Japan International Cooperation Agency

Republic of Iraq

Integrated Study on Improvement of The Baghdad Water Supply System

(Basic Study Report)

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Tokyo JAPAN

Contents of Integrated Study Peport

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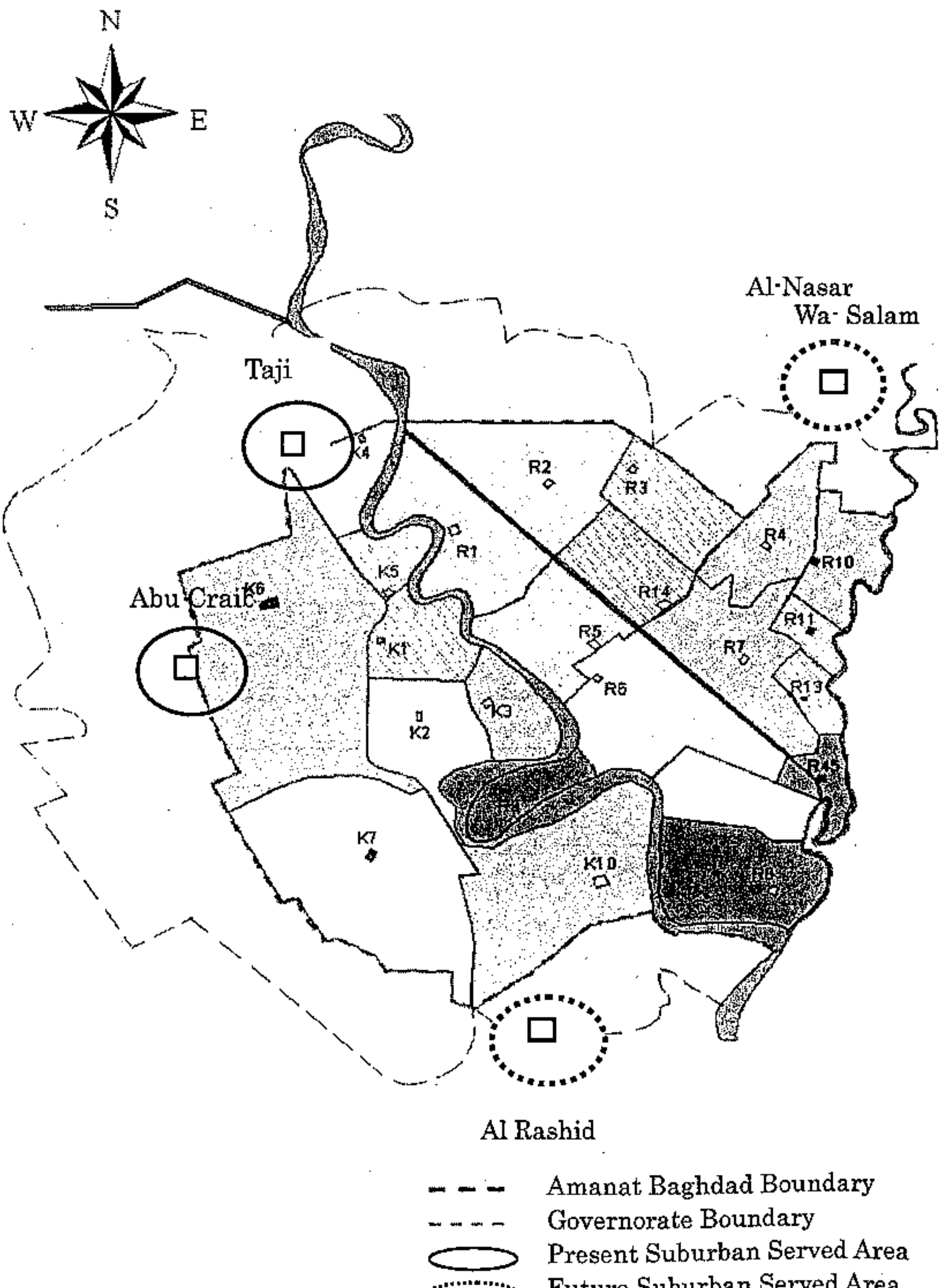
Fig-1.0 Planned Service Area of Baghdad Water Supply System



1. General

1.1 Background of the Training Programme

Japan International Cooperation Agency (JICA) and Water Authority Jordan (WAJ) will cooperate with each other in organizing a training course in the field of Water Supply and Sewage for Iraq (hereinafter referred to as "the Course") under the Third Country Training Programme of JICA.

Long lasting conflicts and successive economic sanctions caused water supply and sewage systems in Iraq to become obsolete and malfunctioned. Compared to the situation before the Gulf War, per capita water supply was declined by 30% in the urban area and half in the rural area. About 50,000 cubic meter per day of wastewater is discharged directly to the river without due treatment. This affected a lot to the people around the region and caused to increase the mortality rate due to diarrhea by 20% for the children under five.

The Government of Japan has supported Iraq reconstruction in this field, i.e. provision of compact water treatment units, water tankers, special vehicles of garbage disposal and sewage cleaning and so forth. In parallel with those assistance in facilities, it is important to assist institutional and human resources aspects. As revealed in relevant study reports, institutional capacities of water supply and sewage authorities have to be strengthened in line with facility rehabilitation and reconstruction. Among various institutional needs, policy and development planning, and operation & maintenance are the most urgent issues to be tackled with.

In this context, JICA, in cooperation with WAJ, carries out the Course with the following two main purposes;

1. Capacity building in Operation and Maintenance for Water Supply
2. Capacity building and practice in Policy and Development Planning for Water Supply and Sewage

The overall goal of the Course is to facilitate smooth reconstruction and rehabilitation process in the sector, and build effective management and operation system in the City of Baghdad.

1.2 Purpose of the Course

Programme of the Course for capacity building and practice in policy and development planning for water supply and sewage is composed of three stages. The purpose of the Course for the expert is to transfer technologies on water supply planning, the purpose of the trainee is to prepare a basic study report by the assistance of the expert until the end of the final stage. The basic study report for the water supply sector aims at formulation of a long range improvement plan of Baghdad water supply system.

1.3 Report by the Expert

During the Course, however, such valuable data as listed below are in hand of the expert. It is possible to improve the Basic Study report prepared by the trainee. Adding recent information related from the trainee and long years experience as a consulting engineer in the water supply field, the expert prepared a report titled "Integrated Study on Improvement of the Baghdad Water Supply System".

No	Name of Report	Abbrebiation
(1)	Baghdad Treated Water Supply Systems Integration Study Review(Final Report) (November 1984 Binnie & Partners London)	The Existing Master Plan
(2)	Integration Study of Drinking Water Requirements for The City of Baghdad up to year 2027 (January 2003 The General Company for Water Projects Implementation)	Unicef Report
(3)	Assessment Project of The Water and Sanitation Sector in IRAQ (Final Report) (January 2003 UNICEF Prepared by SAFEGE)	Company Report
(4)	Integrated Study on Improvement of the Baghdad Water Supply System (Basic Study Report) (March2005 Policy and Development Planning Trainee of BWA Engineers)	Basic Study Report

For preparing the report, however, the expert did not investigate the site of Baghdad water supply system and instead he used a lot of assumptions and engineering estimates for planning by his experience. There might be some deviations from the actual condition, and it is expected to modify or add necessary facts or data to the present report for a preferable improvement of the Baghdad water supply system.

2. The Existing Systems and Their Problems

2.1 The Existing System

The existing water supply systems and the present conditions the water supply of Baghdad city are summarized in the Appendix-1.

By troubles suffered repeatedly and economic sanction during these ten to fifteen years, little extension of the water supply facilities has been realized and operation and maintenance have been insufficient. These have worsened the water supply conditions of the city. Basic problems on the water supply system are as follows. Overall problems will be discussed in the next section.

(1) chronic water shortage, especially in the east area,

(2) very low water rates because of the national policy to supply water by the subsidy of the country,

(3) operation and maintenance cost id also relying on the subsidy because of very low water rates,

(4) consumer meter in use are only 10% of all the connections, and

(5) ratio of UFW is very high.

2.2 Current Problems

In this section, problems which Baghdad water supply system and BWA have been faced with, cause for the problems and solution or remedial measures thereof are discussed and summarized.

At the workshop held in the stage-1 of the third country training program in the field of water supply and sewerage for Iraq, trainees of the planning team from BWA have discussed and listed up problems of Baghdad water supply system and BWA as well by assistance of facilitators for the workshop. These are as shown in Fig-2.1 as in the form of the problem trees.

The problems listed up include various items from administrative to technical fields. Among them, administrative items including finance/fund, management capability, implementation of plans and human resources are rather highlighted.

On the contrary, problems listed up by the trainees of operation and maintenance team which are as listed in Fig-2.2, contain a lot of definite technical items. Piling up each component programs, they have finally introduced to the core problem "Shortage in water supply compared to population". It is felt from the tendency of the problem items the difference of characteristics of the planning team and the operation and maintenance team.

However, even by the extensive study of all the trainees, the problems identified as shown in the above do not always express all of the problems on Baghdad water supply system and BWA. By discussion with the trainees and consideration on various reference and information, overall problems thereof are studied and summarized in the succeeding subsection.

