JAPAN INTERNATIONAL COOPERATION AGENCY

AND

BAGHDAD MAYORALTY

IMPROVEMENT OF INTEGRATED SEWERAGE SYSTEM IN BAGHDAD (BASIC STUDY REPORT)

MARCH 2005

TOKO ENGINEERING CONSULTANTS CO., LTD

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Baghdad Districts

Main Stations
Verticaly Pumping Stations(Common)
Verticaly Pumping Stations(Healthy)
Verticaly Pumping Stations(Rain)
Diver Pumping Stations
Tunnels Stations
Filtering Projects

Rusafa DIS.
Adhamiya DIS.
Karkh DIS.
Khadamiyah DIS.
Sader 2 DIS.
Sader 1 DIS.
AL Mansour DIS.
9 Nisaan DIS.
AL Rasheed DIS.
AL Duraa DIS.
Karadah DIS.

Adhamiya DIS.
Sader 2 DIS.
Sader 1 DIS.
Khadamiyah DIS.
Rusafa DIS.
9 Nisaan DIS.
AL Mansour DIS.
Karkh DIS.
Karadah DIS.
AL Duraa DIS.
AL Rasheed DIS.

Executive Summary

EXECUTIVE SUMMARY

1. PROJECT GENESIS

The total population of 5.776 million residing in Baghdad Mayoralty (BM) and neighboring areas is now generating wastewaters of approximately 1.2 million m^3/day (2004 est.). Most of the wastewater finds it's way either directly or indirectly to the Tigris River, without receiving appropriate treatment.

As the river water quality has been continuously deteriorating, the public health and sanitary conditions in BM and neighboring districts have been ever worsening and now reached a deplorable level. In order to improve such acute deterioration of public health and environmental conditions in Baghdad, BM requested the Japanese Government for technical and financial assistance.

In response to the request, the Japan International Cooperation Agency (JICA) dispatched a sewerage expert to Jordan, from November 2004 through March 2005, to undertake a technology transfer program for the selected BM personnel, and to establish an immediate improvement program for the Baghdad Sewerage System.

2. PURPOSE AND SCOPE OF THE STUDY

This study report presents the results of identification and field survey on the present situation of Baghdad's sewerage system, and provides planning bases for the forthcoming Master Plan (M/P) and Feasibility Study (F/S) on the improvement of Baghdad integrated sewerage system.

This study has examined the need for the sewerage system improvement strategy plan, and selected the priority sewerage components that are to be immediately rehabilitated and/or extended, defined as the First Stage Program for Baghdad sewerage system.

The methodology of this study has been therefore to identify and select the utmost urgently required sewerage system facilities and determine the least cost approach to meet the sewerage needs in Baghdad.

3. IMPLEMENTATION OF THE STUDY

BM dispatched five senior engineers of Baghdad Sewerage Authority (BSA) to Jordan, who are responsible for planning, design, construction, and operation and maintenance of the Baghdad sewerage system. The study was undertaken over a period of four-month from November 2004 through March 2005.

JICA sent off a sewerage expert to Jordan from November 2004 through March 2005, to undertake a technology transfer program for the selected BM personnel, and to establish an immediate improvement program for Baghdad sewerage system.

The BM counterpart personnel worked throughout the study period in close cooperation with the JICA study team to identify and investigate the urgently required improvement of the Baghdad sewerage system.

Because of the present restraints for the JICA expert to visit the project sites in Baghdad, the BSA counterpart staff had played major roles for field investigation/survey on the present conditions, and collected recent data and information necessary for developing the sewerage system improvement program.

4. Present Situation of Baghdad Sewerage System

Baghdad's population has rapidly increased from 4.5 million in 1990 to 6.5 million in 2004. Because of the continuing social instability and economic sanctions in the past decade, sewerage service has become considerably inadequate for its present population, and the adverse sanitary condition has caused increasing hazards to public health environment.

Although the present sewerage system covers about 75 percent of the Baghdad’s urban builtup districts, existing sewerage system has not been fully functioning, hence must be immediately improved and utilized by residents in the sewer service area. The whole wastewaters generated must be collected and properly treated at wastewater treatment plants (WWTPs) to the quality acceptable to the public waters.

5. Project Organization

Baghdad Sewerage Authority (BSA) should be made fully responsible for the Baghdad’s sewerage system management, construction, operation and maintenance. BSA is to implement an improvement program of the integrated sewerage system, and will have significant implications for BSA's organization, staffing, and finances.

As shown in Table-1 below, the BSA staff in 2004 appears too short for catering all the Baghdad sewerage system operation and maintenance works in proper manner.

Table-1 Present BSA Staff

Job Category	Fixed Employee	Temporary Employee	Total
Officer	542	232	774
Technician	420	106	526
Total	962	338	1,300

Source: BWA, March 2005.

6. NEED FOR IMPROVEMENT OF SEWERAGE

A major program is immediately needed to provide improved public sanitation and environment to all the population in the sewered areas of Baghdad and to cope with its future growth.

Though the sewerage system improvement works have already been underway in the Rusafa District, much portions of the sewerage system in Karkh District are left intact, and every day about 480,000m^3 raw wastewaters are being discharged to the Tigris River. In view of this, the improvement of sewers, pumping stations and WWTP in Karkh District is apparently most urgently required among other sewerage facilities.

Without the improvement project, the current severely deteriorated public health and water environment in Baghdad will further get worse, and reducing essential services to its people. Public health conditions will continue to deteriorate in the absence of adequate sewerage services in Baghdad. Pollution of local groundwater and of the Tigris River, already serious, could rise to more dangerous levels.

7. STRATEGIC PLAN FOR SEWERAGE IMPROVEMENT

(1) SELECTION OF HIGH PRIORITY FACILITIES FOR IMPROVEMENT

To determine an appropriate implementation priority of the sewerage improvement program, each of the candidate plans has been evaluated as to its significance in terms of quantifiable and non-quantifiable factors.

The study has led to the conclusion that the facilities listed in Table 2 are those required urgent improvement.

Table-2 Required Sewerage Improvement Works

Items		Sewer District	
		Rusafa	Karkh
(1) Sewers (Trunks and Reticulations)			
1.1	Ghazaliya Connection,	-	ø2,200mm x 5km(shield tunneling)
1.2	West Trunk	-	ø2,800 to ø3,600 mm x 10km
1.3	New West Trunk (gravity)	-	ø3,600x2.2km, ø 3,000 mm x 1.0km, ø2,800x 4.1km)
1.4	New West Trunk (force main)	-	ø1,600mmx 4.5km x 3
1.5	Al-Sadr City Trunk	ø2,000mm x 5km	-
1.6	Southwest Trunk	ø2,200mm x 10km	-
1.7	Northeast Trunk	ø2,800~3,600mm x 10km	-
1.8	Sewer Network Rehabilitation	40% of existing sewers	40% of existing sewers
1.8	Sewer Network Extension	Cover 25 % of service area	Cover 25% of service area
(2) Pumping Stations			
2.1	Rehabilitation, P2 (combined system)	-	Max. discharge 476m^3/min.
2.2	Rehabilitation, N2(combined system)	-	Max. discharge 492m^3/min.
2.3	Rehabilitation, PN(combined system)	-	Max. discharge 1,110 m^3/min.
2.4	Rehabilitation, D1(combined system)	-	Max. discharge 821m^3/min.
2.5	Rehabilitation, P5(combined system)		Max. discharge -
2.6	Construction, D2 (combined system)	-	Max. discharge 729m^3/ min.
(3) Wastewater Treatment Plant			
	Construction of Complete Secondary Treatment Facilities	-	Treatment facilities of 205,000m^3 capacity

Note: These are approximate figures and the exact sizes and numbers are to be determined by detailed design.

(2) IMPLEMENTATION STAGING

The wastewater system improvement program will be implemented over a thirteen-year period from 2005 to 2018. The highest priority sewerage improvement programs are to be carried out under the First Stage Program from 2005 to 2008, whereas other sewerage facilities are to be implemented under the Second and Third Stages from 2009 through 2018.

