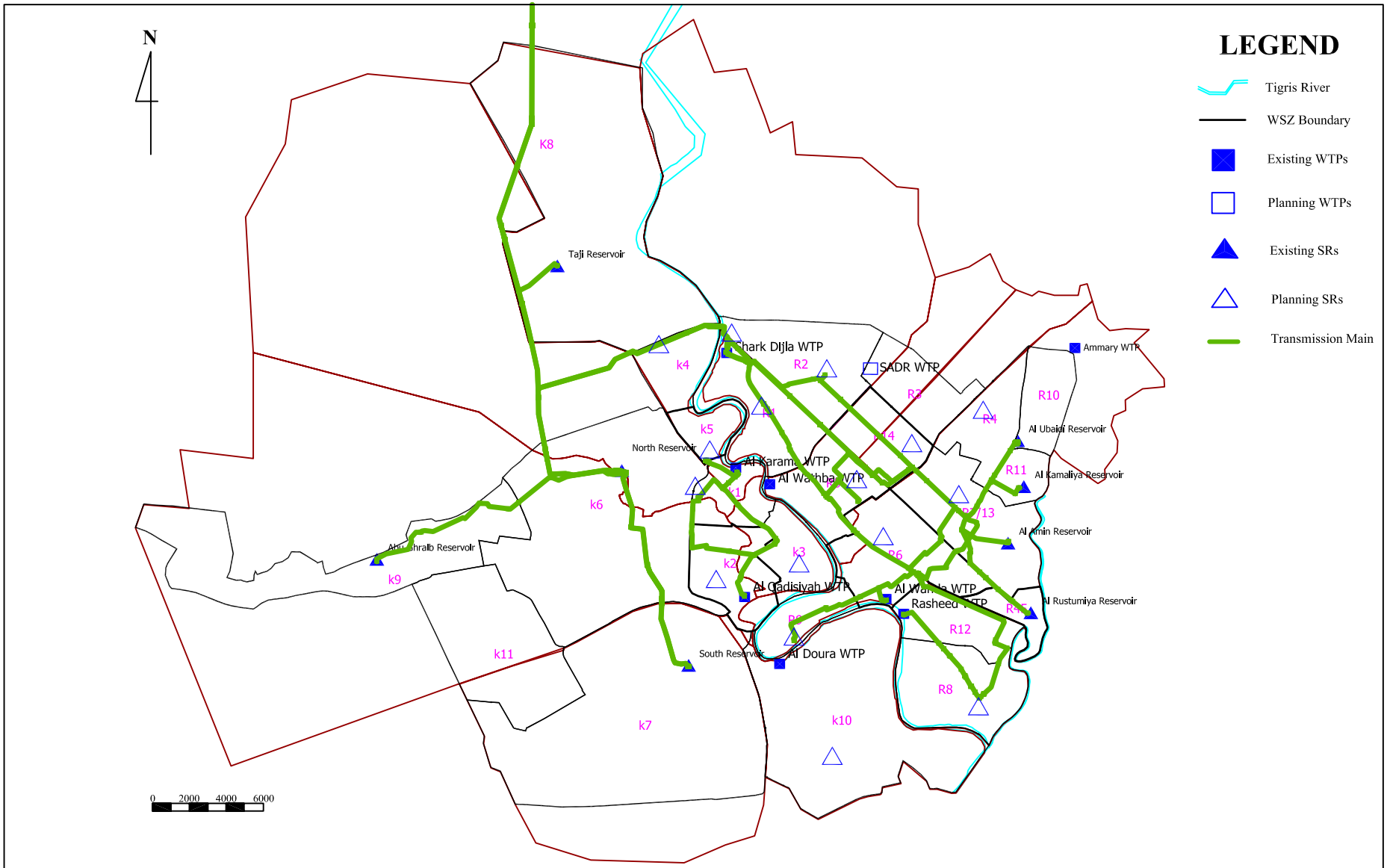
4.4.3 Water Treatment Plants and Compact Units

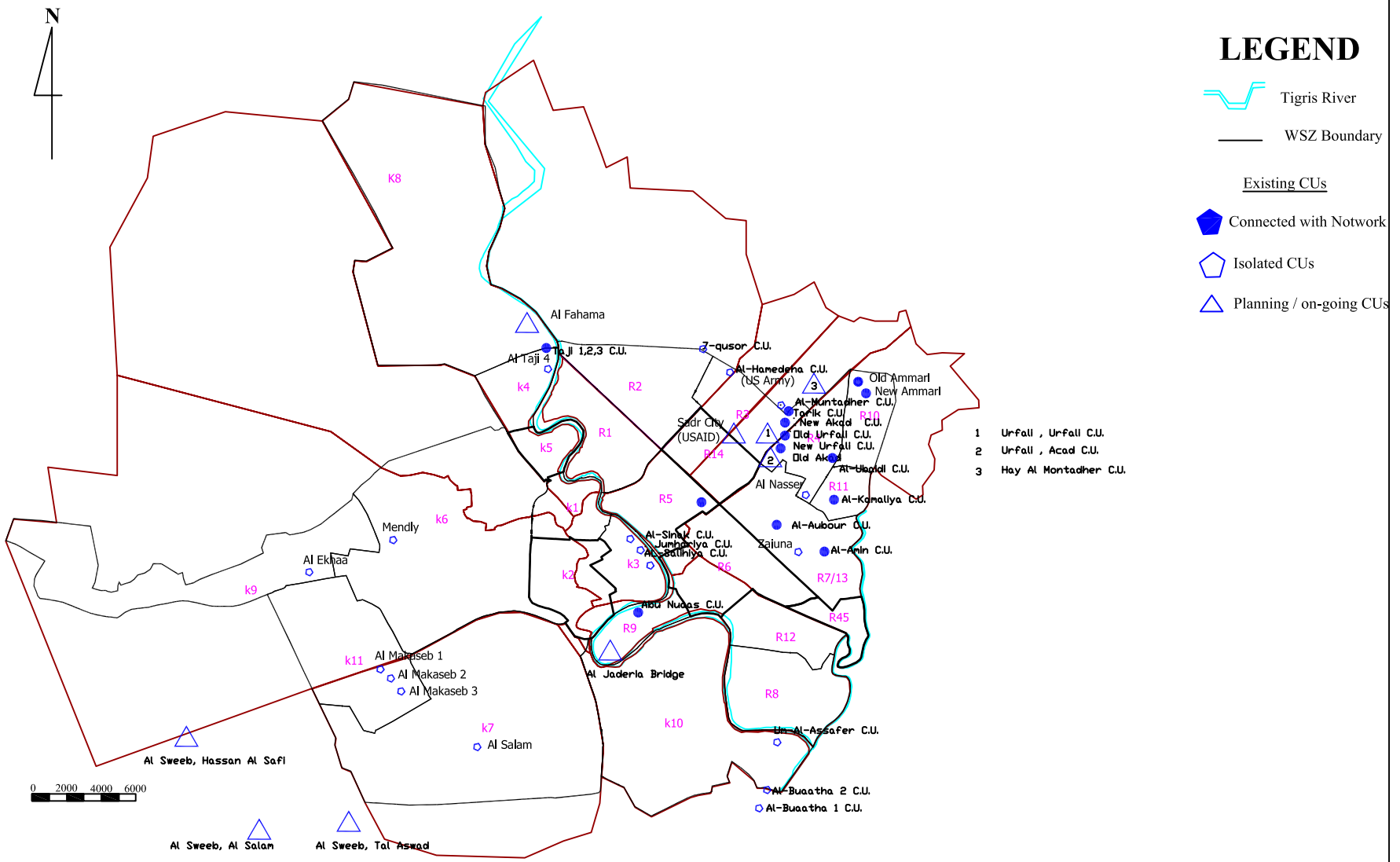
There are the eight WTPs and 34 CUs sites, package WTPs, for the BWA potable water supply as shown in Figures 4.4.3 and 4.4.4. Table 4.4.2 presents the description of facilities for WTPs and CUs. The total production of WTPs and CUs is estimated at 2.5 MCM/d and this almost met the estimated average daily water requirements of 2.6 MCM/d in 2005 as descried below.

(1) Water Treatment Plants (WTPs)

The status of both the existing and planned WTPs is summarized in Table 4.4.3 below:



Japan International Cooperation Agency	The Feasibility Study on Baghdad Water Supply System Improvement Project in the Republic of Iraq	NIPPON KOEI CO.,LTD. / Tokyo Engineering Consultants Co.,Ltd.	Title: WATER TREATMENT PLANTS (WTPs) AND SERVICE RESERVOIRS (SRs)	
			Scale: As-Shown	Date:
				Figure 4.4.3



JICA Japan International Cooperation Agency	The Feasibility Study on Baghdad Water Supply System Improvement Project in the Republic of Iraq	NIPPON KOEI CO.,LTD. Tokyo Engineering Consultants Co.,Ltd.	Title: COMPACT UNITS (CUs)	
			Scale: As-Shown	Date: Figure 4.4.4