Fig-2.1 Problem Tree Developed by The Planning Team

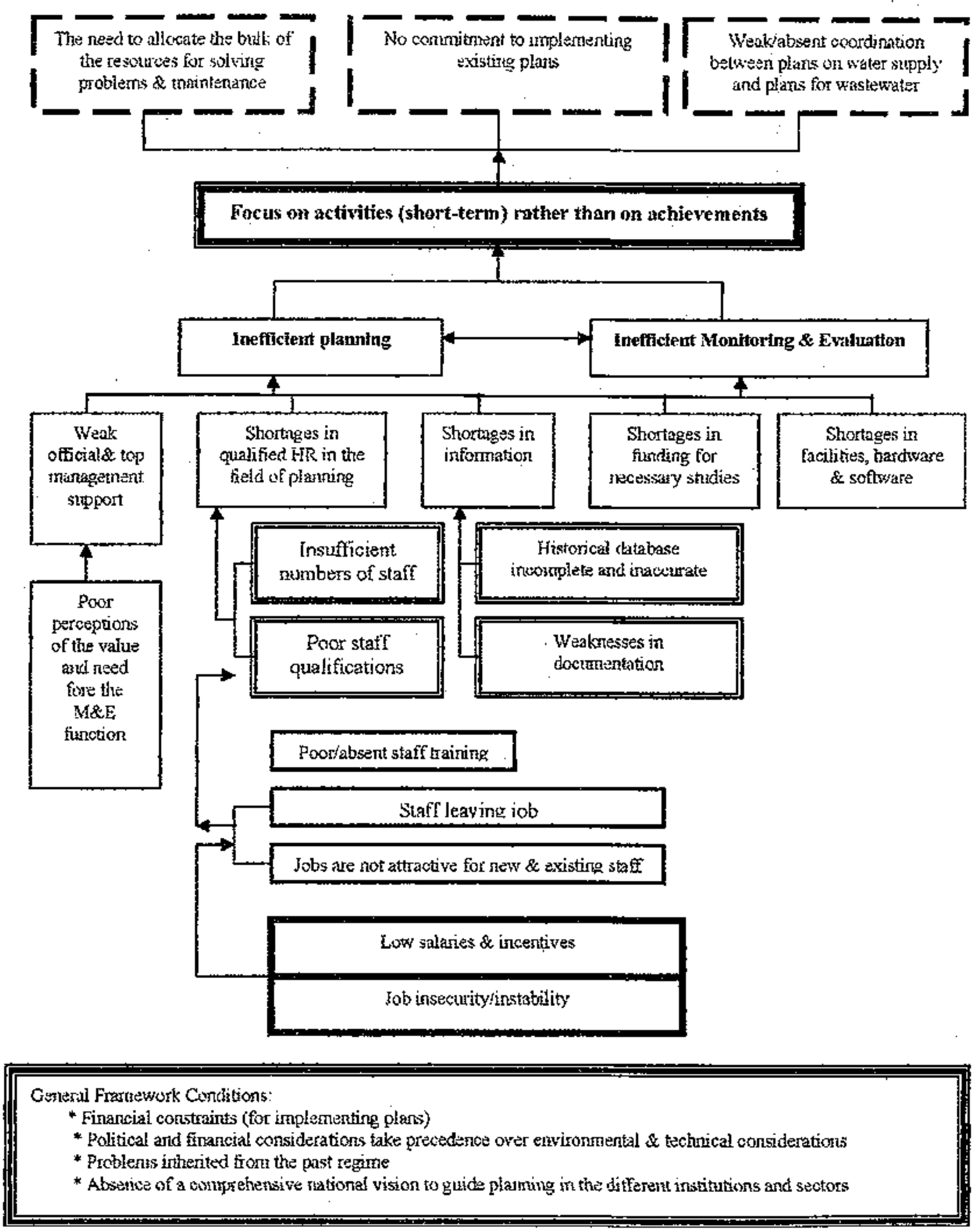
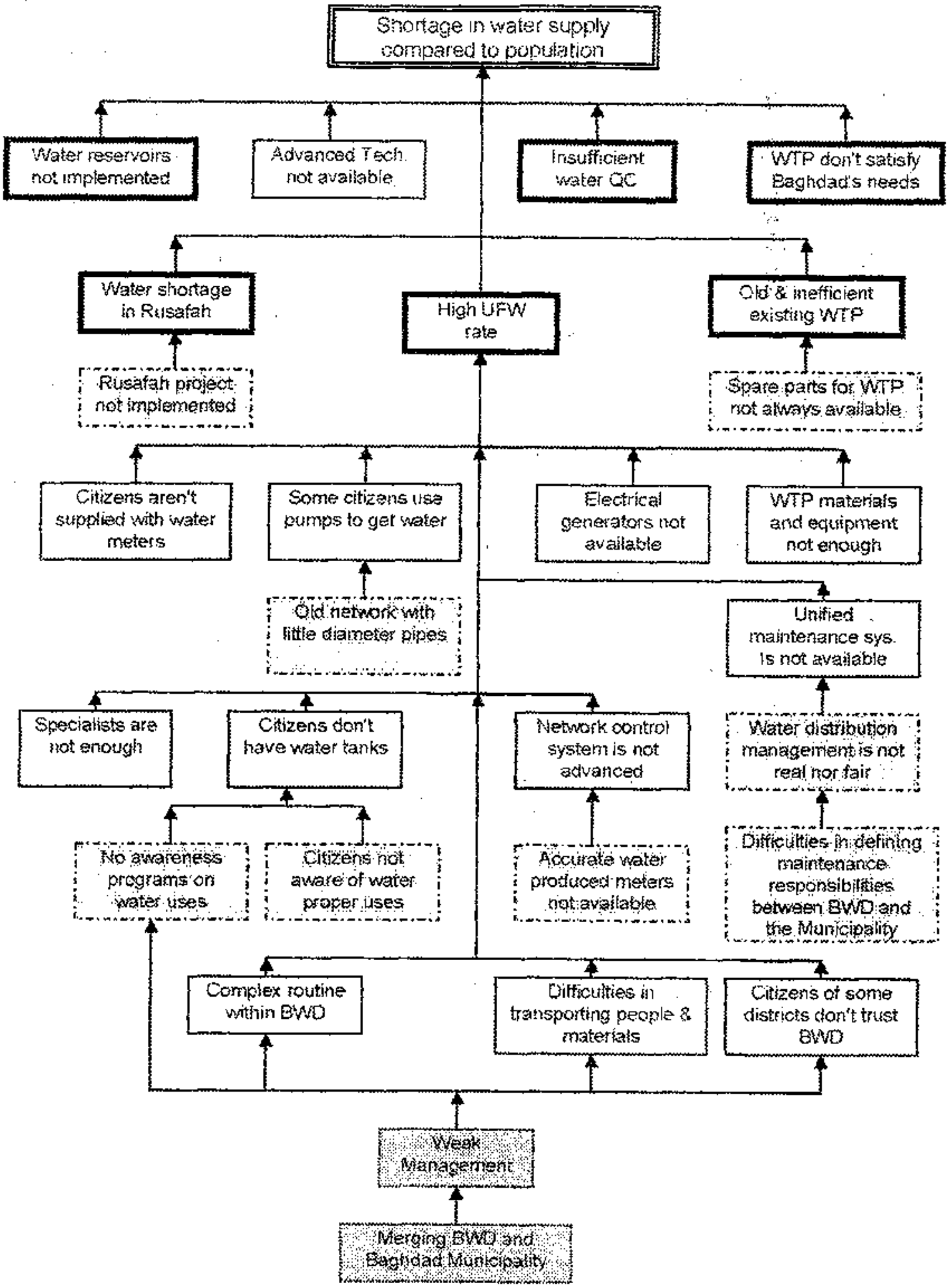


Fig-2.2 Problem Tree Developed by The Operation and Maintenance Team


Shortage in water supply compared to population
Water reservoirs not implemented
Advanced Tech. not available
Insufficient water QC
WTP don't satisfy Baghdad's needs
Water shortage in Rusafah
High UFW rate
Old & inefficient existing WTP
Rusafah project not implemented
Spare parts for WTP not always available
Citizens aren't supplied with water meters
Some citizens use pumps to get water
Electrical generators not available
WTP materials and equipment not enough
Old network with little diameter pipes
Unified maintenance sys. is not available
Specialists are not enough
Citizens don't have water tanks
Network control system is not advanced
Water distribution management is not real nor fair
No awareness programs on water uses
Citizens not aware of water proper uses
Accurate water produced meters not available
Difficulties in defining maintenance responsibilities between BWD and the Municipality
Complex routine within BWD
Difficulties in transporting people & materials
Citizens of some districts don't trust BWD
Weak Management
Merging BWD and Baghdad Municipality

2.3 Problems, Cause and Solution

Based on the problems identified by the trainees and studies on the various references and information, overall problems faced by Baghdad water supply system and BWA are revealed and summarized as shown in Fig-2.3(1/2) and (2/2).

In order to show the problem clearly, the water supply sector is classified into eight categories from technical to administrative ones. They are supply (insufficiency), water sources, installation of facilities, consumer connections, operation and maintenance, management, organization and regulation.