(3) FIRST STAGE IMPROVEMENT PROGRAM (2005 TO 2008)

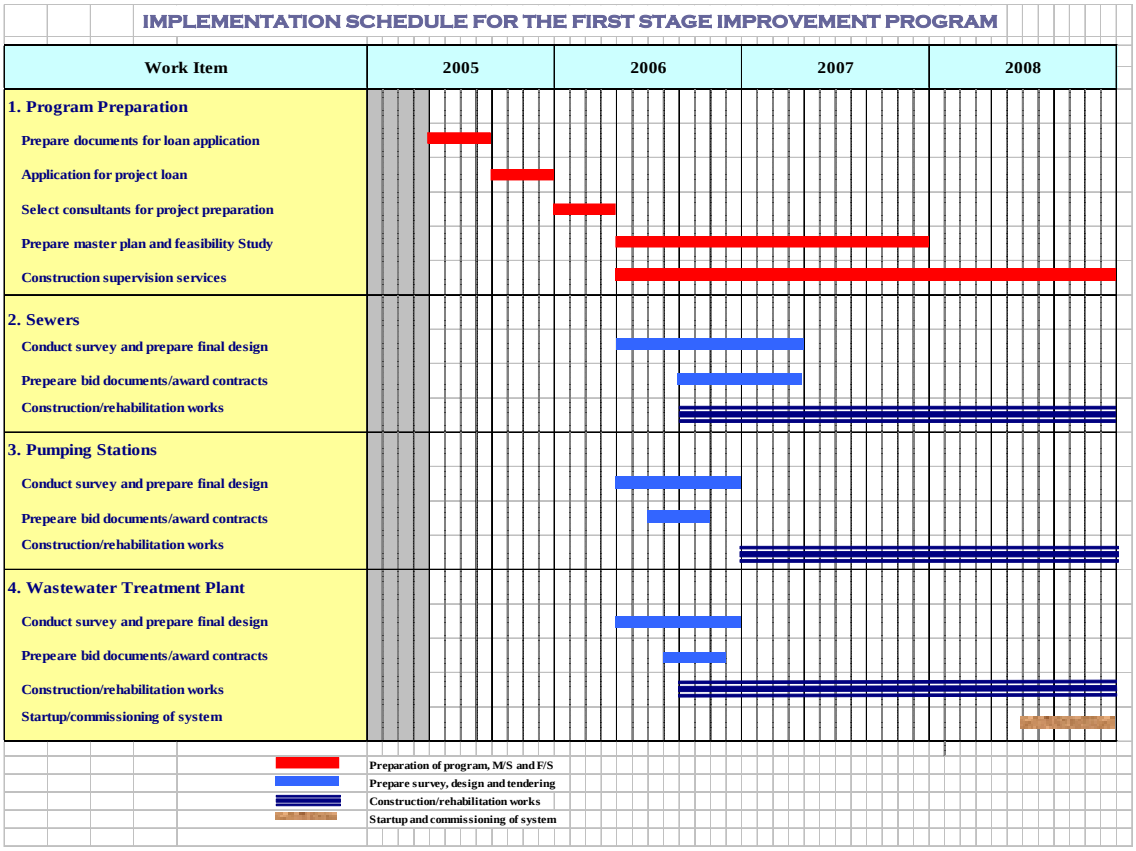
The selected highest priority sewerage components that require immediate improvement are to be implemented under the First Stage Program as tabulated in Table-3 below:

Table-3 Components Included in the First Stage Improvement Program

Component	Type/Size	Remarks
1. Trunk, Network Sewers		
1.1 Rusafa District		
φ3,200mm	10km	
φ2,000mm	5km	
φ2,200mm	10km	
1.2 Karkh District		
Gazaliya connectionφ2,200mm (Shield tunneling)	5km	
West Trunk(Gravity)φ2,800mm toφ3,600mm	10km	
New West Trunk φ3,600mm	2.2km	
- " - φ3,000mm	1.0km	
- " - φ2,800mm	4.1km	
New West Trunk (Force main) φ1,600mm	4.5km x 3 lines	
2. Pumping Stations		
Rehabilitation of P5,P2,N3,N2,PN pumping stations n Karkh	Replacement of pumps, screens, control panels	
Construction of Doura –II pumping station in Karkh	Hydraulic capacity, 729m^3/min	
3. Wastewater Treatment Plant	Primary/secondary treatment facilities.	Av. 205,000 m^3/d capacity.

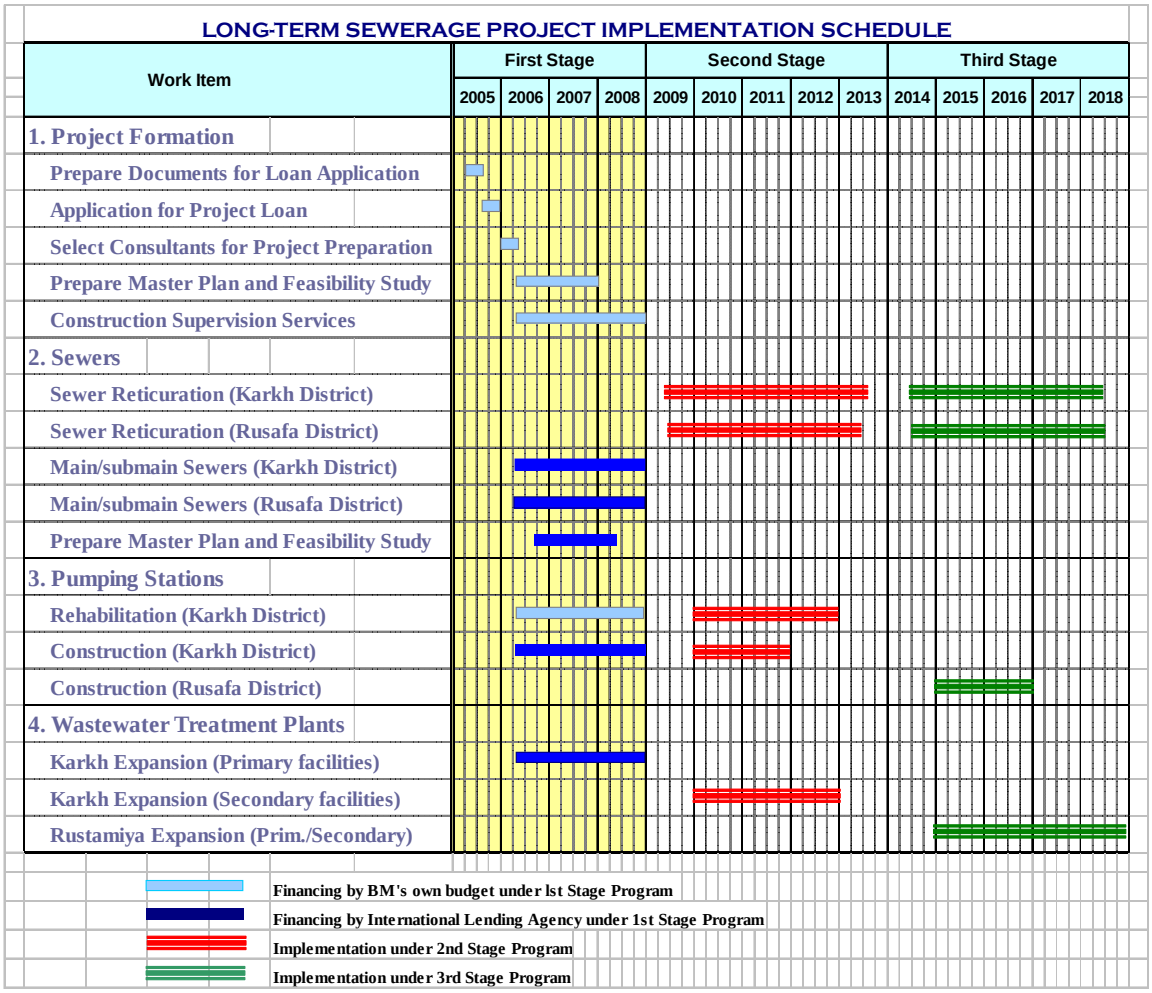
Note: These are approximate figures and the exact sizes and numbers are to be determined by detailed design.

As illustrated in the following Implementation Schedule, the preparatory work for the First Stage Program is scheduled to start in mid-2005 and the construction in 2006, which lasts until the end of 2008:



(4) Long-Term Sewerage Implementation Schedule

The recommended long-term improvement plan leading to the 2018 sewerage system, and its tentative staging for the integrated sewerage system improvement in Baghdad are presented in the following:



8. PROJECT COSTS

The tentatively estimated sewerage facility costs are summarized in Table-4. The costs are indicated in direct costs, estimated based on mid-2004 price level, but do not include costs for escalation, contingency, security, engineering and administration.

The estimated overall direct costs to be expended until 2018 is US$1,163 million, while the direct costs for the First Stage Program is US$ 336.1 million.