Table 4.4.2 Water Treatment Plants (WTPs) and Compact Units (CUs) 1/2

Code No.	Name of Treatment Plant	Side of Tigris	Elevation (m)	Type	Plant Capacity (m^3/d)		Intake Pump			Reservoir		High Lift Pump			Boost to (Distribution Zone)	Completion Year
					Designed	Actual	Type	Number	Specification	Number	Capacity (m^3)	Type	Number	Specification		
	Karkh Side: WTPS								P(kw)xH(m)xQ(m3/h)					P(kw)xH(m)xQ(m3/h)	K1 to K11	
W.1	**Al-Karkh**	West	33.40	WTP	1,365,000	1,150,000	VCP	8+6	780X20X11400 +140X20X1480	3	43680	VCP	8	2300X75X8750+O4		1985 & 1988
W.2	**Al-Qadissia**	West	32.00	WTP	135,000	100,000	HCP	10	150X20X960	1	6000	HCP	3	250X60X1000		1966 & 1978
										1		HCP	6	250X60X1000		
W.3	**Al-Karama**	West	33.10	WTP	227,000	180,000	HCP	4	160X20X680			HCP	4	132X60X600		
							HCP	7	160X20X680			HCP	3+2	132X60X600 +200X60X800		1956, 1961 & 1980
							HCP	5	110X20X1470		5000	HCP	5	315X65X1200		
W.4	**Al-Doura**	West	33.00	WTP	115,000	100,000	HCP	6	110X20X1470		5000	HCP	5	315X65X1200		1980
	Sub-total				1,842,000	1,530,000										
	Rasafa Side								P(kw)xH(m)xQ(m3/h)					P(kw)xH(m)xQ(m3/h)	R1 to R14 & R45	
E.1	**Shark Dijla**	East	34.40	WTP	540,000	500,000	HCP	14	200X19.1X2500	1+2	50,000 +20,000	HCP	10	460X65X1900		1978 & 1984
													4	960X65X3800		
	Expansion 1			WTP	225,000	135,000	HCP		RWN	1	70000		6	2030X65X8540		2005
	Expansion 2			WTP	315,000	-										Plan
E.2	**Al-Wathba**	East	33.5	WTP	78,000	70,000	HCP	7	55X14X1060			HCP	2+1	250X61X680 +110X61X330		1978
											6000		3	250X61X950		
E.3	**Al-Wahda**	East	32.90	WTP	68,000	58,000	HCP	3	X X400			HCP	3	110X40X680		1953 & 1959
								6	X X400	1	775		3	110X40X680		
E.4	**Al-Rasafa**	East		WTP	2,400,000	-										Plan (Stage 1 to 4)
E.5	**Al-Rasheed**	East	31.80	WTP	68,000	50,000	HCP	5	90X20X1060	1	3000	HCP	5	250X55X960		To be abundoned
E.6	**Sadr**	East		WTP	96,000	-			RWN							Under construction
	Sub-total				3,790,000	813,000	979,000		(Designed Capacituy of the Existinf WTPs at Rasafa)							
	WTPs Total				5,632,000	2,343,000	2,821,000		(Designed Capacituy of the Existinf WTPs)							

(Source: BWA, 2006)

Note : 1. WTP: Conventinal Water Treatment Plants, CU: Compact Treatment Units
2. HCP: Horizontal Centrifugal Pump.
3. R.W.N: Raw Water Pipe Network

* : CU connected to the City wide distribution main

Table 4.4.2 Water Treatment Plants (WTPs) and Compact Units (CUs) 2/2

Code No.	Name of Treatment Plant	Side of Tigris	Elevation (m)	Type	Plant Capacity (m^3/d)		Intake Pump			Reservoir		High Lift Pump			Boost to (Distribution Zone)	Completion Year
					Designed	Actual	Type	Number	Specification	Number	Capacity (m^3)	Type	Number	Specification		
	Karkh Side: Compact Units (CUs)													P(kw)xH(m)xQ(m3/h)		
1	**Al-Boathaa 1**	West		CU	1,200	1,000	HCP	2	12X20X60			HCP	2	18.5X50X50	Isolated (K10)	
2	**Al-Boathaa 2**	West		CU	2,400	2,000	HCP	4	12X20X60			HCP	4	18.5X50X50	Isolated (K10)	
3	**Um-Al-Assafer**	West		CU	3,600	3,000	HCP	6	12X20X60			HCP	6	18.5X50X50	Isolated (K10)	
4	**Al-Salam**	West		CU	1,200	1,000	HCP	2	30X80X60			HCP	2	18.5X50X50	Village	
5	**Al-Ekhaa**	West		CU	1,200	1,000		2				HCP	2	18.5X50X50	Isolated	
6	**Al- Salehiya**	West		CU	24,000	2,000	submersable	2	17X20X230			HCP	2	45X50X200	Isolated (K3)	
7	**Taji 1***	West		CU	4,800	4,000	submersable	4	15X20X130			HCP	4	37X50X100	K4	
8	**Taji 2***	West		CU1	1,200	1,000	HCP	2	12X20X60			HCP	2	18.5X50X50	K4	
				CU2	336	280	HCP	2	7.5X17X20			HCP	2	12X50X15		
9	**Taji 3***	West		CU	2,400	2,000	submersable	2	15X20X130			HCP	2	37X50X100	K4	
10	**Al-Makaseb 1**	West		CU1	1,200	1,000	HCP	2	12X20X60			HCP	2	18.5X50X50	Village	
				CU2	336	280	HCP	2	7.5X17X20			HCP	2	12X50X15		
11	**Al-Makaseb 2**	West		CU1	1,200	1,000	HCP	2	12X20X60			HCP	2	18.5X50X50	Village	
				CU2	336	280	HCP	2	7.5X17X20			HCP	2	12X50X15		
12	**Taji 4**	West		CU	1,200	1,000	HCP	2	40X70X70			HCP	2	18.5X50X50	Isolated (K4)	
13	**Mendly**	West		CU		1,000	-	-				HCP	1	18.5X50X50	Isolated	
14	**Al-Makaseb 3**	West		CU	1,200	1,000	HCP	2	12X20X60			HCP	2	18.5X50X50	Village	
	New Compact Units (JICA)	West		CU	9,000	-										Plan 2007
	Sub-total				56,808	22,840										
	Rasafa Side: Compact Units (CUs)													P(kw)xH(m)xQ(m3/h)		
1	**Al-Obour***	East	36.00	CU	19,200	16,000	-	-	RWN			HCP	10	45X50X200	R4	
2	**Al-Nasser**	East	32.20	CU	19,200	16,000	-	-	RWN			HCP	12	45X50X200	Isolated	
3	**Abu Nowas***	East	33.40	CU	19,200	16,000	submersable	12	17X20X230			HCP	12	45X50X200	R9	
4	**Saba Kosour**	East		CU	1,200	1,000		2	12X20X60			HCP	2	18.5X50X50	Isolated	
5	**Al-Rashad***	East	32.20	CU	2,400	2,000						HCP	2	18.5X50X50	R45	
6	**Old Akad***	East	38.40	CU	4,800	4,000	-	-	RWN			HCP	2	37X50X100	R4	
7	**New Akad***															
8	**Tarik***	East		CU	4,800	4,000	-	-	RWN			HCP	4	18.5X50X50		
9	**Al-Amin***	East	35.50	CU	28,800	24,000	-	-	RWN			HCP	6	45X50X200	R7/13	
10	**Al-Kamaliyah***	East	37.10	CU	14,400	12,000	-	-	RWN			HCP	6	45X50X200	R11	
11	**OldAl-Urfali***	East	32.20	CU	9,600	8,000	-	-	RWN			HCP	6	45X50X200	R3	
12	**New Al-Urfali***															
13	**Al-Montadher**	East		CU	2,400	2,000	-	-	RWN			HCP	2	37X50X100	Isolated	
14	**AL-JUMHURIYA**	East		CU	9,600	8,000	-	-	RWN			HCP	4	45X50X200	Isolated	
15	**AL-Senak**	East		CU	9,600	8,000	submersable	2	22X36X230			HCP	4	45X50X200	Isolated	
16	**Al-Obaidi***	East		CU	28,800	24,000						HCP	10	45X50X200	R4	
17	**Zaiuna**	East		CU	4,800	4,000	-	-	RWN			HCP	2	45X50X200	Isolated	
18	**Al-Hamediya(US Army)**	East		CU		500						HCP	1	18X50X50	Isolated	2004
19	**Old Ammari***	East		CU		4,000							2	45X50X200	R10	
20	**New Ammari***	East		CU		4,000							3	45X50X200	R10	
	Sadr City Water CUs	East		CU		405							27		Isolated	2006
	New Compact Units (JICA)	East		CU	76,500	-									Isolated	On-going 2007
	Sub-total				255,300	157,905										
CUs Total					312,108	180,745										
Grand Total Capacity					5,944,108	2,523,745										

(Source: BWA, 2006)

Note : 1. WTP: Conventinal Water Treatment Plants, CU: Compact Treatment Units
2. HCP: Horizontal Centrifugal Pump.
3. R.W.N: Raw Water Pipe Network

* : CU connected to the City wide distribution main

Table 4.4.3 Status of Water Treatment Plants (WTPs)

WTPs	Capacity (1000 m^3/d)		Status
	Designed	Actual	
Rasafa Side			
E.1 Shark Dijla WTP	540	500	Connected with trunk mains Filter media needs replacement
Expansion 1	225	135	Completed in June 2005 (USAID)
Expansion 2	315	-	To be constructed by 2010
E.2 Wathba WTP	78	70	Connected with distribution mains at R5 & R9 Automatic chlorine system is not working This 1976 plant is currently functional
E.3 Wahda WTP	68	58	Connected with distribution mains at R6 Automatic chlorine system is not working This 1959 plant is currently functional
E.4 Rasafa WTP	2,400	-	Planned by BWA To be connected with trunk mains Stage 1 to be constructed by 2011 Stage 2 to be constructed by 2015 Stage 3 to be constructed by 2019 Stage 4 to be constructed by 2023
E.5 Rasheed WTP	68	50	Connected with distribution mains at R8 Automatic chlorine system is not working Water at intake is polluted To be abandoned in 2015
E.6 Sadr WTP	90	-	Under construction (USAID) Water source of existing raw water supply system Connected with distribution mains at R3
Sub-total	979 3,790	813	For the existing WTPs Including planned WTPs
Karkh Side			
W.1 Karkh WTP	1,365	1,150	Connected with trunk mains Automatic chlorine system is not working Critical shortage of spare parts Emergency generator broke down recently Supply to Karkh and Rasafa
W.2 Qadessia WTP	135	100	Connected with distribution mains at K2 Automatic chlorine system is not working This 1975 plant is currently functional
W.3 Karama WTP	227	180	Connected with distribution mains at K1 Automatic chlorine system is not working Pumping station manually controlled This 1984 plant is currently functional
W.4 Doura WTP	115	100	Connected with distribution mains at K10 Automatic chlorine system is not working
Sub-total	1,842	1,530	
Total	2,821 5,632	2,343	For the existing WTPs Including planned WTPs

(Source: Planning and Follow-up Section of BWA, as of April 2006 and JICA Basic Study Report)

Total design capacity of the WTPs is 2,821,000 m^3/d and actual capacity is 2,343,000 m^3/d. All the existing WTPs, except for the Karkh WTP and Shark Dijla WTP, are connected to the distribution mains. The Karkh WTP, which is located about 30km north of Baghdad city, is a major treatment plant with a capacity of 1.15 MCM/d at present and this capacity represents

about 50% of the current system wide capacity. Treated water from the Karkh WTP is conveyed to both sides, Karkh and Rasafa. The Karkh WTP transfers the treated water mainly to the Karkh North reservoir and the Taji reservoir on the Karkh side, and a lesser quantity to the Shark Dijla WTP equipped with a blending station (2B Blending Reservoir) on the Rasafa side.