As the first step, basic problems of each category were thought out as shown, and particular problems on Baghdad water supply system and BWA which are corresponding to the basic problem have been identified. Numbers of the particular problems identified are over forty.

Causes for the problems are then considered as shown. Many problems have single cause but some problems have two or more causes. Finally, solutions against the problems were studied for future implementation for improvement of water supply conditions of Baghdad city. Although, there are same solutions in some categories, numbers of the solutions thought out are as much as sixty items. It can be said that the solutions as shown in Fig-2.3 are comprehensive measures for the system, and these will be reflected in the future planning to be described in the next chapter.

Basic Problems	⇨	**Particular Problems**	⇨	**Cause of Problems**	⇨	**Solution for Problems**

Fig-2.3 Present problems on Baghdad water supply system and their solution (1/2)

Items	Basic Problems	Particular Problems	Cause of Problem	Solution for Problem
Supply sufficiency	Insufficient throughout the year	Very big per capita consumption	National standard is as big as 500 lcd	Field survey of actual water use
			No mind for saving water use	Installation of consumer meters
				Raising awareness of citizens by public information
		Delay of water facility installation	Lack of fund by economic sanction	Early installation by foreign assistance
		Decrease of production capacity of plants	Insufficient O/M by lack of fund	Increase of O/M expenditure by foreign assistance
		Increase of UFW	Insufficient O/M by lack of fund	Increase of O/M expenditure by foreign assistance
				Strengthening of UFW reduction organization
	Supply sometimes insufficient	Big increase of water use in Summer	Overuse by traditional water coolers	Adoption of water reuse system for coolers
			Increase of garden irrigation water	Use of raw water for irrigation where possible
		Water suspension by electric cutoff	Shortage of power supply capacity	Improvement and extension of electric supply system
			Lack of emergent power supply system	Installation of power generators
	Insufficient supply by areas	Severe shortage in east side of Tigris river	Lack of production and transmission facilities	Early construction of Rasafa water treatment plant
		Low pressure in remote areas of pump stations	Delay of installation of ring transmission mains	Installation of the mains in early stage
			Delay in distribution zoning	Formulation of distribution zones along with priority
			Delay of installation of distribution centers	Installation of distribution centers along with priority
			Existence of transmission cum	Independent use of transmission and distribution mains
		Wide distribution of pressure in single zone	Insufficient pipe network capacity	Installation of pipelines where necessary
		Low pressure around pump connection area	Illegal connection by direct pompage	Establishment of a rule to prohibit irregal connection
Water sources	Shortage of water source	Tigris may be insufficient within 30yr	Water demand is ever increasing	Water saving and reduction of UFW should be realized
		No other water sources	Even groundwater is not available	Public Information on necessity of water saving
	Deterioration of water quality	Contamination of Tigris water	City wastewater discharges into Tigris	Intake of water for water supply in upstream of discharge points
				Construction of sewerage treatment plants
Installation of facilities	Problem on treatment plants	Delay in construction of plants	Lack of fund by economic sanction	Early installation by foreign assistance
		A lot of compact unit exist	High O/M cost is necessary	Abolish and merge in large scall treatment plants
		Finished water of high turbidity	insufficient chemical dosing or filter washing	Strengthening of operation and maintenance
				Proper design of new treatment plants for better quality
	Insuffict capacity of transmission mains	Delay on formation of ring mains	Lack of fund by economic sanction	Early installation by foreign assistance
	Uneven water distribution	Delay on formation of distribution zones	Lack of fund by economic sanction	Early installation by foreign assistance
		Delay on installation of distribution centers	Lack of fund by economic sanction	Early installation by foreign assistance

Fig-2.3 Present problems on Baghdad water supply system and their solution (2/2)

Items	Basic Problems	Particular Problems	Cause of Problem	Solution for Problem
Consumer connection	connection without meters	Partiality of water charge collection	Actual water use is unknown	Water charge collection on meter basis
		No effort on UFW reduction	Actual water use is unknown	Installation of consumer meters
		No activity for water saving	Actual water use is unknown	Installation of consumer meters
	Illegal connection	Direct pump connection is many	Introduce water to individual elevated tanks	Raising distribution pressure
				Establishment of rule for prohibiting pump connections
Operation & maintenance	Decrease of plant production capacity	Deteriaration of conventional plants	Lack of spare parts	Capacity recovery by plant rehabilitation
		Poor performance of compact units (70%)	Insufficient operation and maintenance	Abolish and merge in large scall treatment plants
			High operation and maintenance costs	Abolish and merge in large scall treatment plants
	Insufficient conveyance	Distribution flow is not always measured	Lack of transmission and distribution meters	Installation of transmission and distribution meters
		Insufficiency of O/M capacity	O/M methods are not unified	Preparation of integrated O/M planning for water distribution
				Installation of integrated control system of water distribution
Management	Deficit Operation	Insufficient income	Low collection ratio of water charge	Establishment of rules on paying charges for every consumers
				Strenrthening of water charge collection activity
		Sales income is smaller than O/M costs	Water charge is very low	Setting of appropriate water charge
				Public information on necessity of appropriate water charge
		Overuse of water and no saving mind	Constant rate of water charge	Establishment of appropriate watar tariff
		High ratio of UFW	Deterioration of distribution pipelines	Rehabilitation of aged and weak pipelines
			Database of facilities and pipelines not	Installation of GIS system
			Insuficient activity for leakage reduction	Strengthening of the leak team and the reduction activity
Organization	Insufficient staff numbers	Many staff leaving job	Low salary and incentives	Improvement of labor conditions
		Lack of new staff	Jobs are not attractive for new staff	Preparation of appropriate job description
		Insufficiency of qualified staff	Lack of training program	Introduction of staff education system
	Coordination	Insufficient coordination within BWA	Lack of sense of responsibility	Introduction of staff education system
		Insufficient coordination with municipalities	Allocation of roles is not clear	Establishment of a rule of job allocation of BWA and Municipal
	Organization	Lack of properly planned activity	Insufficient direction by top management	Increase of assistant general directors
		Increase of UFW	Insufficient UFW reduction structure	Establishment of appropriate UFW organization and activity
Regulation	Water supply field	Deficit operation of business	Rely on subsidy fron the City	Establishment of a rule for cost recovery based operation
		Uneven distribution of water by areas	Apprecation of direct pumpage connection	Establishment of rule for prohibiting pump connections
		Big increase of water use in Summer	Overuse by traditional water coolers	Establishment of a rule on water reuse for traditional coolers
		Insufficient coordination with municipalities	Allocation of roles is not clear	Establishment of a rule of job allocation of BWA and Municipal
	Coordination with sewerage	Contamination of water source	Discharg of sewerage into Tigris	Establishament of water quality preservation regulation

3. Long Term Water Supply Planning

3.1 Basic Policy and Plan Frame

3.1.1 Basic Policy

Though this plan is a long-term plan, the establishment of the plan with high reliability and realizability for a long term is difficult, considering the fact that the situation in Baghdad City in the past has not been normal and the present status of obtaining the data due to this fact. Accordingly, the target year has been set, by considering both a middle term plan focusing on the realizability and a long term plan showing only the trend.

3.1.2 Plan Frame

1) Target year

From the above, the following target years have been set:

(1) The middle-term target year is 2014, and

(2) The long-term target year is 2027.

2) Planned Served Area

The current served area consists of whole area of Baghdad City (Amanat Baghdad) and its suburbs of two districts of Taji and Abu Chraib. There is a tendency that the people start to live also in the districts of Al Naser Wal Salam and Al Rashid, which are to be included in the service area in the future. The planned served area is shown in Fig-3.1.

3.2 Water Demand Prediction

The future water demand is estimated multiplying population served by unit water demand (Per capita water demand). It is not recommendable to estimate the population and water demand from the experiences in the recent years, as the Republic of Iraq had been under economic sanction in the past. These are determined with various methods.

3.2.1 Prediction of Population Served

The service coverage in Amanat Baghdad reached already 100%, and the population served is equal to the population of the city. Thus, the cities population is predicted, by dividing the population into that in the city and that in the suburbs. Furthermore, lot of weekday inhabitants exist in Baghdad, and these inhabitants are to be also added to the population served in the future. The weekday inhabitants mean the persons who live and work in Baghdad City only during the weekday and return to the countryside in the weekend, without filing the residence in Baghdad City.

1) Future Population by the Previous Study

Company Report predicts the population in the future in the current service area including the suburbs, estimating the population in 2027 as 8.909 million people. On the other hand, UNICEF Report estimates also the population only in the city and determines 6.403 million people as that in 2010, by the prediction in the near future. The UNICEF report sets forth the population increase at the annual increase rate of 2.99%, and 7.931 million people are estimated by extending this trend up to 2017.