Table 4 Overall Project Costs **(in U.S.$ 1,000)**

Item	First	Second	Third	Total
(1) Sewer Reticulations				
Karkh District (Service area of sewer network.)	0	83,400	83,400	166,800
Rusafa District (Service area of sewer networks)	0	76,200	76,200	152,400
Total of (1)	0	159,600	159,600	**319,200**
(2) Trunk Sewers				
Trunk sewer (2,200 to 3,200mm) in Rusafa District	96,000	0	0	96,000
Trunk sewer (1,600 to 3,600mm) in Karkh District	86,000	0	0	86,000
Total of (2)	182,000	0	0	**182,000**
(3) Pumping Stations				
Karkh District (Required p.s. average capacity, m^3/d))	39,000	3,000	3,900	45,900
Rusafa District (Required p.s.average capacity, m^3/d))	96,000	4,500	5,800	106,300
Total of (3)	135,000	7,500	9,700	**152,200**
(4) Wastewater Treatment Plants				
Karkh District (Required average daily capacity,m^3/d)	19,100	96,000	96,000	211,100
Rusafa District (Required average daily capacity,m^3/d)	0	191,000	96,000	287,000
Total of (4)	19,100	287,000	192,000	**498,100**
(5) O/M Equipment	0	5,800	5,800	**11,600**
Total of 1,2,3,4,5	**336,100**	**459,900**	**367,100**	**1,163,100**

Note: Direct costs are estimated based on mid-2004 price level prevailing in Baghdad Region, not including costs for future escalation, administration, security, engineering and contingency. The costs are of order of magnitude or reconnaissance level only, and are not adequate for detailed financing plan and tendering purposes.

9. FINANCIAL IMPLICATION

The largest source of funds in the tentative financing plan for the sewerage improvement program would be international agency, for which a loan of US$ 336 million of the project direct cost is assumed. Other sources may include funds generated from BSA tariffs.

Sources of project financing should be further explored. Basic changes in the institutional framework for sewerage within Baghdad should be agreed. BSA would begin to get necessary approval for components of the proposed project, particularly for main sewers, pumping stations, and wastewater treatment plant in Karkh Sewer District.

The Master Plan (M/P) and Feasibility Study (F/S) for the Baghdad's integrated sewerage improvement project should be issued after this report, so as to evaluate the present situation comprehensively and develop a solid strategic plan for the Baghdad's sewerage system improvement.

10. ENVIRONMENTAL IMPACTS

The sewerage improvement project may have both positive and negative impacts. The preliminary evaluation on the probable impacts due to the program has been made, covering items of i) public health, ii) construction activities, iii) waste and wastewater spills, iv)odor, v) noise and vibration, and vi) other social impacts

As certain items in the preliminary evaluation need to be further clarified from engineering viewpoints, further detailed analyses are to be made in the forthcoming M/P and F/S on the ex-

tent of impacts, mitigation and remedial measures. Nevertheless, it is concluded at this stage that the overall expected environmental impacts of the project on the Baghdad Region are significant and positive.

11. SOUNDNESS OF THE PROJECT

At this stage of the improvement program, detailed analysis on economic and technical soundness is not undertaken; however, when measured by any of the generally-accepted method of appraisal, total benefits of the program will be significant in terms of economic, socioeconomic, environmental and technical issues.

The program is sound and needs for immediate protection and improvement of the quality of receiving waterways and the health of communities. The program is logically related to the present and proposed plans for Baghdad's growth and development.

12. IMPLICATION FOR FURTHER ACTIONS AND STUDIES

The immediate improvement program for sewerage system, several special actions and investigations are necessary to provide a sound basis for detailed planning and system design. In order to execute the program for the wastewater system discussed in this report, it will be necessary to have an expertly managed system of authority, responsibility and control over all aspects of the program.

It is pointed out that such basic data and information are lacking both for present and future, as population distribution by sewer district, long-term wastewater quality and quantity data, detailed sewer layout plans, urban developmental plans, design bases, present conditions of existing facilities, etc., which are imperative for developing the strategic plan for the integrated Baghdad sewerage system.

In view of these, it is considered imperative to develop a master plan (M/P) and feasibility study (F/S) on the Baghdad sewerage system improvement, in parallel with the immediate program (First Stage Program) for the prioritized sewer districts.

Thorough studies and investigations are to be initiated immediately to develop the data necessary to guide future decisions on the integrated sewerage system improvement and management.

13. CONCLUSIONS AND RECOMMENDATIONS

The success of the improvement of sewerage system and environmental conditions in BM requires the implementation of a range of actions, including:

- Establish an improved program implementation section in BSA, to take responsibility for the management, implementation and operation of the program;

- Establish comprehensive sewerage system Master Plan (M/P) and Feasibility Study (F/S), in

parallel with the First Stage Program for Sewerage Improvement, so as to develop a firm strategic plan covering the entire BM area;

- Construct new sanitary sewer reticulations to collect wastewaters from the residences both in Karkh and Rusafa Sewer Districts, followed by full connection of property wastewater discharges to them;

- Rehabilitate the damaged sewers and auxiliary facilities estimated to be about 40 percent of the existing sewer lines;

- Procure necessary operation and maintenance equipment for sewer pipe inspection, cleaning and rehabilitation works;

- Start such major surveys on existing sewer pipelines, pumping stations and WWTPs soon after the program started;

- Rehabilitate existing pumping stations (P5, P2, N2, N3, PN, D1) and construct D-II pumping station in Karkh District;

- Construct additional streams of complete primary treatment facility in Karkh WWTP to increase the present capacity of 205,000 to 410,000m^3/day to treat most of the wastewater flow currently diverted to the River ahead of the WWTP;

- Rehabilitate stormwater runoff intake facilities to the combined sewers to relief the low-lying areas from frequent inundations;

- Train selected personnel for project management, operation and maintenance of wastewater facilities, including overseas training;

- Establish a plan for the comprehensive charging policy, which will be needed in the near future. Tariffs developed on this basis would be levied on all properties located within the service area. Alternative cost recovery approaches may be considered, both providing for full coverage of operating costs and debt service and eliminating the need for operational subsidy; and

Main Text

IMPROVEMENT OF INTEGRATED SEWERAGE SYSTEM IN BAGHDAD

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ANNEX — MAPS AND PHOTOS

UNITS AND ABBREVIATIONS

AGENCIES AND PROGRAMS

ARNI	Autonomous Region in Northern Iraq
BM	Baghdad Mayoralty
BWA	Baghdad Water Supply Authority
BSA	Baghdad Sewage Authority
CSR	Central South Region
IBRD	International Bank for Reconstruction and Development
JICA	Japan International Cooperation Agency
JBIC	Japan Bank of International Cooperation
UNDP	United Nations Development Programme
UNICEF	United Nations Children's Fund
USAID	United States Agency for International Development
WHO	World Health Organization

TECHNICAL TERMS

DWF	Dry weather flow
WWF	Wet weather flow
WWTP	Wastewater Treatment Plant (Sewage Treatment Plant)

CHEMICAL/BIOCHEMICAL TERMS

BOD_5	Biochemical oxygen demands, 5-day, 20℃
COD	Chemical oxygen demands
Cl	Chlorine ion
DO	Dissolved oxygen
F/M	Food-to-microorganism ratio
MPN	Most probable number
MLSS	Mixed liquor suspended solids
pH	The reciprocal of the logarithm of the hydrogen-ion concentration
SS	Suspended solids
TS	Total solids
As	Arsenic
Cr6	Chromium, hexavalent
Cr	Chromium
Fe	Iron
Mn	Manganese
Pb	Lead
Cd	Cadmium
Hg	Mercury
Cu	Copper
Sn	Cyanide
Zn	Zinc

UNITS

mm	millimeter
cm	centimeter
m	meter
km	kilometer
mm^2	square millimeter
cm^2	square centimeter
m^2	square meter
km^2	square kilometer
ha	hectare
mL	milliliter
L	liter
m^3	cubic meter
mg	milligram

g	gram
kg	kilogram
t	ton (1,000 kg)
W	watt
kW	kilowatt
m^3/d	cubic meter per day
m^3/h	cubic meter per hour
m^3/m	cubic meter per minute
m^3/s	cubic meter per second
L/d	liter per day
L/s	liter per second
mg/L	milligram per liter
Lcd	liter per capita daily
$m^3/m^2/d$	cubic meter per square meter per day

CURRENCY EQUIVALENT

ONE (1) US DOLLAR = One Thousand Four Hundred and Sixty (1,460) Iraq Diner
= One Hundred and Five (105) Japanese Yen (As of mid-2004)

1. INTRODUCTION

1.1 PROJECT GENESIS

The total population of 5.776 million (March 2005, BM est.) residing in Baghdad Mayoralty (BM) and neighboring areas is now generating wastewaters of approximately 1.2 million m^3/day (2004 est.). Most of the wastewater finds it's way either directly or indirectly to the Tigris River without receiving appropriate treatment. As the river water quality has been continuously deteriorating, the public health and sanitary conditions in BM and neighboring districts have been ever-worsening and now reached a deplorable level.