The Shark Dijla WTP supplies water to the Rasafa side and its capacity represents about 11% of the system wide capacity. The Shark Dijla WTP, which is located along the Tigris in WSZ R1, channels about 315,000 m^3/d from the Karkh WTP through two transmission mains with diameters of 1,600mm and 1,400mm. The Shark Dijla WTP expansion-1 was conducted by the Iraq government through assistance of USAID. The Sadr WTP with a capacity of 90,000 m^3/d for WSZ R3 is under construction with the assistance of USAID. The raw water for the Sadr WTP is to be supplied through a 500 m long extension to the existing raw water network (USAID). The Rasafa WTP is planned by BWA to be developed in four phases, but this plan is not moving ahead in terms of funding, budgeting or BWA institutional prospects. The Rasheed WTP is to be abandoned after completion of the Rasafa WTP because of river water quality issues. This WTP is located down stream from a petrochemical plant which is discharging wastewater without proper treatment.

Gaseous chlorine is used for disinfection at each WTP. Chlorine gas cylinders, which are imported, are provided by UNICEF at the present. At the existing WTPs, except the Shark Dijla WTP, the chemical dosing and monitoring systems are not functional at all and so manual chlorination and monitoring methods are adopted at present. Almost all flow meters at WTPs are out of order as shown in Table 4.4.4 due to a lack of proper maintenance.

Table 4.4.4 Flow Meters at WTPs

WTPs	Treated Water Flow Meter		
	Number	Type	Status
E.1Shark Dijla WTP	2	Venturi	Not Working
Expansion 1	2	Electromagnetic	Working
Stage 2 B	2	Electromagnetic	Not Working
E.2 Wathba WTP	1	Venturi	Not Working
E.3 Wahda WTP	0	-	No Meters
E.5 Rasheed WTP	1	Venturi	Not Working
W.1 Karkh WTP	2	Electromagnetic	Not Working
W.2 Qadissia WTP	1	Venturi	Not Working
W.3 Karama WTP	2	Venturi	Not Working
W.4 Doura WTP	1	Venturi	Not Working

(Source: Planning and Follow-up Section, BWA, as of April 2006)

It is recommended that the malfunctioning flow meters should be repaired or replaced for the sake of proper management of BWA water works.

(2) Compact Units (CUs)

The existing 34 compact unit (CUs) sites are identified in Figure 4.4.4 and Table 4.4.2. As the CUs were adopted for water supply in Baghdad as emergency measures, in principal, BWA plans to abandon the CUs connected to the distribution network after properly establishing the Baghdad water supply system, such as completion of the Rasafa WTP and Shark Dijla WTP expansion. The CUs to be abandoned may be re-used for rural water supply. The existing CU sites are categorized into the following three groups as shown in Table 4.4.5.

Table 4.4.5 Categories of CUs

Category	CU Site		Location
	Number	Capacity (m^3/d)	
Group 1:			
Connected with Distribution Network	3	7,280	Karkh
	13	118,000	Rasafa
Sub-total	16	125,280	
Group 2:			
Isolated Service Area within City	5	9,000	Karkh
	7	39,905	Rasafa
Sub-total	12	68,000	
Group 3:			
Isolated Local Area and Village	6	6,560	Karkh
	-	-	Rasafa
Sub-total	6	9,560	
Total	34	180,745	

(Source: Planning and Follow-up Section, BWA, as of April 2006)

The above Groups 2 and 3 are to continue to be used even after completion of the proposed Rasafa WTP, while that in Group 1 is to be removed. The following CUs are scheduled to be installed within the year of 2006 and to be isolated from the distribution network as shown in Table 4.4.6.

Table 4.4.6 On-going Projects for CUs

CUs	Number	Capacity (m^3/d)	Water Source	Status
USAID:				
Sadr City CUs at R3	25	n/a	RWN*	On going (for Schools & Hospitals)
at R14	2	n/a	RWN	Completed (for Schools & Hospitals)
Sub-total	27	405		
Japan's Grant:				
Orfally, Orfally	1	4,500	RWN	On going (at R3 Rasafa)
Orfally, Akad	1	4,500	RWN	On going (at R4 Rasafa)
Hay Al-Montadher	1	4,500	RWN	On going (at R3 Rasafa)
Al-Qaderiya Bridge	12	54,000	Tigris	On going (at R9 Rasafa)
Al Fahama	1	4,500	Tigris	On going (at K8 Karkh)
Al Sweeb, Tal Aswad	1	4,500	RWN	On going (at K7 Karkh)
Al Sweeb, Al Salam	1	4,500	RWN	On going (at K7 Karkh)
Al Sweeb, Hassan Al Safi	1	4,500	RWN	On going (at K7 Karkh)
Sub-total	19	85,500		
Total	46	153,500		

(Source: USAID and JICA, as of April 2006) *: Raw Water Network

4.4.4 Water Supply Zones (WSZs) and Service Reservoirs

The BWA service area within Baghdad is divided into two parts, Karkh on the west side of the Tigris River and Rasafa on the east side of the river. In terms of water supply management, BWA divides the service area into 25 WSZs consisting of 11 WSZs on the Karkh side and 14 WSZs on the Rasafa side as shown in Figure 4.1.1. The WSZs are numbered with the prefix "K" for the area in the Karkh side and "R" for the area in Rasafa side (see Figure 4.1.1). Area and population of individual WSZs are presented in Table 4.2.1. Zone R13 is united with Zone R7 at present. Each WSZ consists of administrative districts called Mahalah as shown in Table 4.4.7 and the present status of each WSZ is summarized in Table 4.4.8.

Table 4.4.7 BWA Water Supply Zones (WSZs) and Mahalahs

Water Supply Zone (WSZ)	WSZ Area (km2)	WSZ Developed Area (km2)	Administrative Area (Municipality)	Mahalah Number	Total Number of Mahalahs
Rasafa Side					
R1	27.39	20.46	Adhamiyah	301, 302, 303, 304, 305, 306, 307, 308, 309, 310, 311, 312, 313, 314, 316, 318, 320, 322, 324, 326, 328, 330, 332, 334, 336,338, 340, 342	28
R2	30.74	22.03	Shaab	315, 317, 319, 321, 323, 325, 327, 329, 331, 335, 339, 341, 343, 344, 346,348,351, 353, 357, 333, 337	21
R3	18.48	16.54	Sadr 1 & 2/Shaab	543, 536, 538, 540, 542, 544, 546, 547, 548, 549, 550, 551, 552, 553, 554, 555, 556, 557, 558, 559, 560, 561, 562, 563, 564, 565, 567, 569, 571, 573, 329 (Shaab)	31
R4	16.98	10.45	9 Nisan	736, 742, 746, 750, 752, 754, 756, , 758, 760, 762, 764, 766, 768, 770, 772, 774, 798	17
R5	20.49	19.15	Rasafa	101, 102, 103, 104, 105, 106, 107, 108, 109, 110, 111, 112, 113, 114, 115, 116, 117, 118, 119, 120, 121, 123, 127,129, 131, 133, 135, 137, 139, 141, 143, 145, 147, 149, 501, 502, 503, 504, 505, 506, 507, 509, 510	43
R6	31.87	30.29	Karadah	901, 902, 903, 904, 906, 908, 910, 702, 704, 706, 708, 710, 712, 714, 716, 718, 720,722, 724, 701, 703, 709, 711, 713, 715, 717, 719, 721, 723, 725, 727	31
R7/13	34.55	24.65	9 Nisan	726, 728, 729, 731, 733, 737, 739, 728, 730, 732, 734, 741, 742, 743, 745, 747, 736, 738, 740, 744,742, 746, 748, 751, 752, 753, 754, 761,	28
R8	30.09	17.13	Karadah	949, 950, 951, 952, 953, 954, 955, 956, 957, 958, 959, 960, 961, 962, 964, 965, 966, 969, 970, 977, 979	21
R9	11.96	9.72	Karadah	901, 905, 907, 909, 911, 913, 915, 919, 921, 923, 925, 927	12
R10 : Ammari	14.43	11.87	9 Nisan/Suburban	763, 767, 771, 773, 775, 777 and Amman	6
R11	8.06	4.77	9 Nisan	755, 757, 759, 761, 765, 767, 799	7
R12	17.09	16.79	Karadah	701, 705, 707	3
R14	16.4	15.49	Sadr 1 & 2	509, 512, 511, 513, 514, 515, 516, 517, 518, 519, 520, 521, 522, 523, 524, 525, 526, 527, 528, 529, 530, 531, 532, 534, 535, 537, 539, 541, 545, 543	30
R45	7.65	3.9	Karadah/9 Nisan	701, 705, 707, 747	4
Sub Total	286.18	223.24		Substantial Number of Maharh: 272	282
Karkh Side					
K1	13.83	11.02	Karkh/ Shola /Kadhemiyah/Mansour	201, 202, 204, 206, 208, 210, 401, 402, 403, 404, 406, 407, 409, 619, 625, 621, 623,	17
K2	21.64	18.78	Karkh/ Mansour / Karadh	203, 205, 211, 213, 215, 219, 601, 602, 603, 604, 605, 606, 607, 608, 609, 610, 612, 611, 613, 615, 616, 617, 917	23
K3	14.64	13.44	Karkh	207, 209, 210, 212, 215, 216,217, 218, 220, 222, 224, 226, 228, 230, 232	15
K4	14.17	3.81	Kadhemiyah	-	
K5	8.92	7.19	Kadhemiyah	405, 411, 413, 415, 417, 419, 421, 423, 425, 427, 429	11
K6	106.46	81.49	Shola/Mansour	408, 410, 412, 414, 416, 418, 420, 422, 424, 426, 428, 430, 432, 434, 436, 438, 446, 448, 450, 452, 454, 456, 458, 460, 462, 614, 618, 620, 622, 624, 626, 627, 628, 629, 630, 632, 634, 636, 638, 640, 643, 645, 647, 649, 651, 653, 655, 657, 665, 667, 671, 673, 679, 681, 685, 691, 631, 633, 635, 637, 639, 641, 661	63
K7	127.21	59.41	Rashid	801, 802, 803, 805, 807, 809, 811, 813, 815, 817, 819, 821, 823, 825, 827, 829, 831, 833, 835, 837, 839, 841, 843, 845, 847, 849, 851, 853, 855, 857, 861, 863, 865, 867, 869, 871, 873, 875, 877, 879, 881, 883, 885, 887, 889, 891, 893, 895, 897,	49
K8: Taji Center	134.7	75.79	Suburban	Taji Center	
K9: Abu Ghrab	56.67	36.65	Mansour/Suburban	Abu Ghraib	
K10	85.33	39.66	Doura	804, 806, 808, 810, 812, 814, 816, 818, 820, 822, 824, 826, 828, 830, 832, 834, 836, 838, 840, 842, 846, 848, 850, 852, 854, 856, 858, 860	28
K11	47.72	47.72	Mansour	Airport	
Sub Total	631.29	394.96		Substantial Number of Maharh: 205	206
TOTAL	917.47	618.2		Substantial Number of Maharh: 477	488