Table-3.1 Future Population by Previous Study

Year		1947	1957	1965	1977	1987	1997	2000	2007	2012	2017	2022	2027
Company	Amanat	500	1000	1657	2664	3841	4402	4685	5419	6030	6750	7533	8586
	Suburban						166	177	207	230	253	286	323
	Total						4568	4862	5626	6260	7003	7819	8909
Unicef	Amanat						4400	4769	5907	6847	7931	—	—

2) Population by projection formula

The population growth ratio in the city of Baghdad has been decreasing in the last 15 years due to the economic control for the sanction for the country. Therefore, such growth rate is not reliable and cannot be applied for appropriate future population projection. Then, the future population is projected taking into account the past long time trend by a statistical equation based on the census data from the year of 1947. The population is projected based on the linear model equation and the exponential model equation. The outcome of the projection is shown in the table below.

Table-3.2 Future Population by Statistical Equation

Year		1947	1957	1965	1977	1987	1997	2000	2007	2012	2017	2022	2027
Data	Census	500	1000	1657	2664	3841	4402						
Estimation (Amanat)	Arithmetic						4418	4667	5248	5663	6078	6493	6907
	Exponent-1						4388	4670	5329	5817	6305	6810	7314
	Exponent-2						4644	4983	5775	6373	6970	7596	8221

3) Suburban resident and weekday inhabitant

The figures of suburban residents and weekday inhabitants in 1997 are shown in the table below. The population projection for the suburban residents and weekday inhabitants are made based on the yearly growth rates of 2.2 % up to the year 2020 and 2.25% thereafter according to the Company Report. The districts of Al Naser Wal Salam and Al Rashid are considered to be incorporated into the service area in 2012, taking the proposed water supply planning into account.

Table-3.3 Suburban Residents and Weekday Inhabitants

(unit : 1,000)

	Year	1997	2000	2007	2012	2017	2022	2027
Suburban	Total	107	114	127	404	451	502	561
East	Al-Naser	(125)	(134)	(149)	166	185	206	230
West	Taji & Ab	107	114	127	141	158	176	197
	Al-Rashid	(73)	(78)	(87)	97	108	120	134
Commuter		200	213	238	265	296	330	369
	East	120	128	143	159	178	198	221
	West	80	85	95	106	118	132	148

4) Population served in the future

The population served in the future is figured out based on the population in the city, population in the suburbs, and weekday inhabitants. As for the population in the future, it is estimated by five ways including Company report, UNICEF report, and 3 sorts of projection equations. The results are shown in the following figure and table.

Figure-3.2 Future Served Population (in 1000)

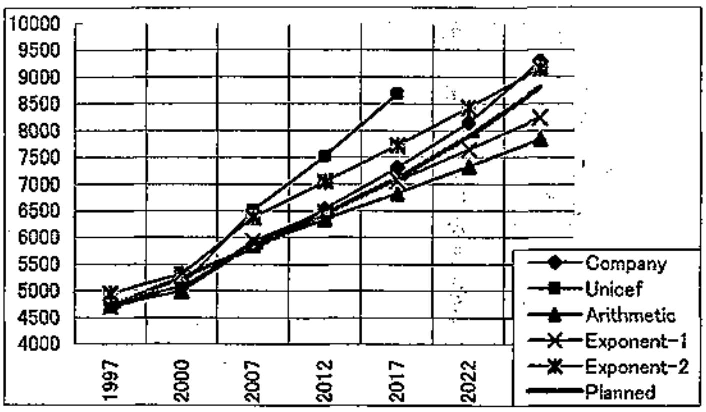


Table-3.4 Future Served Population (in 1000)

Year		1997	2000	2007	2012	2017	2022	2027
Company	Amanat	4400	4685	5419	6030	6750	7533	8586
	Suburban	166	177	207	230	253	286	323
	Commuter	200	213	238	265.4	295.9	330.2	369.1
	Total	4766	5075	5864	6525	7299	8149	9278
Unicef	Amanat	4400	4769	5907	6847	7931	—	—
	Suburban	107	114	363	404	451	—	—
	Commuter	200	213	238	265	296	—	—
	Total	4707	5096	6508	7517	8678	—	—
Arithmetic	Amanat	4418	4667	5248	5663	6078	6493	6907
	Suburban	107	114	363	404	451	502	561
	Commuter	200	213	238	265.4	295.9	330.2	369.1
	Total	4725	4994	5849	6333	6825	7325	7837
Exponent-1	Amanat	4388	4670	5329	5817	6305	6810	7314
	Suburban	107	114	363	404	451	502	561
	Commuter	200	213	238	265	296	330	369
	Total	4695	4998	5930	6487	7052	7642	8244
Exponent-2	Amanat	4644	4983	5775	6373	6970	7596	8221
	Suburban	107	114	363	404	451	502	561
	Commuter	200	213	238	265	296	330	369
	Total	4951	5311	6376	7042	7717	8428	9151
Planned	= Average	4700	5200	5700	6400	7000	7700	8500

Since the five kinds of projected figures vary more or less, the average of the five is taken as designed served population. They are shown as "Planned" in the figure and the table. It is noted that 60 % of the present population is distributed on the left bank (East) of the Tigris, and the rest 40 % on the right bank (West), so population on the east of the Tigris River is larger than that of west by 50%.

3.2.2 Unit water demand

Water demand in the future is ordinarily estimated as multiplied future served population by unit water demand (per capita water demand). This sub-section discusses the basic factor of the supply unit and then set a proposed future demand.

1) Standard unit water demand

In Iraq, the standard unit water demand is already provided by the Planning Board Decision in 1977, as shown in the table below. The standard unit water demand is 500 lpcd including unaccounted-for water, which is 15 % of the standard unit water demand. It may be a kind of water policy that the city of Baghdad serves this amount of water supply to the citizen out of its municipal budget. Flat rate and low tariff setting correspond with the above. The standard unit water demand of 500 lpcd is employed as proposed unit water demand in UNICEF Report, while in Company Report the unaccounted-for water is somewhat reviewed as 20 % of the standard unit water demand.

Table-3.5 Per Capita Water Demand (lpcd)

Item	Standard	Company	Yokohama	Tokyo
Domestic	330	300	244	246
Commercial	40		59	
Governmental	55		19	
Sub-total	425	400	322	356
UFW	75	100	28	34
Total	500	500	350	390
Served Population	4.77 M		3.47M	11.63M

Note : Served Population (for Baghdad in 2001,and for Yokohama and Tokyo in 2000)

2) Actual measurement

According to the UNICEF Report, water supply in 2000 is recorded as in the table-3.6. Average per capita water supply is as large as 372 lpcd, while average per capita water use is only 180 lpcd due to large amount of UFW.

Table-3.6 Water supply in 2000

Item	Amount	Remarks
Average water supply	1.775 Mm^3/d	
Amount billed	0.860 Mm^3/d	Consumption
Population served	4,769,072	
Average per capita water supply	372 lpcd	
UFW	52%	
Average per capita water use	180 lpcd	

As water source is abundant in Baghdad City, the citizen's water consumption is traditionally rather large and the ratio of those who considered as water shortage with this amount reaches 47 % and they feel severe shortage especially in summer. Per capita water demand of 180 lpcd seems rater small although it is doubtful whether per capita water demand of the city exceed the figures of Yokohama or Tokyo City in Japan.

3) Monthly production

Per capita water demand is also estimated based on the Monthly Production Data of Baghdad Water Supply System as attached in the appendix-1.

Production amount in the water treatment plant is considered as water actually supplied, and both of the maximum and average amounts had increased from 10 years ago up to 2001 although economically controlled. The maximum amount, however, already reaches the actual treatment capacity of 2.3

Mm3/day. It is considered that water shortage might be occurred in summer because the ratio of Max Month to Mean Monthis recorded around 1.1.

As for other months, operation ratio is rather high as the eighties in percentage, however, it is not considered to be reached water shortage.

Table-3.7 Monthly Production in Water Treatment Plant

Year	1996	1999	2001	2003	2004
Max Month	2.324	2.292	2.390	2.186	2.080
Mean Month	2.066	2.101	2.196	1.980	1.991
Peak Factor	1.13	1.09	1.09	1.10	1.06
Other Month	1.955	2.038	2.075	1.895	1.953
Other Factor	0.84	0.89	0.87	0.87	0.94

Note : Peak Factor = Max Month／Mean Month
Other Month (Monthly average except months from May to September).
Other Factor =Other Month／Max Month

Water users in the city feel as water shortage even in months except summer, and have intermittent supply of water. This might be local and temporary conditions of the city's water supply such as:

(1) lowered pressure in pipes due to the remote pump stations,

(2) lowered pressure in downstream area in case pumped connection is applied by upstream users, and

(3) lowered pressure due to the insufficient distribution capacity of existing pipes especially in peak hours.

On the other hand, in summer for four months, the monthly average temperature goes over 30 degrees centigrade; sometimes people experience the temperature exceeds 50 degrees. Under these circumstances,

(1) people take a shower many times a day,
(2) people use too much water for the traditional water-cooled air conditioner popular in the city, and
(3) people use too much potable water for garden watering,

then, the per capita water use becomes eventually high.

Assuming the maximum monthly supply amount recorded in summer as the maximum daily supply, peak factor will be only from 1.06 to 1.10. This assumption is because of long summer in Baghdad, almost daily maximum supply continues for a month. The above peak factor is too small compared with the past record of 1.35 to 1.4, this may be the result that water production capacity is insufficient.

Considering the above, the unit water demand in the year of around 2000 (Q_{use}, Q_{ave}, Q_{max}) will be estimated based on the water use discussed in the above.