In order to improve such acute deterioration of public health and environmental conditions in Baghdad, BM requested Japanese Government for technical and financial assistance.

In response to the request, the Japan International Cooperation Agency (JICA) dispatched a study team to Jordan in April 2004, to identify the present conditions of the sewerage system in Baghdad, and the need for an immediate sewerage improvement/rehabilitation program to prevent further water pollution in the Tigris River and deteriorated public health and sanitary conditions in the Baghdad urban districts.

Following the result of the identification work, JICA sent off a sewerage expert to Jordan from November 2004 through March 2005, to undertake a technology transfer program for the selected BM personnel, and to establish an immediate improvement program for Baghdad sewerage system. The BM counterpart personnel have worked throughout the study period in close cooperation with the JICA study team to identify and investigate the urgently required improvement of the Baghdad sewerage system.

1.2 STATUS AND SCOPE OF THE STUDY

The present study has identified that the sanitary/environmental conditions are severely deteriorated throughout Baghdad urban areas due mainly to the failure of sewerage system. Although international agencies are taking part in the improvement/rehabilitation of sewerage system, much portion has been left intact, for which urgent improvement program is sought.

This report presents the study results leading to the identification of the recommended tentative long- and short-range programs for the sewerage management for the BM area, and further set up the planning bases for Master Plan (M/P) and Feasibility Study (F/S) on the improvement of integrated sewerage system. The preliminary bases of the planning study are described and necessary actions are discussed.

1.3 IMPLEMENTATION ARRANGEMENT FOR THE STUDY

BM dispatched to Jordan five senior engineers of Baghdad Sewerage Authority (BSA), who are responsible for planning, design, construction, and operation and maintenance of the Baghdad sewerage system. The study was undertaken over a period of four-month from November 2004 through March 2005.

Because of the present restraints for the JICA experts to visit the project sites in Baghdad, the counterpart staff had played major roles for field investigation/survey of the present conditions, and collected recent data and information necessary for developing the sewerage system improvement program.

1.4 STUDY CONSTRAINTS

In view of the limited time available for the study and restriction for the site visit, the maximum reliance was placed on the data and information obtained from other previous and on-going studies.

Of particular importance were the following:

- Population projections adopted for the study were those recently prepared by BM based on the past available data, which do not necessarily indicate the present numbers based on census data;
- Projections of wastewater flow were developed based upon the estimated populations and the wastewater production rates were developed based on the projected water consumption rates; and
- City developmental data and information were lacking that accurately indicate the current conditions in the builtup urban areas.

2. WATER SUPPLY AND SEWERAGE SECTORS

2.1 WATER RESOURCES AND DEVELOPMENT

At present the Baghdad's water supply system covers 4,769,073 inhabitants in BM area (BM's estimate) including 0.33 percent rural population (as of 2000), with water pipe connections of 567,551. The water supply system relies its water sources mostly on the Tigris River water, producing an average water of 648 million m^3/year.

The water supply rates by water use type are as follows:

Table-2.1 Per Capita Water Supply Rates (Lpcd)

Category of User	Baghdad	Municipality	Municipalities	Rural
Domestic users	330	300	250	180
Industrial/commercial	40	30	20	0
Institutional	55	50	40	10
Total	425	380	310	190

Source: BSA

The Tigris River has an average annual flow rate of about 48,000million m^3, which is considered sufficient to meet all the present water demands for Baghdad Region. The Ministry of Health has the overall mandate for water quality surveillance and regulation, and direct responsibility for water quality control of small rural water systems.

The quality of public waters is rapidly deteriorating due to direct discharge of the raw wastewater, industrial wastewaters and excessive agricultural runoffs into drains. Also, the raw wastewater discharge to the River increases salinity in water. The Tigris River water has total dissolved solids content of 280mg/L at its border crossing with Turkey increases to 1,500mg/L at Amara. Such high water salinity level increase affected to significantly to agricultural productions.

2.2 WASTEWATER QUALITY AND QUANTITY

2.2.1 TREATED WASTEWATER EFFLUENT QUALITY STANDARDS

The water discharge quality standards to the national rivers were established by Government Act as set forth in Regulation No.25, 1967, Table 2 Column Bi. The Minister of Health was charged with applying the Regulation through his Department, the Directorate General of Human Environment.

The limits for the major physical conditions and pollutant concentrations in the treated wastewater effluent are as follows:

Table-2.2 Regulation 25"Limits for Discharge of Sewage Effluents to Rivers"

Item	Component	Column B1
1	Colour	-
2	Temperature	Lower than 35ºC
3	Suspended Solids	60mg/L
4	pH	6 to 9.5
5	Dissolved Oxygen	-
6	BOD_5	Lower than 40mg/L
7	$COD(Cr_2O_7)$	Lower than 100mg/L

8	Cyanide (CN)	0.05mg/L
9	Fluoride (F)	5mg/L
10	Free Chlorine	Trace
11	Chloride (Cl)	When the ration of the amount of the discharged water to the amount of the water of the source is 1:1000 or less, it is allowable to increase the concentration in the source by 1% before discharging. When the ration of the amount of the discharged water to the amount of the water of the source is more than 1:1000, the chloride concentration in the discharged water should not exceed 600mg/L.
12	Phenol	0.01 to 0.05mg/L
13	Sulphate (SO_4)	as “chloride” a. as “chloride” b, but limit is 400mg/L
14	Nitrate	50mg/L
15	Phosphate	3mg/L
16	Ammonium	-
17	DDT	Nil
18	Lead	0.1mg/L
19	Arsenic	0.05mg/L
20	Copper	0.2mg/L
21	Nickel	0.2mg/L
22	Selenium	0.05mg/L
23	Mercury	0.005mg/L
24	Cadmium	0.01mg/L
25	Zinc	2.0mg/L
26	Chromium	0.1mg/L
27	Aluminum	5.0mg/L
28	Barium	4.0mg/L
29	Boron	1.0mg/L
30	Cobalt	0.2mg/L
31	Iron	0.2mg/L
32	Magnesium	0.2mg/L
33	Silver	0.2mg/L
34	Total hydrocarbons and its compounds	Only allowable to rivers and streams in a state of continuous flow. The following limits shall not be exceeded: 10mg/L when the ratio of the amount of the discharged water to the amount of water of the source is 1:1000 or less. 5mg/L when the ratio of the amount of the discharged water to the amount of water of the source is 1:500 or less. 3mg/L when the ratio of the amount of the discharged water to the amount of water of the source is 1:300 or less.
35	Sulphide $S^{=}$	-
36	Ammonia (N as NH_3)	-

37	Ammonia gas (N as free NH_3)	-
38	Sulphur dioxide (SO_2)	-
39	Petroleum Alcohol	-
40	Calcium Carbide (CaC)	-
41	Organic Solvents	-
42	Benzene	-
43	Chlorobenzene	-
44	T.N.T.	-
45	Bromine	-

Note: Extract from the Ministry of health, Directorate General of Human Environment, Environmental Engineering Department, "New Limits for the Regulation of the Protection of Rivers and Public Waters from Pollution"-No.25 -1967, Table 2

2.2.2 PRESENT WASTEWATER QUALITIES

Table 2.3 shows the influent wastewater quality data to Rustamiya 0, 1, 2 and Karkh WWTPs (locations of these WWTPs are shown in Figures 3.1.

Table-2.3 Influent Wastewater Quality to WWTPs (mg/L)

WWTP	BOD_5			COD			SS			T-P		
	Max.	Av.	Min.	Max.	Av.	Min.	Max.	Av.	Min.	Max.	Av.	Min.
R 0,1 and 2	492	-	114	1,196	-	566	504	-	201	-	-	-
R 3	300	-	190	-	-	-	400	-	240	-	-	-
Karkh	200	150	100	600	200	100	400	300	200	30	15	10

Source: BSA

As shown in the above table, the influent BOD_5 concentrations to Rustamiyah 0, 1, 2 WWTPs are generally higher than other WWTPs, indicating that the living patterns in these tributary districts are different from other sewer districts.