(Source: BWA)

Table 4.4.8 Status of Water Supply Zones (WSZs)

WSZ	Area (km^2)	Developed Area (km^2)	Municipality	Total Number of Mahalahs
R1	27.39	20.46	Adhamiyah	28
R2	30.74	22.03	Shaab	21
R3	18.48	16.54	Sadr 1 & 2/Shaab	31
R4	16.98	10.45	9 Nisan	17
R5	20.49	19.15	Rasafa	43
R6	31.87	30.29	Karadah	31
R7/13	34.55	24.65	9 Nisan	28
R8	30.09	17.13	Karadah	21
R9	11.96	9.72	Karadah	12
R10	14.43	11.87	9 Nisan/Ammari	6
R11	8.06	4.77	9 Nisan	7
R12	17.09	16.79	Karadah	3
R14	16.4	15.49	Sadr 1 & 2	30
R45	7.65	3.9	Karadah/9 Nisan	4
Sub Total	286.18	223.24	**Rasafa Side (272)***	282
K1	13.83	11.02	Karkh/ Shola /Kadhemiyah/Mansour	17
K2	21.64	18.78	Karkh/ Mansour / Karadh	23
K3	14.64	13.44	Karkh	15
K4	14.17	3.81	Kadhemiyah	
K5	8.92	7.19	Kadhemiyah	11
K6	106.46	81.49	Shola/Mansour	63
K7	127.21	59.41	Rashid	49
K8	134.7	75.79	Taji Center	Non
K9	56.67	36.65	Mansour/Abu Ghrab	Non
K10	85.33	39.66	Doura	28
K11	47.72	47.72	Mansour	Non
Sub Total	631.29	394.96	**Karkh Side (205)***	206
TOTAL	917.47	618.2	**(477)***	488

(Source: BWA, as of April 2006) Note ()*: Substantial Numbers of Mahalahs

The substantial number of Mahalahs in Baghdad city is estimated at 477 in total and consists of 272 Mahalahs on the Rasafa side and 205 on the Karkh side. Some Mahalahs have areas that lie in two or three different WSZs. Each WSZ is managed based on each Mahalah and replacement of the distribution mains in Baghdad city have been conducted based on each Mahalah.

At present, implementation of the water supply zoning to hydraulically isolate the distribution network from other zones is not yet completed because of lack of funds. It is necessary to install new pipelines to form isolated zones and meters to measure the flow of each zone. Among the above-listed 25 WSZs, 8 WSZs, K6, K7, K8, K9, R7/13, R10, R11, and R45 have

service reservoirs though their capacities are not always sufficient. The remaining 17 WSZs are waiting for service reservoirs to be constructed. WSZs R3 and R14 were chosen by BWA as the highest priority and WSZs R2 and R7 are the second priority.

At present, there are eight service reservoirs providing a total capacity of about 564,140 m^3 as listed in Table 4.4.9. There are four service reservoirs on the Karkh side and four on the Rasafa side as shown in Figure 4.4.3. The four reservoirs of the Rasafa side are located at the southern end of the supply system (see Figure 4.4.3). Three of these service reservoirs are supplemented with a CU connected to each service reservoir for the net effect of increasing available flows at the far end of the Rasafa side.

Table 4.4.9 Existing Service Reservoirs and Booster Pump Stations

(As of April 2006)

Name Reservoir	Location	Reservoir		Status of Chlorination	Boost to	Pump per unit					Flow Meter		Completion Year
		Number of Tank	Total Volume (m^3)			Type	Designed Nos.	Operating Nos.	Head (m)	Unit Capacity (m^3/h)	Type	Status	
Taji	K8	2	29,560	No Chlorination	K8	VCP	4	4	31.19	1,042	E	NW	1983
						VCP	2	2	31.19	521	E	NW	
Karkh North	K6	2	231,660	Manual adding & monitoring	South, Abu Gharib, K1 to K4 & K6	VCP	5	5	17.22	5,333	E	NW	1986
						VCP	4	4	15.00	1,708	E	NW	
						VCP	8	8	31.77	4,521	E	NW	
						VCP	2	2	31.77	2,292	E	NW	
Karkh South	K7	2	162,500	No Chlorination	K7 & K10	VCP	7	7	31.95	4,250	E	NW	1983
						VCP	2	2	31.95	2,125	E	NW	
Abu Gharib	K9	2	80,420	No Chlorination	K9 & K11	VCP	5	4	32.09	1,800	E	NW	1984
						VCP	2	2	32.09	900	E	NW	
Sub Total		8	504,140										
Obaidi	R10	1	15,000	Manual adding & monitoring		HCP	7	4	35.00	500	E	NW	1986
						HCP	2	1	35.00	250	E	NW	
Kamaliya	R11	1	15,000	Manual adding & monitoring		HCP	7	7	35.00	500	E	NW	1985
						HCP	2	2	35.00	250	E	NW	
Amin	R7/13	1	15,000	Manual adding & monitoring		HCP	7	6	35.00	500	E	NW	1983
						HCP	2	2	35.00	250	E	NW	
Rostamiya	R45	1	15,000	Manual adding & monitoring		HCP	7	4	35.00	500	E	NW	1983
						HCP	2	2	35.00	250	E	NW	
Sub Total		4	60,000										
Total		12	564,140										

Source: Technical report, Hydraulic Model Potable Water Distribution System Baghdad Water Authority, USAID, January 2006

Note: 1. HCP: Horizontal Centrifugal Pump
2. VCP: Vertical Centrifugal Pump
3. E: Electromagnetic Flow Meter
4. NW: Not Working

All the flow meters for the distribution network are out of order as shown in Table 4.4.9 due to a lack of proper maintenance. The existing conditions of service reservoirs and booster pump stations are summarized in Table 4.4.10.

Table 4.4.10 Capacity of Service Reservoirs and Booster Pumps

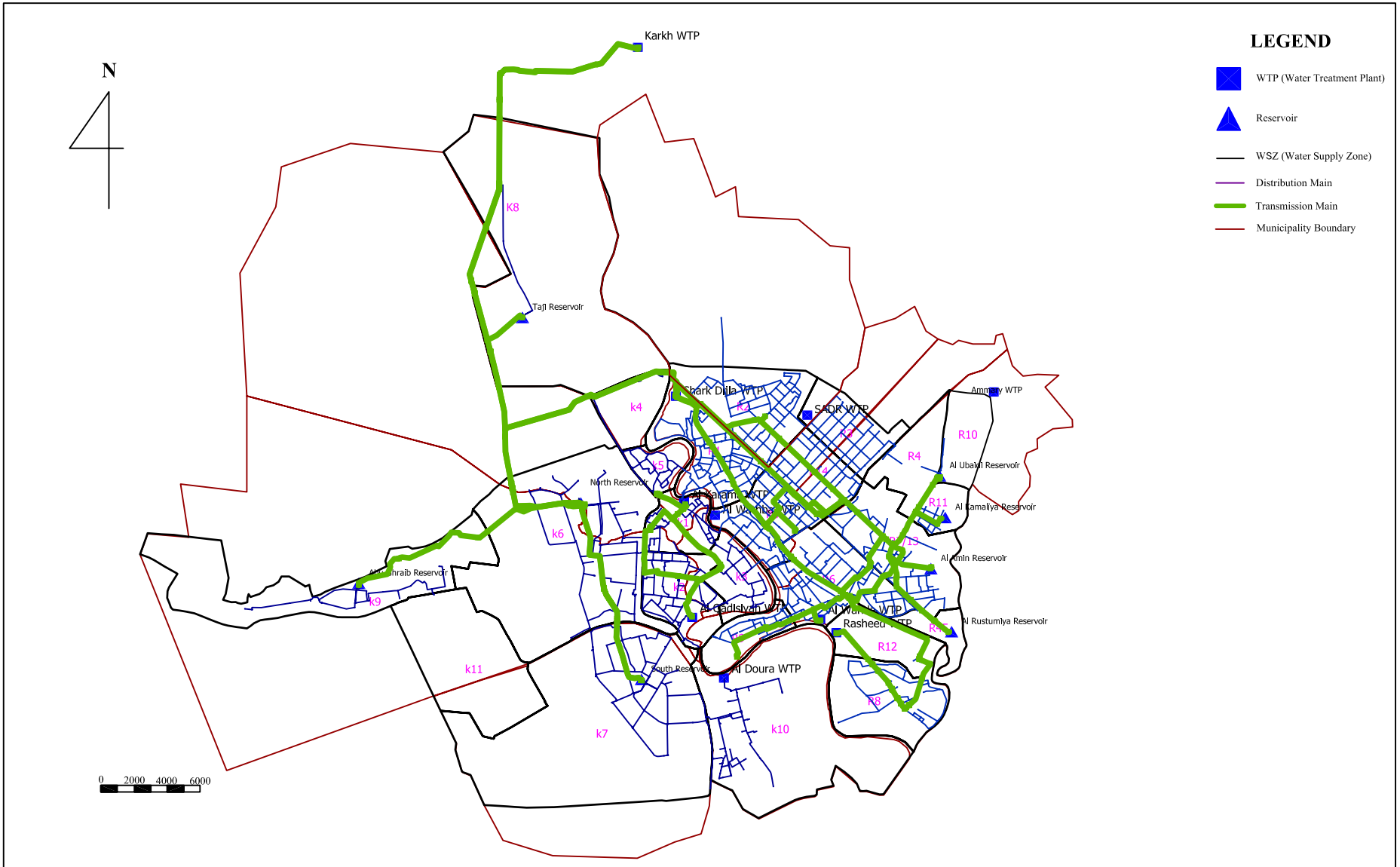
Name of Service Reservoir	Location (WSZs)	Reservoirs		Booster Pumps
		(m^3)	% of total	(m^3/h)
Taji	K8	29,560	5	5,210
Karkh North	K6	231,660	41	74,249
Karkh South	K7	162,500	29	34,000
Abu Gharib	K9	80,420	14	9,000
Sub Total	Karkh	504,140	89	122,459
Obaidi	R10	15,000	3	2,250
Kamaliya	R11	15,000	3	4,000
Amin	R7/13	15,000	3	3,500
Rostamia	R45	15,000	3	2,500
Sub Total	Rasafa	60,000	11	12,250
Total		564,140	100	134,700