Per Capita Water Demand : Q_{use} = 460×(1.00－0.52) = 221 lpcd = 230 lpcd

Per Capita Daily Average Water Supply: Q_{ave} = 2,196,000／4,769,072 = 460 lpcd

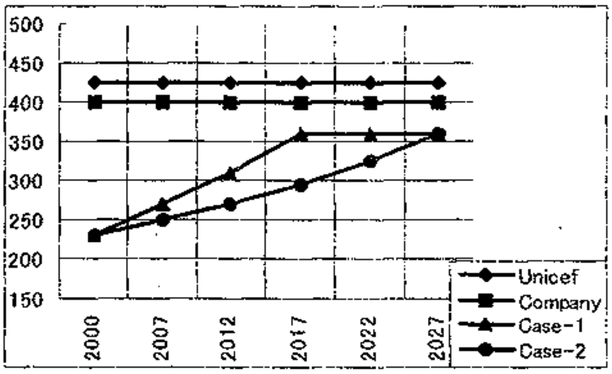
Per Capita Daily Maximum Water Supply: Q_{max} = 460×(1.35～1.4) = 621～644 lpcd

On the other hand, as for the proposed unit water demand, those in in large cities in Japan as shown in Table-3.5 is considered to be much sufficient, and larger unit of 425 or 400 lpcd of UNICEF and Company reports seems to be question. Water use in Japan is extremely high in the world, and the unit of Tokyo is high among the cities in Japan. If the unit of Tokyo is employed as the proposed unit, it will be much sufficient. So, 350 lpcd is taken as the proposed unit water demand.

4) Future water demand

Two kinds of the future water demand are considered: one based on the standard unit demand discussed in the previous reports, the other based on the water use actually recorded. The present water demand is thought somewhat controlled under the country's economic sanction. Generally, this kind of demand would be larger as the country's economy recovers from now on. As for increase of the unit, two kinds of paces are considered: rapid and slow paces. In rapid pace of increase, the target year is 2017 which is middle term target, and in slow pace, 2027 which is long term target. These are summarized in Fig-3.3.

Fig-3.3 Future Water Demand



It is proposed that the future water demand be estimated based on the water supply and consumption measured by flow meters and service meters, provided such metering system is equipped in the earliest possible.

3.2.3 Setting water demand

The future water demand is set considering estimated future population served, per capita water demand, UFW and daily maximum factor.

1) Reduction of UFW

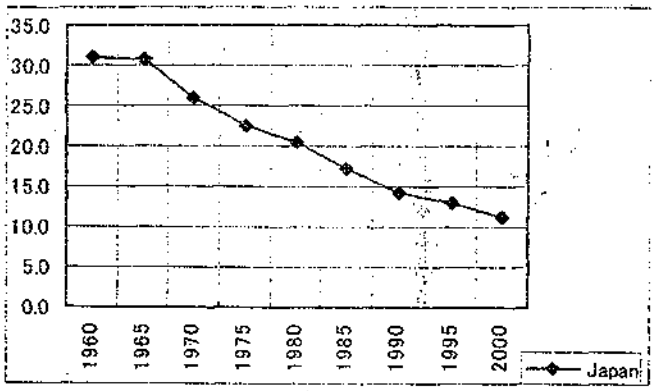
UFW in Baghdad Water Supply is said to be 50 % at present, and in order to reduce the amount of UFW to 15 % of the standard value or 20 % of the Company Report, long term steady efforts and sufficient funding for the reduction of UFW are needed. As is shown in Fig-3.4, it took 25 years of long period to reduce UFW by 50 %, for instance, from 32 % to 16 %, or from 24 % to 12 %, in Japan's Water Supply.

The proposed UFW reduction rate in 2027 for Baghdad Water Supply is considered as 25 %, which is a half of present ratio, taking 25 years for the achievement as well as Japan, supposing Baghdad Water Supply might conduct a long term UFW reduction activities preparing a suitable plan, necessary organization, and financing.

Up to the target year 2027, the UFW reduction rate is considered as gradually reduced as shown in the right.

2000	07	12	17	22	2027
50%	45	40	35	30	25

Fig-3.4 UFW Reduction in Japan

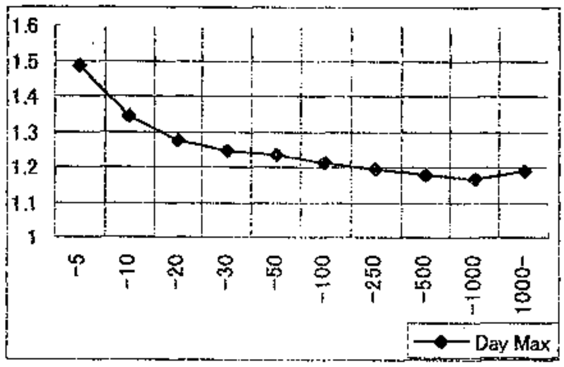


2) Daily peak factor

The ratio of daily maximum water supply to daily average water supply is generally smaller, as the capacity of water supply increases like large cities. This is because water demand for office and commercial use, which is constantly used throughout the year, is increased as a city is more urbanized. In Japan, the ratio is 1.2 or less in cities serving more than 250,000 of population as shown in Fig-3.5. On the other hand, in Baghdad, the ratio was rather high, from 1.35 to 1.4 in the past. As stated, this is from the rapid increase in water use for the traditional air conditioner and garden watering. Amount of water use for an air conditioner is reportedly 1.5 m^3/day, remarkably large consumption.

Fig-3.5 Day Max. Factor by Size in Japan

Served Population in 1000



Source: JWWA

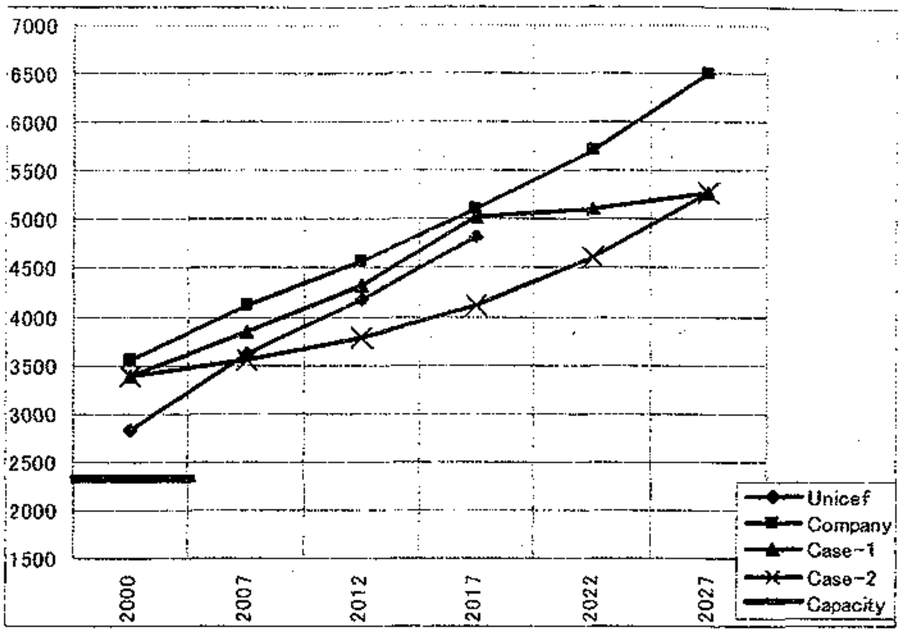
As for the proposed value, it is considered that the value can be decreased in the future by promoting raw water use and water reuse. So, the proposed value of 1.25, which is smaller than the present value and larger than that of Japan, is employed.

3.2.4 Setting of Proposed Water Supply Amount

1) Future water supply by different methods

Future water supply amount is estimated considering population served, per capita water demand, UFW ratio and daily maximum ratio. Following four kinds of methods are taken for the future water supply amount estimation. Calculation of the future water supply amount is as shown in Table-3.8, and the future water supply amounts (daily maximum water supply amount) are as shown in Fig-3.6.

Fig-3.6 Future Water Demand by Various Mthods



The future water demands thus estimated are figured as shown in Fig-3.5 and considerable variation is seen among them. In any case, the future demand is over the present facilities' capacity indicating water supply shortage as shown.