Since Karkh WWTP receives combined wastewaters, the excess wastewater commingled with stormwater runoff is discharged to the Tigris River after being treated with the preliminary/ primary treatments. Under such conditions, stormwater storage tanks were provided to retain the stormwater so that the polluted water can be disposed of to the River only during the heavy rainfalls.

It was estimated in the original design for WWTPs that even at peak diurnal wastewater flows the dilution ratio to the river flow would not fall lower than 1 to 24 on the minimum monthly river flow, thus appreciable impacts to the river ecosystem could be prevented. As most of the raw wastewaters were being discharged directly into the Tigris River at the downstream of water intake, serious contamination of drinking water source has been avoided.

2.3 PUBLIC HEALTH AND SANITATION INDICATORS

After the 2003 Iraq War, sanitary conditions of water, sewerage and sanitation sectors have been significantly deteriorated, and only about 50 percent of the existing sanitary systems are operable, according to the estimates by UNICEF.

Although persuasive data on the number of water-born diseases or environmental/sanitation conditions in the Baghdad Region were not obtainable, some estimated figures of present conditions in Iraq are available. Tables-2.4 and 2.5 show the present populations served by sanitation systems in Baghdad and other part of Iraq.

Diseases associated with poor sanitation and unsafe water have been increased at alarming rate. It is estimated that water and sanitation related diseases are responsible for about 25percent of all children's deaths. Diarrhea and subsequent dehydration along with acute respiratory infections account for 70 percent of child mortality in Iraq (*Iraq Watching Briefs, Water and Environmental Sanitation, July 2003*).

Table-2.4 Population Served by Sanitation System

Administrative District (km^2)	Population	Sewered Population	Service Ratio (%)
Mayoralty of Baghdad	4,753,379	3,802,703	80
Iraq (excluding Baghdad)	9,387,381	924,394	10
ARNI	2,483,777	0	0
Total	16,245,537	4,727,097	28.4

Source: Government of Iraq and UNICEF August 2002

Table-2.5 Population Service Ratio by Sanitation System

Parameter	CSR (%)	BM (%)	ARNI (%)
Ratio of sewer service population in urban area	**10**	**80**	**0**
Ratio of urban population served by on-site sanitation	**79**	**20**	**66**
Ratio of rural population served by on-site sanitation	**36**	**100**	**38**

Note: CSR;Central South Region BM; Mayoralty of Baghdad,
ARNI; Autonomous region in Northern Iraq

2.4 WATER SUPPLY AND SEWERAGE SECTORS

2.4.1 BM INSTITUTIONS

For the Baghdad Mayoralty (BM) the main sector institutions are shown in Figure 2.1 "Organization Chart of BM" and in the following:

- The Baghdad Water Authority (BWA), responsible for the main water intakes,

treatment plants, transmission lines, storage reservoirs and water distribution network pipes of diameter 250mm and above in Baghdad;

- The Baghdad Sewerage Authority (BSA), responsible for the main sewers, sewage treatment plants and sewage disposal in Baghdad; and

- The Municipality Directorates (MD), established in each of the nine main municipalities that constitute BM. Under the coordination of the Deputy Mayor for Municipalities, which are responsible for the operation and maintenance of the water distribution networks (pipes smaller than 250mm in diameter), service reservoirs, sewer reticulation and pumping stations, solid waste management and street cleaning.

Since 1995 when the sewer networks and all 586 sewage pumping stations were transferred to the municipalities, BSA has been responsible for operation, manages and extensions of systems: However, BSA's activities have been significantly hampered due to the continuing social instability.

