastewater System Improvements. Overloaded pipes in existing conditions shown as CIP 1.

Upstream Manhole ID	Downstream Manhole ID	Pipe Diameter (mm)	Pipe Run Length (m)
49T27	49T36	225	65
49T28	49T27	225	59
49U14	49T20	225	113
ZRR062	ZRR064	300	66
IMM021	IMM025	300	80
IMM052	IMM056	300	62
ZRR114	ZRR062	300	103
IMM210	IMM198	300	83
IMM058	IMM210	300	25
IMM057	IMM058	300	36
RD060	RD103	300	55
ZRR064	ZRR064A	300	108
IMM056	IMM057	300	50
IMM198	IMM199	300	25
AGCC5	MNN401	300	186
49W32	49W31	300	31
FIS050	FIS049	300	25
FIS052	FIS050	300	35
FIS057	FIS052	300	199
FIS049	FIS045	300	115
SAB513	SAB517	300	105
AML117	AML070	300	269
AML070	AML222/1	300	316
49T52	49T36	375	90
48T12	49T52	375	110
MNN401	MR112	375	266
DL001	HUS208	375	56
FIS026	FIS018	375	165
AML222/1	MR117	375	79
FIS032	FIS026	375	145
HRF002	LS_Feisal	450	40
HRF832	HRF001	450	385
49T36	LS_Zareb	450	30
HRF012	HRF009	450	155
46S020	LS_El Arbein	450	50
HRF001	HRF002	450	20
47U098	47U082	450	80
KH166	LS_Kafr Hoda	450	46
IMM195	46P034	450	750
47Q068	47Q073	500	136

Notes:
1) Manhole IDs taken from I & S study.
2) Pipe runs indicated may include intermediate manholes.
3) Diameters shown taken from best available data, however not field verified.
4) Diameters shown indicate existing pipe.
5) To eliminate overloaded conditions, pipes should be replaced or paralleled. Decision to replace or parallel should be made during design and should be based on condition of existing pipe and field conditions.
6) Pipes shown on Figure V2-9.1, Suez Existing System Improvements.
7) Lengths shown are approximate and should not be used for construction.

CIP - 10
Overloaded Pipes -- 2020 Conditions

Pipes shown on Figure V2-9.2, Suez Existing Wastewater System Improvements.
Overloaded pipes in 2020 conditions shown as CIP 10.

Upstream Manhole ID	Downstream Manhole ID	Pipe Diameter (mm)	Pipe Run Length (m)
46U056	46U054	450	62
47U082	47U049	450	87
46U054	46U053	450	31
FIS033	FIS032	375	25
47U049	47U128	600	72
SAB517	SAB521	300	100
SAB521	SAB376	300	96
HRF014	HRF012	450	63
SAB510	SAB513	300	66
AML222/1	MR117	375	186
IMM001	IMM008	300	254
IMM010	IMM013	300	70
FIS034	FIS033	375	27
47P109	47P075	500	62
IMM008	IMM010	300	82
IMM092	IMM073	300	267
HUS204	HRF832	450	465

Notes:
1) Manhole IDs taken from I & S study.
2) Pipe runs indicated may include intermediate manholes.
3) Diameters shown taken from best available data, however not field verified.
4) Diameters shown indicate existing pipe.
5) To eliminate overloaded conditions, pipes should be replaced or paralleled. Decision to replace or parallel should be made during design and should be based on condition of existing pipe and field conditions.
6) Pipes shown on Figure V2-9.1, Suez Existing System Improvements.
7) Lengths shown are approximate and should not be used for construction.

CIP - 10
Overloaded Pipes -- Ultimate Conditions

Pipes shown on Figure V2-9.2, Suez Existing Wastewater System Improvements. Overloaded pipes in ultimate conditions shown as CIP 10.

Upstream Manhole ID	Downstream Manhole ID	Pipe Diameter (mm)	Pipe Run Length (m)
47P075	47P078	500	62
IMM013	IMM016	300	58
IMM016	IMM021	300	215
IMM025	IMM052	300	377
IMM140	IMM137	300	48
47S077	47S075	450	57
47S075	46S016	450	152
46S016	46S020	450	20
46Q169	46Q184	300	105
47Q067	47Q068	500	21
46U053	47U098	450	108
SAB376	SAB373	375	117
SAB373	SAB372	375	23
SAB372	SAB370	375	20
SAB227	SAB228	375	30
SAB246	SAB247	375	24
SAB216	SAB227	300	153
FIS018	HRF014	450	130
LOW011	LOW009	375	103
LOW174	LOW040	375	101
LOW176	LOW174	375	42
RD068	RD060	300	146
AGC013	AGCC5	300	146
ZRR064A	LS_Zaraier	900	62
MLK101	KH169	300	36
MLK103	MLK101	300	59
KH169	KH166	300	114
LOW009	LOW007	375	91
DL009	DL001	375	226
LOW007	MNN031	375	173
RD103	RD104	300	43
RD104	DL009	300	40
HUS096	HUS204	450	213
MNN031	DL017	375	189
44P06	YTT09	800	391
47Q073	47P109	500	331
48Q008	47Q067	500	314
HUS208	HUS096	450	283
47U128	Tal El Qalzam LS	600	22
OCT009	OCT003	300	114

Notes:
1) Manhole IDs taken from I & S study.
2) Pipe runs indicated may include intermediate manholes.
3) Diameters shown taken from best available data, however not field verified.
4) Diameters shown indicate existing pipe.
5) To eliminate overloaded conditions, pipes should be replaced or paralleled. Decision to replace or parallel should be made during design and should be based on condition of existing pipe and field conditions.
6) Pipes shown on Figure V2-9.1, Suez Existing System Improvements.
7) Lengths shown are approximate and should not be used for construction.