Table-3.8 Future Water Supply Amount by Various Methods

	Items	Unit	2000	2007	2012	2017	2022	2027
Unicef	Per Capita Demand	lpcd	425	425	425	425		
	Served Population	10^3 c	5096	6508	7517	8678		
	Water Demand	$10^3 m^3/d$	2166	2766	3195	3688		
	UFW	%	15	15	15	15		
	Average Supply	$10^3 m^3/d$	2548	3254	3758	4339		
	Peak Day Factor		1.11	1.11	1.11	1.11		
	Day Max Supply	$10^3 m^3/d$	2829	3612	4172	4816		
Company	Per Capita Demand	lpcd	400	400	400	400	400	400
	Served Population	10^3 c	5075	5864	6525	7299	8149	9278
	Water Demand	$10^3 m^3/d$	2030	2346	2610	2920	3260	3711
	UFW	%	20	20	20	20	20	20
	Average Supply	$10^3 m^3/d$	2538	2932	3263	3649	4075	4639
	Peak Day Factor		1.4	1.4	1.4	1.4	1.4	1.4
	Day Max Supply	$10^3 m^3/d$	3553	4105	4568	5109	5704	6495
Case-1	Per Capita Demand	lpcd	230	270	310	360	360	360
	Served Population	10^3 c	5250	5800	6450	7100	7900	8800
	Water Demand	$10^3 m^3/d$	1208	1566	2000	2556	2844	3168
	UFW	%	50	45	40	35	30	25
	Average Supply	$10^3 m^3/d$	2415	2847	3333	3932	4063	4224
	Peak Day Factor		1.4	1.35	1.3	1.28	1.26	1.25
	Day Max Supply	$10^3 m^3/d$	3381	3844	4332	5033	5119	5280
Case-2	Per Capita Demand	lpcd	230	250	270	295	325	360
	Served Population	10^3 c	5250	5800	6450	7100	7900	8800
	Water Demand	$10^3 m^3/d$	1208	1450	1742	2095	2568	3168
	UFW	%	50	45	40	35	30	25
	Average Supply	$10^3 m^3/d$	2415	2636	2903	3222	3668	4224
	Peak Day Factor		1.4	1.35	1.3	1.28	1.26	1.25
	Day Max Supply	$10^3 m^3/d$	3381	3559	3773	4125	4622	5280

2) Setting of the proposed water supply amount

Future water demands are discussed with different methods in previous section, among the future demand alternatives, an appropriate water demand is selected as the proposed future water demand. Description and features for each method are tabulated below, and Case-2 is considered appropriate. In this case, per capita average water supply amount is 470, which is nearly the standard value, and per capita maximum water supply is 580 l which exceeds the standard value.

Table-3.9 Comparison of Water Demand Estimated

Case	Description	Features
Unicef	Water demand taken in Unicef Report and its development. Suburban residents and weekday inhabitants are incorporated into population served.	The unit supply amount of 425 l is considered overestimated. 15 % of UFW and 1.1 of daily maximum ratio are considered too small.
Company	Water demand taken in Company Report. Weekday inhabitants are incorporated into population served.	More realistic than Unicef Report, however, the unit supply amount of 400 l is too large and UFW ratio of 20 % cannot be attained soon. Also it is unlikely that the daily maximum factor of 1.4 continues in the future.
Case-1	Per capita water demand of 360 lpcd, UFW ratio of 25 %, and daily maximum ratio of 1.25 in 2017, which is the middle term target year.	More realistic than Company Report. It is unlikely that per capita water demand increases by 50 % in around 10 years provided the country's economy is recovered.
Case-2	Per capita water demand of 360 lpcd, UFW ratio of 25 %, and daily maximum ratio of 1.25 in 2027, which is the long term target year.	The unit supply amount of 360 l as well as that in Tokyo is possible. UFW ratio of 25 % is also possible. Daily maximum ratio can be reduced in the future by rationalization of water use for garden watering and water-cooled air conditioner.

Considering the above, in the present study, the following amount are employed as the proposed water supply amounts in the target year.

* 5,130,000 m3/day	for Daily Maximum Water Supply Amount, and
* 4,100,000 m3/day	for Daily Average Water Supply Amount.

3.3 Water Supply Scheme

A long term water supply plan to meet the future water demand is studied hereunder. In order to increase water supply to Baghdad citizen, both of raising production of the water supply system and reduction of UFW amount are considered necessary.

3.3.1 UFW Reduction

Target of UFW reduction is set 25% in the year 2027 as mentioned in the subsection 3.2.2. In case no reduction of UFW is executed, the necessary water supply capacity would be 7.7Mm^3/d which is 2.6Mm^3/d bigger than the target supply amount. In other word, reduction of UFW to a half of the present level would be equal to install a new water supply system having a capacity of 2.6Mm^3/d. UFW has to be reduced by all means. Measures for UFW reduction is detailed in the section 3.5.

3.3.2 Expansion of the Water Supply System

Capacity of the water supply facilities to be expanded is calculated as 5.130－2.334＝2.796Mm^3/d which is bigger than capacity of the existing system. Considering the size and cost for the expansion, it is difficult to construct the facilities at one time. Instead, it is preferable to employ stepwise implementation of the facilities construction.

1) Urgent Programme

As the urgent programme for improvement of Baghdad Water supply system, the extension-2 of Saba Nissan treatment plant by USA assistance and the compact units of treatment by Japan are under implementation. They are planned to be completed in either 2005 or 2006. Then, the production capacity of the system is to be 2.7Mm3/d

Table-3.10 Production Capacity after Urgent Programme

Name of Treatment Plant	Capacity	Remarks
Existing Plants	2,333,840 m^3/d	84% of designed capacity 2.76Mm^3/d
Extension-1 Saba Nissan	225,000 m^3/d	To be completed in 2005
Compact Units	135,000 m^3/d	To be completed in 2006
Total	2,693,840 m^3/d	Expected production in 2007

2) Succeeding Projects

Considering the target demand, it is still necessary to execute a large scale expansion of water supply facilities, capacity of which is more than 2.0Mm3/d. This is equal to construction of a new facility with a capacity of 100,000m3/d every year. Consideration on the future water supply facilities to be constructed is given as below.

Normally, in case of installation of a large water supply system, the implementation periods of 5 to 6 years including 1 year for F/S, 1.5 to 2.0 for design and tendering and 2.5 to 3.0 for construction are necessary. Its completion is then estimated in 2010 to 2011 and it would be late because the capacity after the urgent programme could meet the average water demand until the year 2009. Therefore, construction of a water supply system has to be completed until 2008.

Fortunately, the extension-2 program of Saba Nissan plant, for which premises including for the intake station are said already acquired and its design is informed underway, has enough capacity of 225,000Mm^3/d and is expected to be completed until 2008 in case an appropriate fund for the implementation could be available. Execution of the extension is very important to meet the average water demand in the recent future.

However, target of the above extension is still in the level of the average demand. To cope with the maximum demand, a larger system must be constructed as early as possible considering an expected increase both of the population of Baghdad city and the unit water demand according to restoration of economical condition in the country. It is not easy and effective to correspond to a large water demand such as of Baghdad city by a lot of small scale water supply facilities, and instead, a few numbers of large scale installations are recommendable. The existing master plan of Baghdad water supply and Company report propose input of Rasafa treatment plant of which capacity is over $2.0Mm^3/d$. The proposal is thought reasonable and should be adopted in the present planning.

3) Stepwise Implementation

As stated above, after the urgent program, implementation of Saba Nissan treatment plant and the Rasafa plant is considered appropriate. It is not easy to implement them at one time from the following view points:

(1) Execution capability of BWA for such large scale installations including related transmission and distribution facilities is not enough, and

(2) Amount of fund for the implementation which is to rely on international lending agencies is far bigger than the past experience of the other countries.

Therefore, it is proposed to construct Rasafa plant stepwise making the one step capacity as $600,000Mm^3/d$ and construct the plant in four stages.

3.4 Planning of Water Supply Facilities

3.4.1 Basic Idea for the Planning

The basic idea for planning the future water supply system of Baghdad city, which is necessary for sustainable development and management of the system, is discussed in this section.

Characteristics of Baghdad water supply is as follows.

(1) It is a very large scale water supply system having its served population nearly 10 million people in the future,

(2) It served area has flat geographical features,

(3) The large scale Tigris river runs almost in the center of the city from north to south,

(4) Ratio of the population in the east side area (Rasafa) and the west side area (Karkh) of the Tigris is 60 : 40 ,

(5) On the contrary, water production in Karkh side is bigger than in Rasafa side at present,

(6) The Tigris which has sufficient stream flow is a sole water source for the system,

(7) There are a lot of small compact units of water treatment and such large treatment plants as over 200,000m^3/d are only three,

(8) The present water transmission and distribution is mainly made by pumpage from treatment plants, although the planned water distribution method is the zoning system, and

(9) Only about 10% of consumer connections are equipped with water meters and mostly water consumption is not measured.