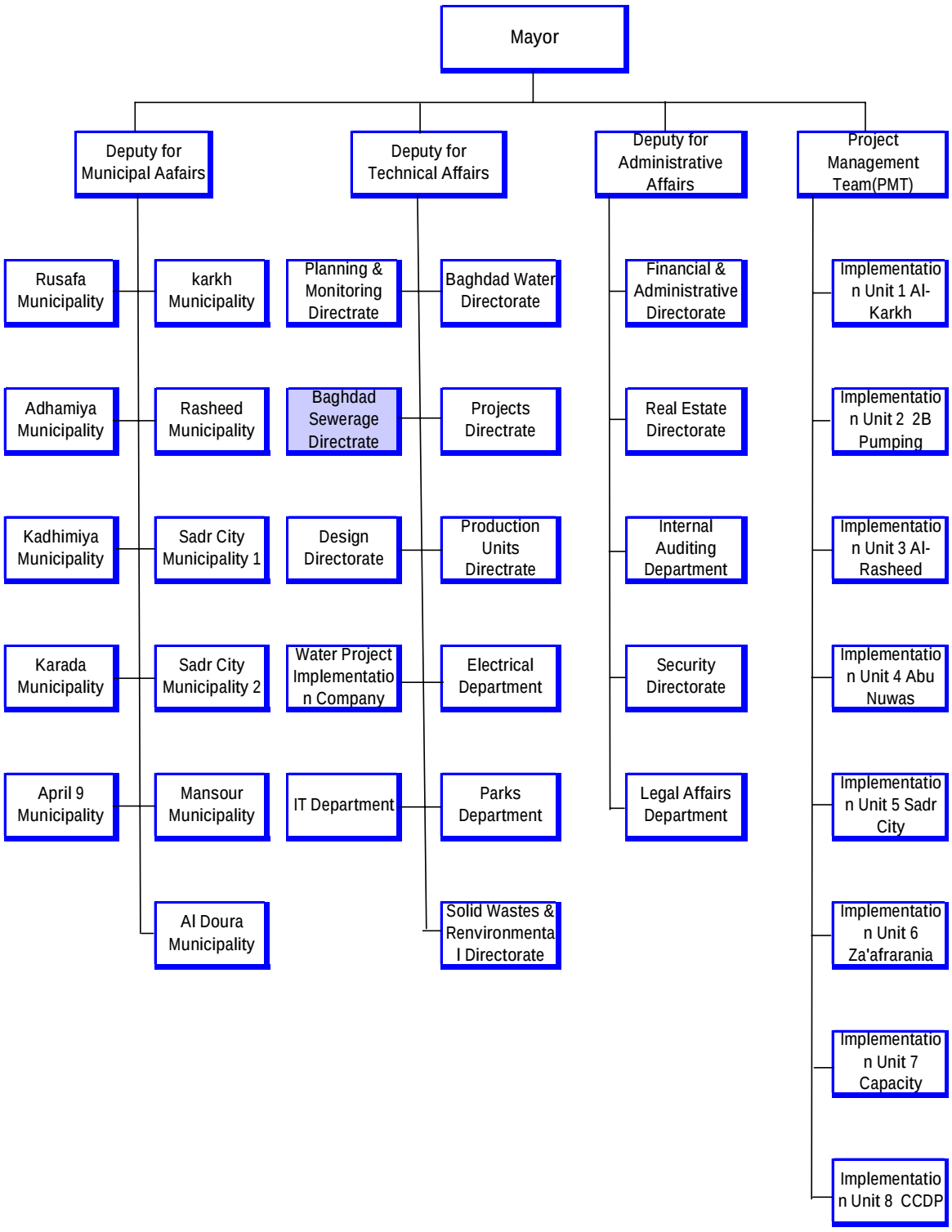


Figure 2.1 Organization Chart of Baghdad Mayoralty

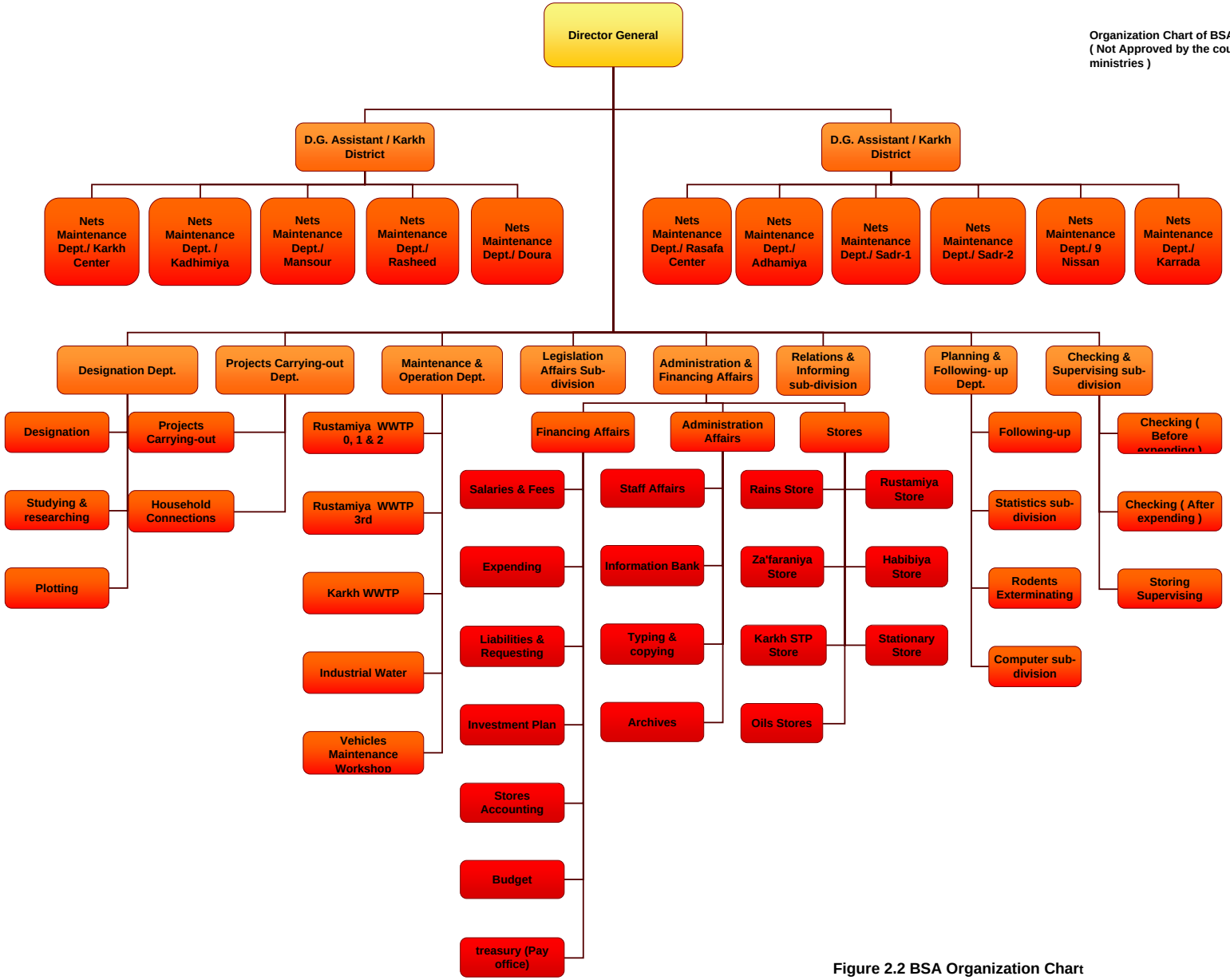


Figure 2.2 BSA Organization Chart

The water supply and sewerage management staff of Baghdad Water Authority (BWA) and BSA before the War are summarized. The difference of the total number of BSA staff between Tables 2.6 and 2.7 may be because those were provided in the different time.

Table-2.6 Water Supply and Sewerage Sector Organization and Staff of BM

Staffing	BM	BWA	BSA
Approved positions	12,954	2,223	597
Position filled	5,954	1,223	197
Vacancies	7,000	>1,000	>1,000
Vacancies % of approved	54%	>45%	>67%

Source: BM

The organization of BSA is shown in Figure 2.2. The current BSA staff numbers by job category and employment status (as of March 15, 2005) are as shown below:

Table-2.7 Present BSA Staff

Job Category	Fixed Employee	Temporary Employee	Total
Officer	542	232	774
Technician	420	106	526
Total	962	338	1,300

Source: BWA

Activities of BSA's staff assigned deal essentially with the operation and maintenance of sewerage system. It is apparent that system operations leave much to be desired in terms of reliability and efficiency. Analyses of the activities of the sewerage system management indicate recurring problems, which are generally due to several common causes discussed briefly hereafter.

Management strategies are not explicit, and the staff lack specific guidance on their objectives and responsibilities. The poor performance of the sewers, pumping stations, wastewater treatment plants, and high quantities of infiltration and inflow (I/I) are examples, yet the staff could not overcome these and related weaknesses.

Due mainly to the weakened administrative organization, manpower for the sewerage system O/M becomes acutely short, and most are poorly trained and few could discharge their responsibilities effectively. The shortage of skilled and experienced staff results in overall poor performance.

Equipment such as sewer cleansing equipment, transportation, pumps, for example, is definitely short and poorly maintained and often out of service as a result. The responsible operating staffs are often not possible for doing their job effectively.

Shortage of resources obviously aggravates many operational problems. Budgets for spare parts

and consumable materials such as chemicals are often cut, resulting in serious scarcities. These problems are compounded by difficulties in ordering and obtaining new supplies.

The workshops and stores are plagued by inadequate facilities as well as poor procedures. The net result is that maintenance of sewerage system is severely constrained by delays and shortages in obtaining materials for repairs of installations.

Problems with the vehicles and cleansing equipment used for operations illustrate the situation.

2.4.2 OTHER INSTITUTIONS

Urban stormwater drainage systems are under the responsibility of Baghdad General Corporation for Water and Sewerage (GCWS), but not BSA's responsibility. Road surface stormwater runoffs are collected through side ditches and discharged directly to nearby stream or river. Where the combined sewers are provided, management of collected stormwater is under BSA's responsibility.

2.5 INVOLVEMENT OF INTERNATIONAL AGENCIES

Currently various international agencies have been involved in rehabilitation and restoration of the Baghdad sewerage system, major activities of the agencies involved in sewerage sector are:

- UNICEF: Emergency investigations and rehabilitation of sewage and stormwater pumping stations;
- UNDP: Rehabilitation for wastewater treatment plants in Rusafa District; and
- USAID: Rehabilitation of auxiliary facilities of Karkh Wastewater Treatment Plant.

3. PROJECT AREA AND NEED FOR PROJECT

3.1 STUDY AREA

Baghdad is located at both sides of the Tigris River, covering about 86,000ha. administrative area with a total present population of 6.5million. The study area covers the whole BM area is divided into eleven districts (municipalities).

Of this total, excluding main highways, river and other areas, urban districts of about 34,000 hectares*(Greater Baghdad Study, Land Use Year 2000)* comprise various types of urban developments for which the sewerage system provision was considered. The BM area is divided into eleven administrative districts (municipalities) comprising:

1. Adhamiya
2. Sader 1
3. Sader 2
4. Rusafa
5. Nissan
6. Karadah
7. Khadamiyah
8. Mansour
9. Karkh
10. Rasheed
11. Doura

3.2 LAND USE PLANS

Until about 1960 virtually all of the urban developments were contained within the old city limits as defined by the perimeter flood protection bunds. After the completion of river control project, the development took place beyond the old city limits and now reached to the present developed area of 35,000ha.

BM developed three approved city plans, starting 1956 with the Development Board, and Baghdad 2000 master plan in 1976. Although the 1976 Master Plan has not been reviewed or updated, the plan is the only adequate Master Plan and remains relevant up to date. In the 1980s attempt was made to establish 'Baghdad 2001' but was aborted for financial or other reasons.

The City's Master Plan, adopted in mid-1970s, incorporated a decision that was originally implemented in mid-1950s by the Development Board, which decision established two main longitudinal thoroughfares along the Tigris River in Rusafa and Karkh Districts, but other developments in the City did not necessarily follow the original plan.

The sewerage system constructions undertaken during the 1980s as part of the Master Plan for 2000, generally followed the principles established in the Master Plan for 2000. The Master Plan categorized the whole master plan area into six land use zones, including:

- Residential
- Industrial
- Public utilities
- Commercial
- Administration
- Public facilities

General land use map of the Master Plan 2000 is shown in Figure 3.1, and the area of each district is summarized in Table-3.1 below:

Table-3.1 Land Use 2000 (in ha.)

District No.	Residential	Industrial	Public Utilities	Commercial	Administ-ration	Public Facilities	Total
1	248	52	-	222	45	55	622
2	179	9	-	100	238	76	602
3	2,782	171	106	80	23	407	3,569
4	3,546	589	7	120	7	470	4,739
5	3,053	288	10	132	17	430	3,930
6	2,763	90	15	50	60	231	3,209
7	4,428	491	80	124	5	321	5,449
8	5,440	1,303	141	155	10	179	7,228
9	3,500	438	41	122	10	436	4,547
Total	25,940	3,431	400	1,105	415	2,605	33,895

Source: Greater Baghdad Study, Annex-4.1 Land Use Year 2000.