(Source: Technical report, Hydraulic Model Potable Water Distribution System, Baghdad Water Authority, USAID, January 2006)

The 564,140 m^3 total storage capacity of the service reservoirs represents 4.8 hours storage based on design capacity of the existing WTPs with 2,821,000 m^3/d and 2.4 hours storage based on the future design capacity of WTPs including the planned WTPs. About 89% of the storage capacity is located on the Karkh side of the water supply system. It is known that the number of service reservoirs is lacking and the present storage capacity is insufficient throughout the system. Especially, the water supply system on the Rasafa side is facing a problem of sever shortage. BWA plans that each WSZ is to be provided with a service reservoir and booster station according to the 1984 Baghdad water supply master plan. The service reservoir is designed to be supplied by transmission mains interconnected throughout Baghdad city. The booster stations are used to supply potable water at adequate pressure to WSZs individually. The service reservoir for R14 is planned to be supplied through the Shark Dijlah WTP by BWA. The reservoir for R3 is suspended due to Iraqi conflicts.

4.4.5 Transmission (Trunk) and Distribution Networks

The water supply system from Karkh WTP to service reservoirs plays an integral role in supplying water to the Karkh side consisting of 11 WSZs. The Karkh WTP also supplies water to the Rasafa side through connections to the 2B blending reservoir and pump station located at the Shark Dijla WTP site. The Shark Dijla WTP and four service reservoirs supply water to the Rasafa side consisting of 14 WSZs. The existing transmission (trunk) and distribution mains are presented in Figure 4.4.5. The present condition of the water mains is described below:



Japan International Cooperation Agency	The Feasibility Study on Baghdad Water Supply System Improvement Project in the Republic of Iraq	NIPPON KOEI CO.,LTD. / Tokyo Engineering Consultants Co.,Ltd.	Title: TRUNK AND DISTRIBUTION MAINS	
			Scale: As-Shown	Date:
				Figure 4.4.5

(1) Transmission (Trunk) main

The treated water is conveyed to Baghdad City, through the 40 km long transmission pipelines from the Karkh WTP to Baghdad city as shown in Figure 4.4.5. The water is stored in the Karkh North and Karkh South reservoirs and then distributed to several service reservoirs located throughout the Karkh side. The Shark Dijla WTP located in zone R1 of the Rasafa side is supplemented with treated water of 315,000 m^3/d from the Karkh WTP through two transmission mains with diameters of 1,600mm and 1,400mm. Total length of transmission mains is estimated at 280 km as summarized in Table 4.4.11. The detail condition of present transmission mains are presented in Table 4.4.12. On the Rasafa side, the transmission system is not built properly. The existing four service reservoirs are feeding water through the distribution mains around them. The three WTPs locating in WSZs R5, R6 and R12 supply treated water directly to the distribution mains in each WSZ.

Table 4.4.11 Summary of Transmission Mains

(Unit: km)

Diameter	DIP
DN2300	38.7
DN2100	38.7
DN1800	2.7
DN1600	57.0
DN1400	57.5
DN1200	34.3
DN1000	14.0
DN900	4.0
DN825	0.9
DN800	11.4
DN700	10.4
DN600	1.4
DN500	8.2
Total Length (km)	279.4

(Source: BWA) DIP: Ductile Iron Pipe,

The future BWA transmission network is planned to be a combination of ring transmission mains and WSZs. In order to connect the Karkh side with the Rasafa side, the ring transmission main is to cross the Tigris River. Within each side, an inner ring main is to be installed for interconnecting service reservoirs of WSZs.

Table 4.4.12 Transmission Mains

Ref. No.	Section: Station Name	EL	Service Reservoir or Distribution Zone	EL	Head (m)	Type of Flow	Inside Dia. (mm)	Length (m)	Material	Remarks
W.1	Karkh WTP	33.40	Karkh North SR (Service Resrevoir	32.83		Pump-up	DN2300	38,700	DI	
							DN2100	38,700	DI	
	Karkh WTP	33.40	Taji SR	33.80		Pump-up	DN800	2,724	DI	
	Karkh North SR	32.83	Karkh South SR	30.30	17.22	Pump-up	DN1600	17,000	DI	
							DN1600	17,000	DI	
	Karkh North SR	32.83	Abu Graib SR	33.60	15.00	Pump-up	DN1400	36,770	DI	
	Karkh WTP	33.40	Shark Dijlah WTP			Pump-up	DN1600	13,268	DI	
							DN1400	13,268	DI	
W.2	Qadish WTP	32.00	Inner Karkh: K5, K1, K2, K3			Pump-up	DN1200	5,356	DI	Distribution
W.3	Karama WTP	33.10	Inner Karkh: K5, K1, K2, K3			Pump-up	DN1000	9,933	DI	Distribution
							DN800	4,524	DI	Distribution
W.4	Doura WTP	33.00	K10 SR			Pump-up	Distribution	-	DI	Plan
	Sub Total							197,243		
E.1	Shark Dijlah WTP		Distribution Mains			Pump-up	DN1600 - DN700	71,102	DI	Distribution
	Distribution Mains		Ubaidi SR (R10)			Pump-up	DN500	2,910	DI	
	Distribution Mains		Kamaliya SR (R11)			Pump-up	DN500	3,856	DI	
	Distribution Mains		Amin SR (R7/13)			Pump-up	DN500	2,889	DI	
	Distribution Mains (from R12)		Rustamiya SR (R45)			Pump-up	DN600	1,400	DI	
E.2	Wathba WTP		R5 SR			Pump-up	Distribution	-	DI	Plan
E.3	Wehda WTP		R6 SR			Pump-up	Distribution	-	DI	Plan
E.4	Rasheed WTP		R12 SR			Pump-up	Distribution	-	DI	Plan
E.5	Rasafa WTP		Plan			Pump-up	-	-	DI	Plan
E.6	Sadr WTP		Plan (R3 & R14)			Pump-up	DN1500	-	DI	Distribution
	Sub Total							82,157		
	Total							279,400		

Note DIP: Ductail Cast Iron Pipe, CIP: Cast Iron Pipe, ACP: Asbest Cement Pipe, PVC: Poly Vinyl Chloride Pipe, STP: Steel Pipe

(2) Distribution networks

The existing distribution network is presented in Figure 4.4.5. Distribution ability of the Karkh side is better than that of the Rasafa side. The typical distribution network consists of the following three hierarchies:

Hierarchy	Range of Pipe Diameters (mm)
1) Distribution Mains	500mm to 1200mm
2) Distribution Sub-mains (Secondary)	300mm to 500mm
3) Distribution Sub-mains (Tertiary)	100mm to 250mm

Length of the existing distribution pipelines is estimated based on classification of pipe material in Table 4.4.13. Distribution pipelines with a total length of 7,746 km consist of Ductile Iron Pipes (DIP), Steel Pipes (STP), Cast Iron Pipes (CIP), Polyvinyl Chloride pipes (PVC) and Asbestos Cement Pipes (ACP). DIP is mainly used for distribution mains and STP is used for sleeve pipe at river crossings. Sub-mains are mostly composed of CIP, PVC and ACP. Degradation of pipelines is evaluated as being directly related to age, which is given in Table 4.4.13.