As for the basic idea of the planning, the existing M/P and Company report are describe as,

(1) The served area is to be divided hydraulically into more than 20 distribution zones and each zone is equipped with a distribution center consisting of a distribution reservoir and distribution pumps for impartial supply of water, and

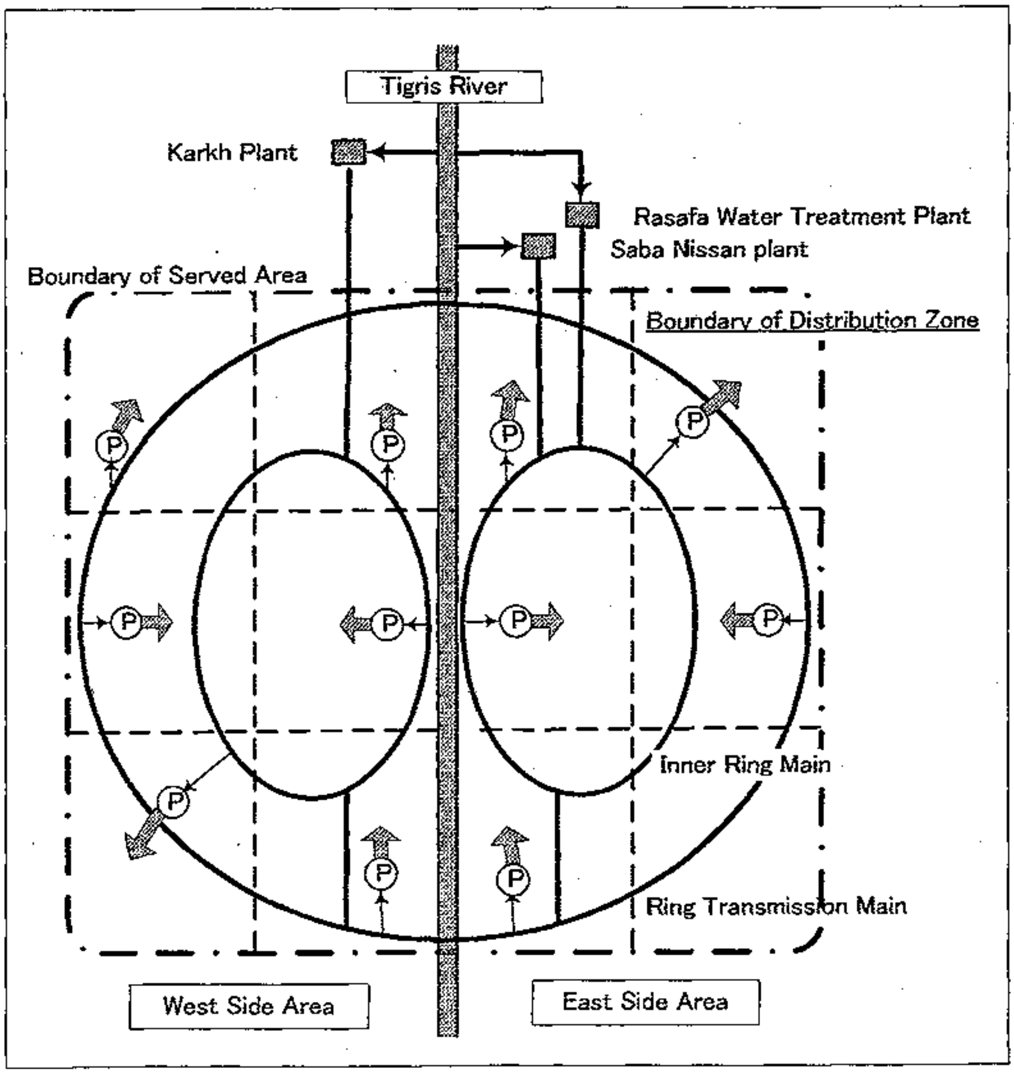
(2) A large scale ring transmission main is to be installed in order to transmit potable water produced at the water treatment plants to the distribution center in each distribution zone.

Considering the above, the basic idea for planning the future water supply facilities of Baghdad city, is set as listed in the table-3.11, and its image is illustrated as shown in Fig-3.7.

Table-3.11 Basic idea for planning the future Baghdad water supply system

(1) Install a few numbers of large water treatment plants in both sides of the Tigris in order to balance of the water demand and the supply capacity in each side. Small scale plants and compact units will be demolished and merge into large plants along with their life in operation.
(2) Install a trunk ring main to ease water transmission from the treatment plant to the distribution center in each zone. The ring mains inside east and west areas are already formed respectively. In an urgent case, water of any plant could be transmitted to any distribution center.
(3) Establish the distribution zones hydraulically isolated with each other for even distribution of water.
(4) Install a distribution center consisting of distribution reservoirs and distribution pumps in each distribution zones. Water from the ring main is once stored and regulated in the reservoir and pumped to the service area.
(5) Install distribution and consumer meters in order to operate the water supply system based on the ,easurement.

Fig-3.7 Image of Future Baghdad water Supply System



3.4.2 Water Source Plan

Source of Baghdad water supply depends solely on Tigris river. She has abundant stream flow and the recent average flow is as much as 400 m^3/s. Estimation by several researchers mention stream flow of Tigris is much sufficient against the whole water demand up to 2020. However, decrease in the river flow is rather acute, and it is necessary to transfer the precious water source to next generation as it is.

As shown in the appendix-1, water quality of Tigris down stream is more deteriorated than her upstream because of discharge of any kind of wastewater into the river shed. It is recommendable to take raw water from the upper stream of Tigris river.

3.4.3 Plan of Water Treatment Plant

1) Direction of Installation

There are 8 conventional water treatment plants and 23 compact treatment units of small capacities. Itit is proposed to construct a few large scale water treatment plant considering that,

(1) The compact units require big operation and maintenance work load and cost, and

(2) Through the ring main, potable water produced at a treatment plant can be transmitted to distribution centers in any of the distribution zones.

This proposal meets to the basic idea for the planning as stated in the above. The existing compact units, total capacity of which is 125,840m^3/d and deteriorated Rasheed plant are to be abandoned along with their life and with increase of production capacity by the new installation in the future. It is considered that the new treatment plants to be constructed from now on are limited to a few numbers including Karkh, Rasafa and Saba Nissan.

It is also considered to install large treatment plants in both of east and west areas and to balance water demand and water supply in each of both areas.

2) Necessary Treatment Plant in the Target Year

Water demand and supply capacity/production capacity are described in the Table-3.12. As shown in the table, the followings items are confirmed.

(1) Total production capacity of the treatment plants exceeds day max water demand in year 2027,

(2) As new installation is planned in the east area only, demand and supply in both of the east and the west areas are not in good balance. A quantity of 520,000m^3/d has to be transmitted from the east area to the west area in the target year, and

(3) The existing river crossing trunk mains of d1600mm and d1,400mm have sufficient conveying capacity for the quantity.

Table-3.12 Water Demand and Supply in 2027 (Unit : m^3/d)

Supplu & Plant	Total	East Area	West Area	Remarks
Day Max. Supply	5,133,000	3,080,000	2,053,000	Esat:West=60:40
Day Average Supply	4,107,000	2,464,000	1,643,000	
Treatment Plant	5,143,000			>5,133,000m³/日
East		(3,613,000)		520,000 to North Extension
Saba Nissan		950,000		
Wathba		70,000		
Wahda		58,000		
Rasafa		2,400,000		New Construction
Compact Units		135,000		New Units Only
West			(1,530,000)	
Karkh			1,150,000	
Quadish			100,000	
Karama			180,000	
Doura			100,000	

2) Stepwise Construction of the Plants

Application of stepwise construction is mentioned in section 3.3 and its detailed plan is prepared in this subsection.

Table-3.13 Stepwise Construction of the Plants

Year	Name of Plant	Capacity	Remarks
2009	Saba Nissan-2	135,000	Operation
2011	Rasafa-1	600,000	Operation
2015	Rasafa-2	600,000	Operation
2015	Rasheed	-50,000	Abandon
2019	Rasafa-3	600,000	Operation
2019	1/2 Compact U.	-63,000	Abandon
2023	Resafa-4	600,000	Operation
2023	1/2 Compact U.	-63,000	Abandon

As shown in the table-3.13, the existing deteriorated Rasheed plant will be demolished in 2015. A half of the existing compact treatment units is to be abandoned in the year 2019, and the remaining half to be in 2023. However, compact units under implementation by Japanese grant are planned to be in operation even after the target year. Other compact units or small scale treatment plants are informed to be constructed by the assistance of international agencies or other foreign countries, but they are not included in the plan because of their small capacities. Capacity recover of the existing treatment plants is not included too. As for the new installation, Saba Nissan and Rasafa treatment plants are planned to be constructed as shown in the table-3.13.

Those installation and demolishing of the facilities are summarized together with the future water demand up to the year 2027 in the table-3.14. From the table, it is clearly seen relation between capacity of the system and the future water demand for each year in the future. The Table also shows balance of the capacity and the demand in each of east and west areas. As mention earlier, for balancing a quantity of 520,000m^3/d must be transmitted from the east area to the west area in the target year. For this countermeasure, the existing river crossing trunk mains of d1600mm and d1,400mm have sufficient conveying capacity for the quantity.