3.3 SEWER SERVICE AREA

The sewer service area is divided into two sewer districts, i) Rusafa and ii) Karkh as illustrated in Figure.3.1 below:

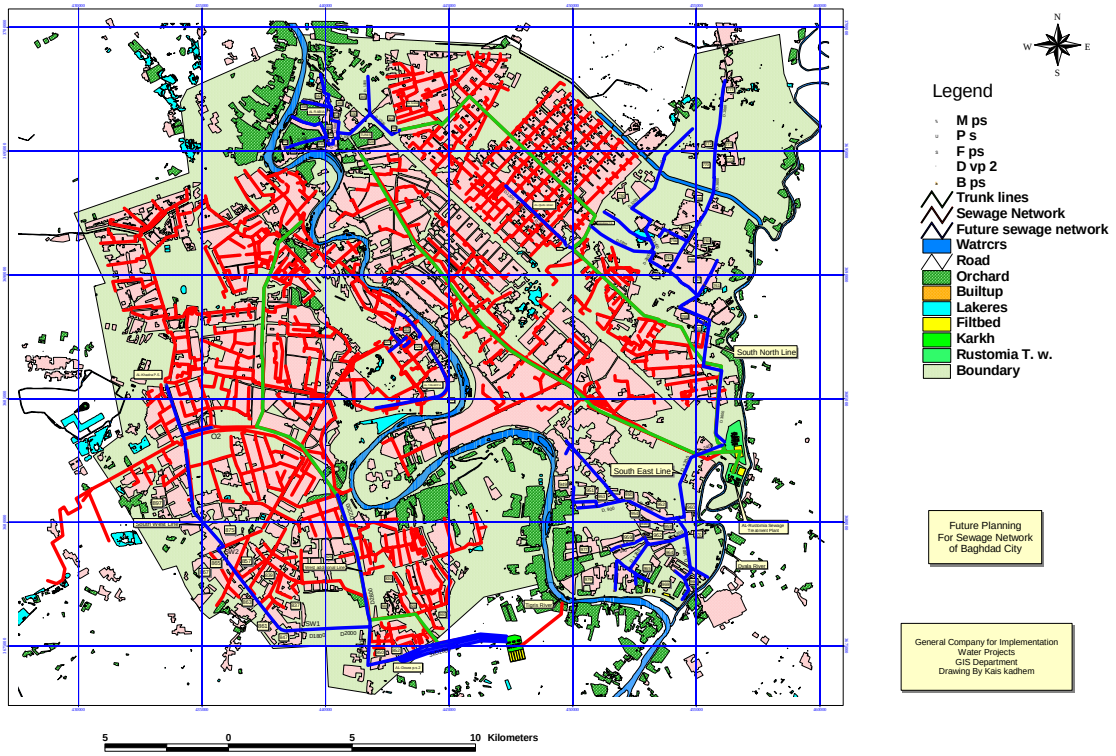


Figure 3.1 Sewer Service Area and Layout Plan (*Source: BM GIS group)*

3.4 POPULATION PATTERNS

The Baghdad's population has been rapidly increasing at high growth rate. In 1945 it was approximately 500,000, and now it is estimated to have reached at almost 6.5 million as MB estimates.

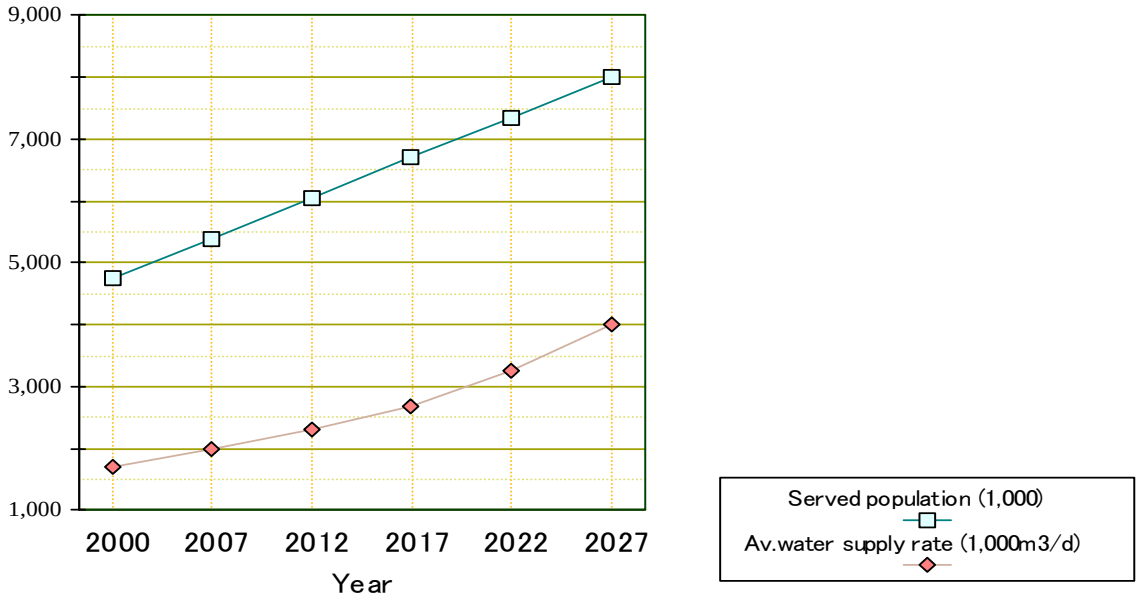
The average population growth rate in Baghdad in the last twenty years is 2.19 percent per annum calculated based on the past 20 years census data. Should this trend further continue in future, the Baghdad's population is estimated to reach at 8 million by 2027.

As shown in Table 3.3 and graph below, the water supply sector estimates the total water service populations and water supply demands in the years from 2000 through 2027.

Table-3.3 Water Service Population and Water Supply Rate

Item	2000	2007	2012	2017	2022	2027
Service population (in 1,000)	4,769	5,400	6,050	6,700	7,350	8,000
Av. per capita supply (Lpcd)	360	370	380	400	442	500
Av. water supply ($1,000m^3/d$)	1,717	2,000	2,300	2,680	3,250	4,000

Source: BWA



3.5 GEOGRAPHY

Baghdad is located at about 33.29ºN 44.40ºE. The ground elevations in the area range 32 to 34 m above sea level with very slow ground surface slopes. The soil consists of about 10 m deep silt-clay soil strata on the surface, and thick sand/gravel strata exist beneath it. Particular characteristics of the surface soil are that the soil's cohesion is generally high (γ =2.1t/m^3, C=10~15t/m^2) with high groundwater elevation ranging from 1 to 3m below the ground surface.

Because water of the Tigris and Euphrates Rivers above their confluence are heavily silt laden, irrigation and fairly frequent flooding deposit large quantities of silt-loam in much of the delta area. Windborne silt contributes to the total deposit of sediments.

It has been estimated that the delta plains are built up at the rate of nearly twenty centimeters in a century. In some areas, major floods lead to the deposit in temporary lakes of as much as thirty centimeters of mud.

The Tigris and Euphrates also carry large quantities of salts. These, too, are spread on the land by excessive irrigation and flooding. A high water table and poor surface and subsurface drainage tend to concentrate the salts near the surface of the soil. In general, the salinity of the soil increases from Baghdad south to the Persian Gulf and severely limits productivity in the region south of Al Amarah.

3.6 CLIMATOLOGY

As shown in Table-3.4, Baghdad's temperatures range from the average July maximum of 34.6 ˚C to the average January minimum of 9.4˚C. In much of the country, temperatures frequently exceed 40˚C during late spring and summer afternoons, and will often remain above 30˚C overnight during the summer.

Throughout Iraq, overall surface winds come from the northwest at 5 to 10 knots on average. The strongest winds generally occur with passing cold front. Conditions are calm and 15 to 20 percent of the time in most part of the country.

Dew points and humidities are usually quite low. Precipitations in Baghdad concentrate mostly in the wintertime from November to April.

Table-3.4 Climatic Data in Baghdad

Item	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Yr.
(1) Av. temperature (˚C)	9.4	11.8	16.2	21.7	27.7	32.3	34.6	34.2	30.8	24.9	17.2	11.1	22.7
(2) Av. high temperature (˚C)	14	17	22	28	35	40	43	42	39	32	23	16	30
(3) Av. low temperature (˚C)	3	6	10	15	20	23	25	23	21	15	8	5	15
(4) Av. rainfall (mm)	27. 1	27.5	26.9	18.8	7.3	0.0	0.0	0.2	0.1	2.6	20.0	26.3	154.8
(5)Av. pressure (mb)	1016.3	1013.7	1011.6	1008.2	1005.4	1000.2	996.0	997.4	1003.6	1009.9	1014.5	1016.6	1007.0
(6) Av. number of days above 32˚C	-	-	-	8	27	30	31	31	29	22	-	-	178
(7) Av. number of days below 32˚C	8	2	–	–	–	–	–	–	–	–	1	3	15

Source: (1) Data derived from GHCN2 Beta, 933 months between 1888 and 1980.
(4) Data derived from GHCN1, 967 months between 1888 and 1990
(5) Data derived from GHCN2 Beta, 471 months between 1896 and 1980
Others derived from Qwikcast.com Weather Forecast.