Table 4.4.13 The Age of the Pipelines

(unit: km)

Diameter (mm)	ACP	DIP	CIP	PVC	STP	Total	%
1600-1000		250				250	3.2%
900-500		375			165	540	7.0%
450-250		275			125	400	5.2%
225-200	500	200	100	47		847	10.9%
160-110	1,000	400	200	489		2,089	27.0%
100-90	2,200	900	500	20		3,620	46.7%
Total Length	3,700	2,400	800	556	290	7,746	100.0%
%	47.8%	31.0%	10.3%	7.2%	3.7%	100.0%	
Very Old (>35 years)			86		11	96	
Old (>20 years)	1,835					1,835	
Medium (>10 years)		684		42		726	
Total Length > 10 yrs old	1,835	684	86	42	11	2,657	
%	49.6%	28.5%	10.7%	7.5%	3.7%	34.3%	At each category

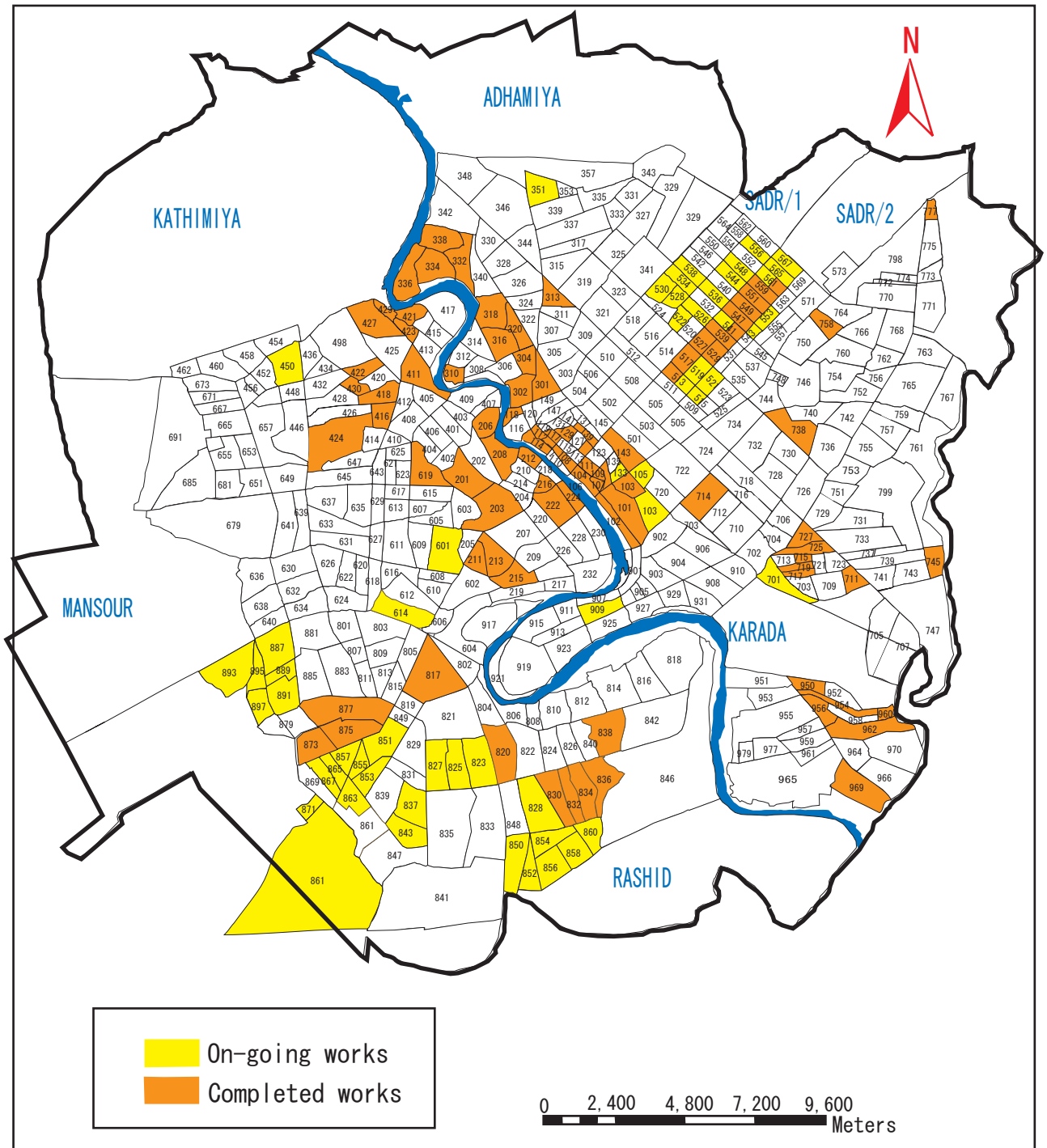
(Source: BWA, as of 2005)

The above total length of 7,746 km excludes pipes in WSZs K4, K8 and K11. It is assumed that the total length of the existing distribution networks is more than 10,000 km in the BWA service area.

At present, ACP, CIP and PVC are all of 225mm or less in diameter. Length of ACP, CIP and PVC represent respectively 48%, 10% and 7% of the total pipeline length. Of the total

pipeline length, 34% has been in use for more than 10 years. CIP, with a total length of 86 km, which is equivalent to 11% of the total length of all pipes, has been used for more than 35 years and about 50% of the ACP has been in use for more than 20 years. Use of these aging pipes increases water leaks at a high rate.

BWA has been conducting pipe replacement works throughout Baghdad as shown in Figure 4.4.6. Some of implemented Mahalah were carried out with the assistance of international organizations, such as USAID, GRD-PCO, UNICEF and World Bank. Pipe replacement works mainly aim at improvement of distribution tertiary of less than 300mm diameter which is ACP, CIP, DIP and PVC. The present condition of pipe replacement works is summarized in Table 4.4.14.



Source: BWA, as of April 2006

JICA Japan International Cooperation Agency	The Feasibility Study on Baghdad Water Supply System Improvement Project in the Republic of Iraq	NIPPON KOEI CO.,LTD. Tokyo Engineering Consultants Co., Ltd.	Title: PIPE REPLACEMENT WORK AT EACH MAHALAH Figure 4.4.6

Table 4.4.14 Pipe Replacement Works at WSZs

Water Supply Zone (WSZ)	Mahalah Number Completed Works		Mahalah Number On-going/Contracting/Funding Works		Total
Rasafa Side					
R1	BWA: 301 & 318 (only Pach Work), 302, 304, 310, 313, 316 (House connection remains), 318, 320, 332, 334, 336,338	13			13
R2	BWA: 357	1	BWA: 348, 343, 341, 339, 335, 329, 327, 325, 323, 319, 317, 315	12	13
R3	BWA:552, 550, 563, 569	4	BWA: 562, 560, 558, 542, 571	5	9
	USAID: 559, 551, 549, 547, GRD: 561(46),	4.5	GRD: 567, 565, 561(44), 556, 548, 544, 538, 536, 553, 543 (55A), 554, 546, 540	12	16.5
R4	BWA: 758	1			1
R5	BWA: 101, 102, 103, 104, 107, 108, 109, 111, 112, 114, 117, 118, 129, 139, 143	15			15
R6	BWA: 714, 711, 715, 717, 719, 725, 727 (only Pach Work)	7			7
R7/13	USAID: 745, 738	2			2
R8	USAID: 950, 954, 956, 960, 962, 969	6			6
R9			BWA: 909	1	1
R10 : Ammari	BWA: 777	1			1
R11					0
R12			UNICEF: 701	1	1
R14	BWA: 520,	1	BWA: 545, 543 (55B), 532, 531, 512	5	6
	USAID: 539 (14), 527, 529, 517 (8), GRD: 541(19), 539 (15), 517 (9), 513(7),	5	GRD: 541(18), 534, 530, 528, 526, 522(60), 521, 519, 515(1), 513(4), 524	9	14
R45					0
Sub Total		60.5		45	105.5
Karkh Side					
K1	GRD: 201 BWA: 206, 208, 619	4			4
K2	GRD: 203 BWA: 211, 213, 215	4	GRD: 601	1	5
K3	BWA: 212, 216, 222, 224	4			4
K4	-				0
K5	BWA: 411, 421, 427, 429	4			4
K6	BWA: 416, 418, 422, 424, 430	5	GRD: 450, 614	2	7
K7	BWA: 817, GRD: 873, 875, 877	4	GRD: 861,	1	5
			Designed: 823, 825, 827, 851, 853, 855, 857, 863, 865, 867, 871, 887, 889, 891, 893, 895, 897	17	17
K8: Taji Center	Taji Center				0
K9: Abu Ghrab	Abu Ghraib				0
K10	GRD: 820, 830, 832, 834, 836, 838	6	GRD: 828, 850, 852, 854, 856, 858, 860	7	13
K11	Airport				0
Sub Total	Sbstantial Number of Maharh: 195	31		28	59
TOTAL	Sbstantial Number of Maharh: 464	91.5		73	164.5

(Source: BWA and GRD-PCO, as of August 2006)

As shown in the above Table, USAID and GRD-PCO are conducting the pipe replacement works intensively in WSZs R3 and R14 under Sadr City Water Project. Replaced pipes range from 100mm to 250mm in diameter and service pipes are also being replaced. Length of replaced pipelines in each Mahalah is estimated to be about 13 km on average.

(3) Water service tankers

BWA usually uses water service tankers with a capacity of 10 m^3 in order to supply potable water to residents and hospitals since water shortage and disrupted water supply are caused by low pressure in the existing distribution system. Daily operation records of water service tankers during May to July 2005 are presented in DATA BOOK 1, Volume IV. Total average

daily water supply by tankers in the BWA service area is estimated at 1,864 m^3/d consisting of 1,174 m^3/d (63%) for the Rasafa side and 690 m^3/d (37%) for the Karkh side as shown in Table 4.4.15. About 0.1% of WTPs' daily production is supplied by water service tankers.

Table 4.4.15 Summary of Water Service Tanker Supply in 2005

BWA Service Area	May (m^3)		June (m^3)		July (m^3)		Average (m^3)	
	Monthly	Daily	Monthly	Daily	Monthly	Daily	Monthly	Daily
Rasafa Side	29,250	1,125	27,837	1,071	34,464	1,326	30,517	1,174
Karkh Side	21,221	816	27,516	1,058	5,069	195	17,935	690
Total	50,471	1,941	55,353	2,129	39,533	1,521	48,452	1,864

(Source: BWA)

More than 50% of total water by tankers is supplied to the study area of Shaab and Sadr as shown in Table 4.4.16. It is supposed that water demand in the study area is higher than other areas and furthermore the existing distribution system in the study area is in worse condition.

Table 4.4.16 Water Service Tanker Supply in Study Area in 2005

Study Area	May (m^3)		June (m^3)		July (m^3)		Average (m^3)	
	Monthly	Daily	Monthly	Daily	Monthly	Daily	Monthly	Daily
Shaab (R2)	20,347	783	18,899	727	27,577	1,061	22,274	857
Sadr (R3 & R14)	3,549	137	3,501	135	1,687	65	2,912	112
Total	23,896	919	22,400	862	29,264	1,126	25,187	969

(Source: BWA)

4.4.6 Service Connections and Water Consumption Meters

The number and classification of service connections are presented in Table 4.3.2 and described in Section 4.3. The present service connections, based on the billing records, are summarized in Table 4.4.17.