Table 3.14 Increase of Water Demand and Production Capacity

Year	2000	2002	2004	2006	2008	2010	2012	2014	2016	2018	2020	2022	2024	2026	2028
Water Demand															
Day Max.	3381	3412	3442	3473	3517	3576	3634	3746	3859	4014	4211	4408	4698	4988	5278
East	2029	2047	2065	2084	2110	2146	2180	2248	2315	2408	2527	2645	2819	2993	3167
West	1352	1365	1377	1389	1407	1430	1454	1498	1544	1606	1684	1763	1879	1995	2111
Day Ave.	2415	2463	2512	2560	2626	2711	2795	2900	3005	3146	3323	3499	3742	3985	4229
East	1449	1478	1507	1536	1576	1627	1677	1740	1803	1888	1994	2099	2245	2391	2537
West	966	985	1,005	1,024	1,050	1,084	1,118	1,160	1,202	1,258	1,329	1,400	1,497	1,594	1,692
Treatment Plant															
East	804	804	804	1164	1164	1389	1989	1989	2539	2539	3076	3076	3613	3613	3613
Nissan	500	500	500	725	725	950	950	950	950	950	950	950	950	950	950
Rasheed	50	50	50	50	50	50	50	50							
Wathba	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70
Wahda	58	58	58	58	58	58	58	58	58	58	58	58	58	58	58
Rasafa							600	600	1200	1200	1800	1800	2400	2400	2400
Compact U.	126	126	126	261	261	261	261	261	261	261	198	198	135	135	135
West	1530	1530	1530	1530	1530	1530	1530	1530	1530	1530	1530	1530	1530	1530	1530
Karkh	1150	1150	1150	1150	1150	1150	1150	1150	1150	1150	1150	1150	1150	1150	1150
Quadish	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Karama	180	180	180	180	180	180	180	180	180	180	180	180	180	180	180
Doura	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Total	2334	2334	2334	2694	2694	2919	3519	3519	4069	4069	4606	4606	5143	5143	5143

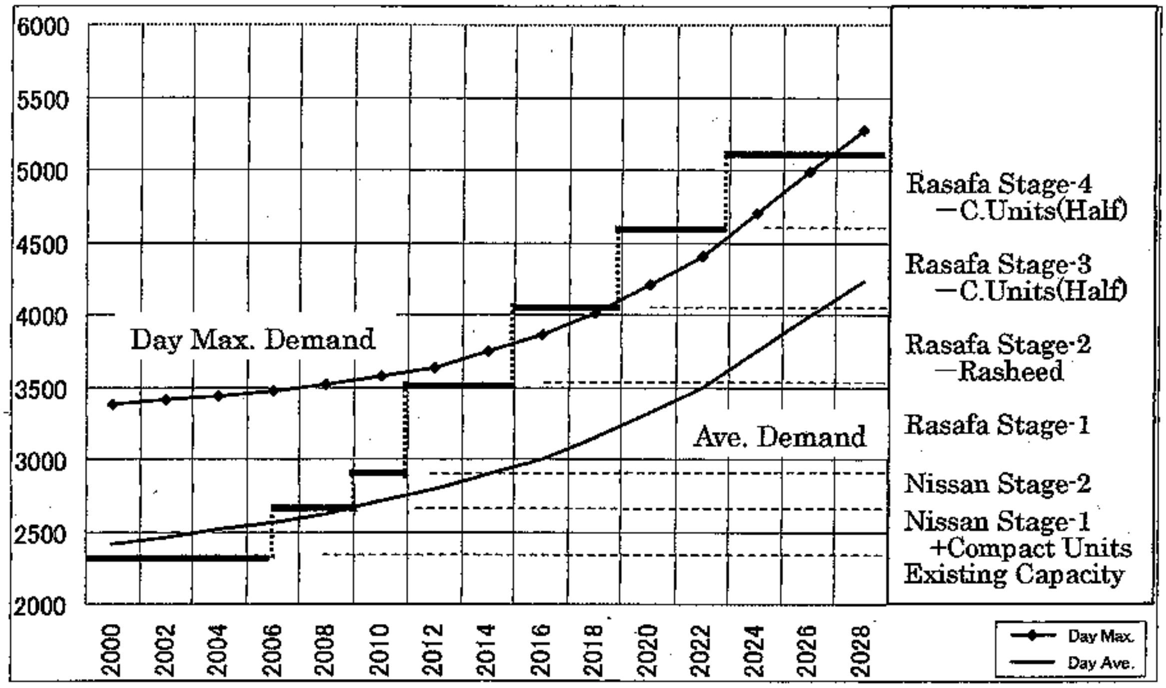
By the above implementation of the water treatment plants in the future, water supply condition in Baghdad city is expected to be improved step by step as shown in the followings.

Table-3.15 Stepwise Implementation and Water Supply Condition

(1) Construction of Saba Nissan extension-1 and compact treatment units covers average water demand up to the year 2009.
(2) Succeeding construction of Saba Nissan extension-2 will cover increasing average demand until 2011 or 2012.
(3) Installation of Rasafa-1 raises production greatly approaching to the day maximum water demand.
(4) Installation of Rasafa-2 covers the day maximum water demand, which is the normal water supply condition, in 2015 about ten years from now on.
(5) After construction of Rasafa-3 plant, water production/supply capacity will be sufficient and small deteriorated nints could be abandoned.
(6) By construction of Rasafa-4 plant in 2023, the target water demand in the year 2027 will be covered.

Summary of the implementation scheduled as planned so far is illustrated in the following figure. It is clearly understood that the water supply condition of Baghdad city improves year by year in the future.

Fig-3.8 Stepwise Implementation Program of Baghdad Water Supply System



3.4.4 Water Transmission and Distribution

Basis of water transmission and distribution of the future Baghdad water supply system is combination of the ring trunk main and zoning systems. In order to complete the ring trunk main system, installation of pipelines crossing the big Tigris river at least two locations is necessary. For this purpose, there already exists a set of transmission mains of d1,600mm and d1,400mm which cross Tigris. In the future, another river crossing will be necessary in the south.

As for zoning of the distribution network, it is planned to establish 24 zones with in the served area. Implementation of the distribution zones to isolate hydraulically the distribution network from other zones is not yet made because of lack of fund. It is expected to install necessary pipelines to form isolated zones and meters to measure flow of each zone. Among the planned 24 distribution centers consisting of clear water reservoir and distribution pumps, eight centers, though their capacity is not always sufficient, are now in operation, and the remaining 16 units are waiting for execution. The centers for zones R3 and R14 is said most urgently required and R2 and R7 are of the second priority.

3.4.5 Installation of Consumer meters

Considering the fact that only 10% of service connections is equipped with consumer, It could be said installation of the consumer meter is a most urgent requirement for better management of Baghdad water supply system.. This is discussed in the succeeding section.

3.5 UFW Reduction and Water Saving

3.5.1 Necessity of UFW Reduction

Because of policy of the country of supplying 500 lpcd water and sufficiency of the water source of Tigris river, there has been scarce mind for Baghdad citizen of saving water. Under these circumstances, the water supply management becomes ineffective.

Usually, 80% of leakage which is one of major causes for UFW is said to be occurred in the service connections. However, because of very high UFW in case of Baghdad water supply system, other component than the above such as (1) existence of a lot of deteriorated distribution pipes, (2) estimated consumption without meters, (3) a low collection ratio and (4) many illegal connections must be taken into account. As for the water saving, it is not always practiced because of (1) estimated consumption without meters, (2) very low water rates and (3) standardization of big unit consumption of 500 lpcd.

As mention in 3.3.1 that the planned UFW reduction is equivalent to installation of 2.6Mm^3/d treatment plant, its realization is of vital importance for the sound operation of the water supply system. As for the water saving, its realization is also required in order to preserve the precious water source of Tigris to the next generation as it is and to avoid an excessive finance to facilities installation.

Management of a water supply relying on subsidy by the city or the country lessens responsibility of the water supply agency and brings sometimes about insufficient finance in case the fund for the service improvement is necessary. The present states of Baghdad water supply system would be the result of such a way of the management. A water supply management should be on self sustaining basis and should be operated in line with needs of the consumers not of the city nor the country.

3.5.2 UFW Reduction and Water Saving Plan

Comprehensive measures for UFW reduction and for the water saving including organizational, institutional and technical ones are listed in the table-3.16. Among other measures, Unicef report describes such various units as listed in the table-3.15 are necessary for UFW organization to have successful implementation of the reduction.

Table-3.15 Necessary Unit for UFW reduction

Unit	Role of Unit
Hydraulic Unit	Hydraulic analysis, Waste district metering.
GIS Unit (Geological Information System)	Description of pipe network and consumer meters.
MIS Unit (Management Information System)	Collect operational & billing data and treat. Prepare reports.
Leak Detection Unit	Tests and routine leak detection surveys
Consumer Survey Unit	Setting up of a customer management system. Reduction of non-physical losses.
Pipe Repair Unit	Repair of defective pipes and accessories.

Table-3.16 Complehensive Measures for UFW Reduction and Water Saving

No	Measures for UFW Reduction & Water Saving	Activity Priority		
		Urgent	Middle	Long
Measures for UFW Reduction				
1	Setting up necessary UFW organization	■		
2	Establishment of rules to prohibit irregal connections	■	■	
3	Strengthening bill and collection	■	■	■
4	Strengthening of meter reading		■	■
5	Formation of pilot areas and UFW survey thereof	■		
6	Installation of bulk meters	■		
7	Repair/replace source meters	■		
8	Rehabilitation of service mains and connections	■	■	■
9	Replacement of oldest pipes	■	■	■
10	Rehabilitation/replacement of pipes subject to leaks		■	■
11	Rehabilitation/replacement of defective valves		■	
12	Rehabilitation/replacement of defective meters		■	
13	Implemantation of routine leak detection			■
14	Suvey of large consumers		■	
15	Creation of distribution zones		■	■
16	Construction of distribution centers		■	■
17	Installation of GIS system	■	■	■
Measures for Water Saving				
1	Installation of consumer meters	■	■	■
2	Improvement of tariff system		■	■
3	Public Information for water saving		■	■