4. EXISTING SEWERAGE SYSTEM

4.1 WASTEWATER GENERATION

As estimated by BM, about 60 percent of the consumed water turns out to be the wastewater and is collected to the public sewers. The estimated per capita wastewater generations by type of water use in Baghdad, municipalities, and rural areas are shown in the following table.

Table-4.1 Per Capita Wastewater Generation (Lpcd)

Category of Users	Baghdad	Municipality	Municipalities	Rural
Domestic users	200	180	150	110
Industrial/commercial	25	20	15	0
Institutional	35	30	20	10
Infiltration	40	40	35	30
Total	300	270	220	150

Source: BM

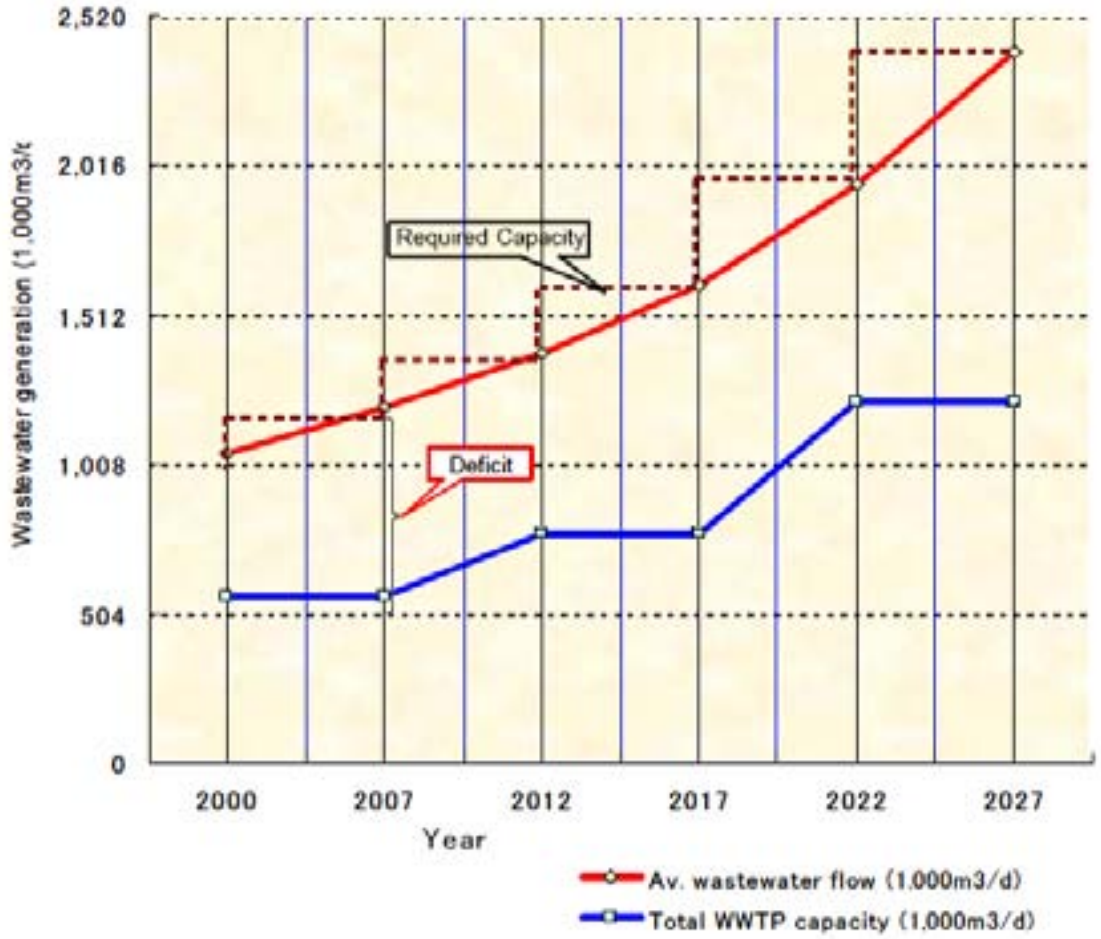
The wastewater productions will increase as the population and per capita water consumption increase. The future wastewater productions in the BM area are estimated for every five years until 2017 based on the estimated water consumption rates.

Table-4.2 and graph show a tentatively estimated wastewater production rates from 2000 through 2017 and the required WWTP capacities to treat all the inflowing wastewaters. According to the original expansion plan for Rustamiyah and Karkh WWTPs, the total WWTPs capacity could reach a level of 770,000 m^3/day, even after the presently on-going or planned improvement programs are completed,.

In 2017, out of the expected 1,610,000m^3/day wastewater generated, 840,000m^3/day raw wastewater would still be disposed of to the River without receiving any treatment. The shortfall could be more significant in the future if the WWTPs treatment capacity is not increased.

Table-4.2 Estimated Wastewater Flow Rates up to the Year 2017

Items	2004	2007	2012	2017
Served population (1,000)	4,769	5,400	6,050	6,700
Av. per capita wastewater flow (Lpcd)	216	222	228	240
Av. wastewater flow (1,000m^3/d)	1,040	1,200	1,380	1,610
(*)Total WWTP capacity (1,000m^3/d)	565	565	770	770
Deficit of WWTP capacity (1,000m^3/d)	475	635	610	840



4.2 SEWER SYSTEM

4.2.1 SEWERS

The Baghdad's sewerage system is distinctively separated by the Tigris River into Rusafa and Karkh Districts on the left and right bank respectively. The present sewerage system covers approximately 75 percent of the Baghdad's sewer planning area, which collects and conveys wastewater and stormwater to the wastewater treatment plants (WWTPs).

Before the 1950s no modern sewer pipe system existed in Baghdad City. The sewerage system construction started in the 1960s lasting until the end of the 1970s, with separate sewer system mainly in the Rusafa District.

In the Rusafa District, most of the sewerage system is of the separate system, but in the Karkh District the combined sewer system was constructed except for old sewerage. Because of the flat ground surface prevailing throughout the area, wastewaters are raised through pumping stations at many locations

By the end of the1980s, about 200km trunk sewers and 2,000km branch/lateral sewers were constructed throughout the BM areas. The lengths of existing sewers by sewerage type are:

Table-4.3 Sewer Length in the Baghdad Mayoralty by Type (km)

Sewer Length			Stormwater system	Total pipe length
Separate	Combined	Total		
1,407	2,636	4,044	51,268	55,312

Source: BM. Some other information indicate that the sewer length may have reached 7,000km. In this report 4,000km is used.

A rough hydraulic analysis on some of the major sewers indicated that such sewers were likely to have some allowances to convey the dry-weather flow (DWF) to WWTPs, if and when the sewers were properly cleaned and necessary rehabilitation made.

However, as most of the sewers were built more than 20 years ago, many of the aged sewers have been obsolete, damaged and chocked, thereby causing wastewater flow blockages at many locations throughout the area..

Furthermore, many concrete sewer pipelines have been damaged by “sulfate attack,” because the soil in the area has high salt contents (*i.e. chlorine ion, sulfate*). In particular, where capillary phenomena take place, the salt content is higher than other locations and accelerates the attack and damages the sewer.

Although no persuasive data are available at present to estimate the actual conditions of sewer failures, it could be assumed from the BSA’s past experience of sewer management that about 40 percent of those pipes are more or less damaged, and many sewer lines need some urgent repair and replacement. On the basis of the assumption, approximately 1,600km long sewer pipes will require the cleaning, rehabilitation or replacement.

It should be noted, however, that during heavy rainfalls significant quantity of stormwater runoffs inflow to sewers through deficit sewer facilities and improperly connected surface drainage system both to separate and combined pipelines. Also, many street stormwater inlets and connecting pipes to drains/sewers are either damaged or chocked due to traffic or other reasons, and causing inundation on streets or nearby low-lying areas.

In addition, insufficient sewer operation and maintenance, alongside the damaged house connections, have led to the present sewage overflows at many locations throughout BM areas.