Table 4.4.17 Number of Service Connections

Consumer Category	Meter Equipped Connections						Unmetered Connections	%	Total
	Functional	%	Malfunction/ Not accessed	%	Sub-Total	%			
Domestic Use	104,683	21	128,880	27	233,563	48	249,915	52	483,478
Non Domestic Use	23,299	32	29,637	41	52,936	73	19,186	27	72,122
Total	127,982	23	158,517	29	286,499	52	269,101	48	555,600

(Source: Billing Section of BWA, as of December 2005)

About 52% of the recorded 555,600 service connections are equipped with water consumption meters. Only 23% of the total number of service connections are metered properly and water consumption of the remaining 77% connections is not known by BWA. For water consumption meter reading and a proper billing system, meter installation is required urgently.

The number and size of water consumption meters based on BWA customer category as listed in BWA's installation record are shown in Table 4.4.18.

Table 4.4.18 Number and Size of Water Consumption Meters by Customer Category

Categories	12 mm	18 mm	25 mm	37 mm	50 mm	75 mm	100 mm	150 mm	200 mm	Total	(%)
1. Govermental	3,319	1,225	1,399	55	414	113	169	8	10	6,712	1.1%
(%)	49.45%	18.25%	20.84%	0.82%	6.17%	1.68%	2.52%	0.12%	0.15%	100.00%	
2. Domestic	437,330	48,590	48,590	450	60	20	20	≧50		535,110	86.2%
(%)	81.73%	9.08%	9.08%	0.08%	0.01%	0.00%	0.00%	0.01%	0.00%	100.00%	
3. Commercial & Industrial	63,230	7,020	7,020	1,440	240	40	40	≧50		79,080	12.7%
(%)	79.96%	8.88%	8.88%	1.82%	0.30%	0.05%	0.05%	0.00%	0.00%	100.00%	
Total	503,879	56,835	57,009	1,945	714	173	229	58	60	620,902	100.0%
(%)	81.15%	9.15%	9.18%	0.31%	0.11%	0.03%	0.04%	0.01%	0.01%	100.00%	

(Source: Planning and Follow-up Section of BWA, as of February 2006)

More than 620,902 meters have been installed by BWA to date and of those, 535,110 are for domestic use. Over 98% of customers are categorized as small consumption domestic users with water consumption meters of less than 37mm in diameter. Maximum size of water consumption meters for domestic users is 50mm. Large size water consumption meters of more than 50mm in diameter are usually used for governmental and commercial/industrial users.

According to the BWA's standard specifications, the service connection pipe from the distribution pipe to the individual premises is generally made of Polyethylene Pipe (PEP). In case of large size water consumption meters of more than 50mm, distribution pipe are extended up to the water consumption meter to be installed as a service connection pipe. In the case house of connections inside individual premises, Galvanized Steel Pipe (GSP) is used. The direct tapping method, which makes a tapered and threaded tap into the main pipe wall using a tapping machine has been adopted by BWA for connections between the distribution main and the service pipe. Adoption of saddles instead of direct tapping is recommended to ensure water-tightness of the connections. For large service pipes of more than 50mm, tees with flanged branches are recommended.

Brass union sockets and stop cocks/valves are generally used for the branch connections. An average length of PEP for a service connection is estimated at 10 m per connection. In principal, each customer provides galvanized steel pipes with stop cocks/valves for branch connections and BWA has the duty to make the connection and install the water consumption meters for customers. The diameter of the service pipe is selected to match the size of the water consumption meter.

A typical house connection diagram for domestic users is illustrated in Figure 4.4.7. There are three types for connecting individual subscribers based on the classification of water consumption. The preferred and most common type consists of individually metering each small consumption subscriber. The second type is a large consumption subscriber and the

third type is for connecting individual subscribers in multiple dwelling units. Domestic uses of Type 1 with 12mm service pipes and Water Consumption Meters (WCM) are the largest group and represent more than 80% of the total domestic users.

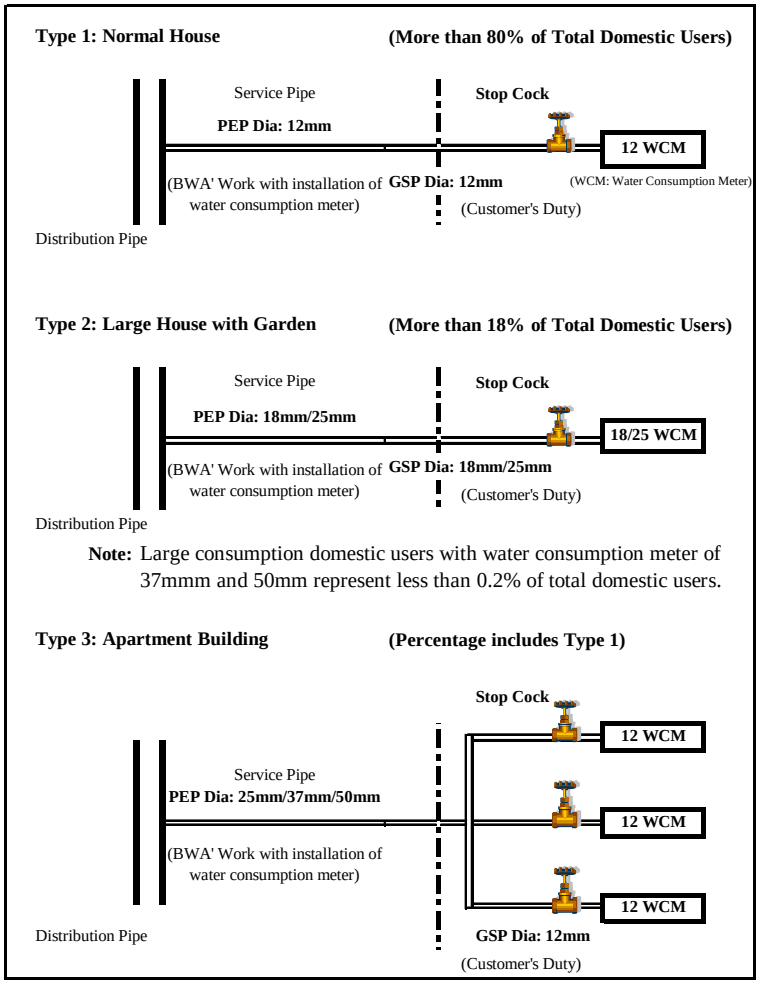


Figure 4.4.7 Typical House Connection

4.5 Unaccounted for Water (UFW)

4.5.1 Introduction

The Unaccounted for Water (UFW) is a critical problem for BWA. Because the Gulf War and international sanctions on Iraq slowed the import of water system spare parts for BWA, the BWA water distribution system has been in a state of continuous deterioration for at least the past 15 years. The UFW study was carried out to assess the present condition of UFW of BWA based on the reports of previous water supply studies and discussions with persons in charge of water leakage that took place in Amman due to safety and security problems in Baghdad. Therefore, this report was prepared without any filed survey in Baghdad.

4.5.2 Components of UFW

The UFW can be described as the difference of between the amounts supplied and those accounted for. The UFW consists of two main categories which are listed following.

(1) System Losses

This is composed of leakage from the older distribution system and leaks from tanks or other structures. Leakage from the older distribution system can be from service connections, or main pipe joints and fractures. Visible leaks are reported to the water company by customers or the general public. Invisible leaks are discernible with leak detection equipment. Visible leaks are repaired by the water section of the municipality or BWA. However invisible leaks are not repaired due to lack of a leak detection system in BWA.

(2) Commercial Losses

1) Illegal use

According to the BWA, there are many illegal connections using small booster pumps to supply private tanks in the parts of the BWA distribution system that are experiencing water shortages. This is because people in the areas experiencing shortages can not received enough water for living through the ordinary water supply system. The people do not pay BWA for the pumped water which is taken illegally. In addition, the informal housing inhabitants are made illegal connections to the nearest water distribution pipe to obtain a water supply without paying for any water that is received.

2) Meter malfunctioning

The malfunctioning of meters can be caused by age, because they are unreadable or damaged. The BWA water consumption meters are installed for about 52% of BWA's subscribers, however about 56% of the total number of those meters are malfunctioning. Therefore, only 23% of the total number of service connections are metered. These figures were provided by the billing section of BWA. Some water consumption meters are difficult to read because there is no access to read the meter because they are located within locked areas in private property.

3) Consumers Billed on a Lump-Sum Basis (without water consumption meters)

In the BWA service area, about 48% of subscribers do not have a water consumption meter. They pay fixed rate tariffs based on the housing area. Therefore, someone can be over-consuming with respect to the lump sum billed. On the other hand, someone paying the fixed rate tariff may be consuming very small volumes of water compared with the average volume of the fixed rate users. Therefore, it is difficult to estimate the actual total water consumption rate of the fixed rate billing system customers.

4.5.3 Previous Studies

Baghdad water supply system doesn't know the correct UFW figures because the basic water balance figures of the BWA system are not available. The major contributory factors to the UFW in the BWA system are production meter errors, un-metered billing systems, high ratio of malfunctioning water consumption meters, and illegal use. However, some previous studies tried to estimate the UFW ratio as follows.

(1) The Binnie Master Plan (Baghdad Water Supply Master Plan, BWA, Binnie & Partners, 1984)

Binnie & Partners documented per capita water consumption in Baghdad of 230 lpcd for 1984 and projected a value of 500 lpcd for the year 2000. The UFW component of Baghdad City developed by Binnie & Partners was reported to be 20%.

(2) UNICEF Report (Assessment Project of the Water Sanitation Sector in Iraq, UNICEF, SAFEGE 2003)

The UNICEF study estimated UFW in the BWA system for the year 2000 using two methods. The first method is an overview of statistics, and the second method is estimated development at the sub-district level.

1) Overview of Statistics

According to BWA statistics for 2000:

- Average monthly water production = 67,245,600 m^3/month ------(a)
- Average monthly water billed = 26,179,274 m^3/month ---------- (b)
- Average monthly losses = 41,066,326 m^3/month ----------(c) = (a) – (b)
- UFW = 62 % ----------(d) = (c) / (a)

It should be noted that the reported volume of water production is almost identical to the total installed capacity. According to the UNICEF efficiency survey, the capacity operating rate is probably less than 80%. Therefore, actual production capacity is 53,796,000 m^3/month (80% of 67,245,600m^3/month). The UFW figure 50% is based on this figure.

2) Estimated development at the sub-district level

On the basis of the network efficiency survey conducted by UNICEF at the sub-district level in 2000, average system losses in the Mayoralty of Baghdad (MOB) were estimated at 40%. This figure was calculated based on leakage per pipe length: 95m^3/km/day.

(3) USAID Report (Hydraulic Model Potable Water Distribution System Baghdad Water Authority, Parsons, 2006)

This report estimates UFW to be 50% for the BWA water supply system in 2000, based on the UFW figure of the above mentioned two studies.

(4) JICA Basic Study Report (Integrated study on Improvement of the Baghdad Water Supply System, JICA, 2005)

The estimate of this report is 50 % based on the UNICEF Report.

4.5.4 Estimation of Unaccounted for Water

(1) Inaccuracy of water consumption meters and billing system

Treated water of the BWA system is supplied from several water treatment plants to the network. However, correct amounts supplied can not be estimated because flow-meters at the point of discharge to the network are malfunctioning except at expansion-1of the Shark Dijla WTP.

According to the meter billing section of BWA, water consumption meters are installed for only 52 % of BWA subscribers. However, only 23% of service connections are functionally metered because of the malfunctioning of older water consumption meters. Some of these meters are inaccurate, which is one of the major factors in the UFW estimation. In addition, about 48% of service connections are fixed price contracts without water consumption meters, so the actual consumption rate of 77 % of the subscribers is not known.

(2) Illegal Use

Many illegal connections to the nearest distribution pipe have been made to obtain water due to the chronic water shortage and informal housing inhabitants. These illegal taps are badly constructed which results in high leakage rates. There has been no effort by MOB or BWA to restrict the illegal connections. The average illegal use rate is not available because BWA has never carried out a survey of the illegal use. Consequently, total losses due to illegal use can not be estimated.

(3) Water Leakage

Water leakage is common in older systems within the Baghdad water supply system. BWA and municipalities carry out pipe repair work at water leakage points based on visible leaks reported to the BWA or the water section of the municipalities by customers or the general public. But invisible leaks are not repaired due to the lack of a leak detection system in BWA and the municipalities.

Accurate water system leakage can not be determined in Baghdad because none of the system is metered.

The study team requested that BWA and the water sections of Sadr 1&2 municipalities collect records of the pipe repair work in the Project area (R2, R3 and R14) to determine the current water leakage condition of the project area. The records of pipe repair work were collected for R2, R3 and R14 in the Rasafa area from March 20 to April 20, 2006.

A total of 163 pipe repairs were carried out by water sections of Sadr 1&2 municipalities in that one month. The pipe repair works are summarized in the following table.

Table 4.5.1 Summary of Pipe Repair Works in R2, R3 and R14

WSZ	R2	R3	R14	Total
Distribution Mains	0	2	2	4
Distribution Sub-mains (Secondary and Tertiary)	3	13	8	24
House Connections	59	13	63	135
Total	62	28	73	163

Source: Water section of Sadr 1&2 Municipality (2006)

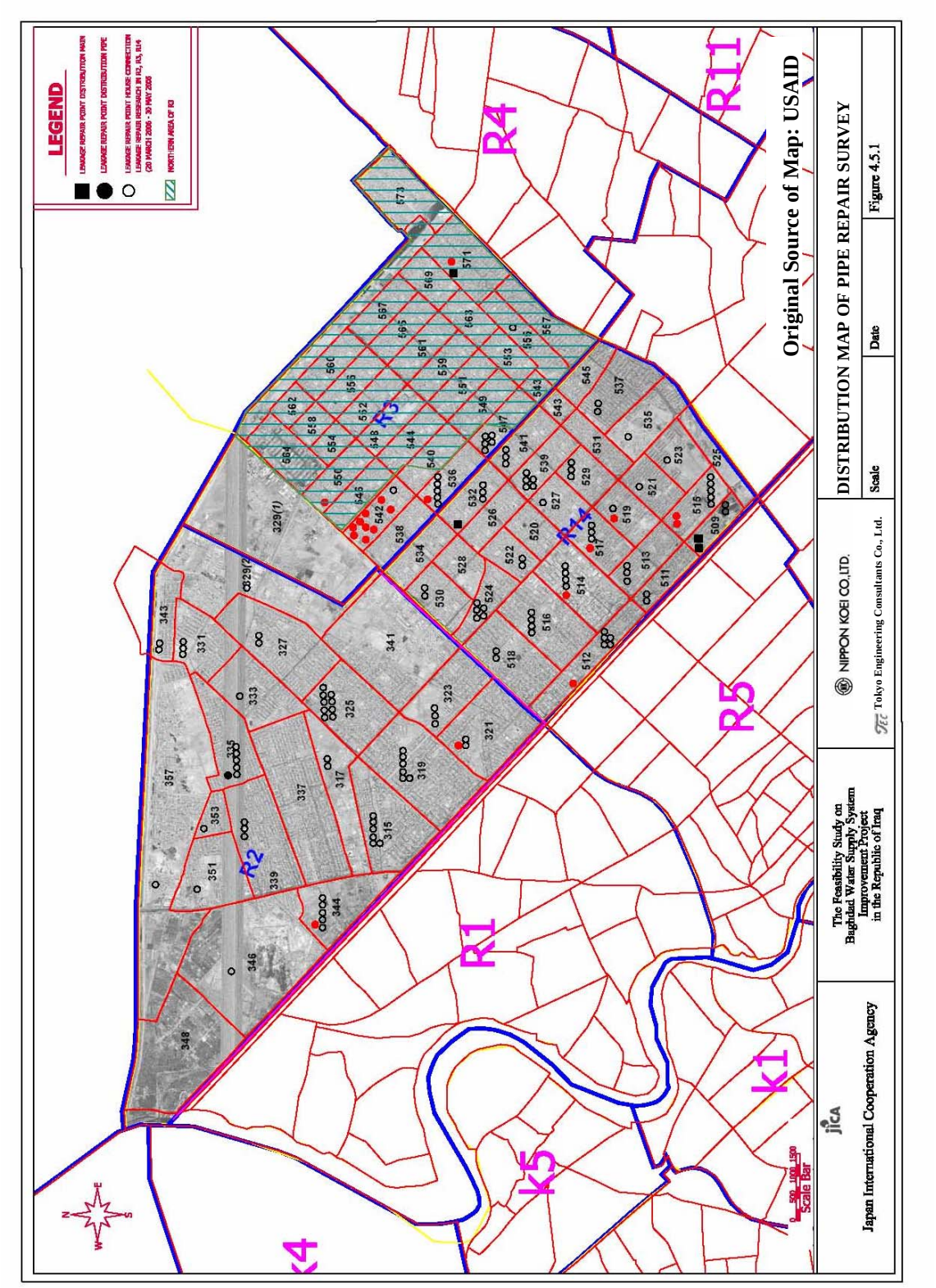
Major findings from the records of pipe repair works are as follows.

- A total of 83% of all repairs were for house connections: it is easy for the public to find these leaks and also the repair work is easy compared with distribution pipes.
- An average of 3 out of 4 distribution main repairs were to address problems caused by terrorism attacks: these need to be repaired urgently because major damage to a distribution main can have a significant influence on the water supply of the entire distribution network.
- An average of 5.3 repairs were made daily in R2, R3 and R14: pipe repair is only one place per day. A far greater amount of work needs to be undertaken on a daily basis if the water shortage in the Project area is to be rectified. This lack of effort is attributed to the fact that repairs are, in principle, limited to the information received from the public, i.e. visible leaks. Therefore, it is generally assumed that there is a great deal of water leakage which is invisible.
- The number of house connection repairs in R3 is very small compared with other WSZs. It is assumed that water was not available at the house connections or water taps, so that the water leakage at the house connections was not apparent.

Distribution of sub-mains repair work in each Mahalah in the project area is shown in Figure 4.5.1. Major findings from the distribution map of pipe repair works are as follows.

- In the northern part of R3 (Hatched area in Figure 4.5.1), no repair work has been done. This is because there is almost no hydraulic pressure and therefore, leakage of water has not been strong enough to surface and become visible.
- The repair of house connections was most frequent in Mahalas in R2 and R14.

- The repair of distribution pipes is concentrated in Mahala No. 542: this suggests that distribution pipes in this Mahala are in especially bad condition.



(4) Water Balance

System unaccounted for water (UFW) is usually calculated as the percentage of total water supplied to the network from the water treatment plant or service reservoir. The main factors of UFW are composed of system losses and commercial losses as mentioned 4.5.2.

Generally, in order to estimate the UFW, the figures for billed water and un-billed water (meter malfunction, illegal use) are deducted from total water production and the balance is assumed to be UFW. However, it is difficult to assess current water losses precisely in the BWA system.

Therefore, an approach using the performance value in 2000 as given in the UNICEF report was used. However, statistics for 2000 and afterwards do not exist. Therefore, it is assumed that the present UFW is 40 - 50% from the UNICEF report.

CHAPTER 5 PLAN FORMULATION

The study consists of four major tasks: 1) reviewing the previous studies for planning information, 2) conducting a preliminary hydraulic analysis for the Baghdad water supply system, 3) formulating the development plan for the distribution networks for the Water Supply Zones (WSZs) to be selected as priority areas, and 4) formulating the implementation program for the Baghdad Water Supply System Improvement Project.

5.1 Basic Concepts

5.1.1 Evaluation of the Existing Water Supply System

The existing water supply system and its present conditions are described in Chapter 4. In order to evaluate the existing water supply system, the following studies were reviewed.

(1) Baghdad Treated Water Supply Systems Integration Study Final Report, Binnie & Partners, November 1984 (Binnie Master Plan)

(2) Assessment Project of the Water and Sanitation Sector in IRAQ Final Report UNICEF, SAFEGE, January 2003 (UNICEF Report)

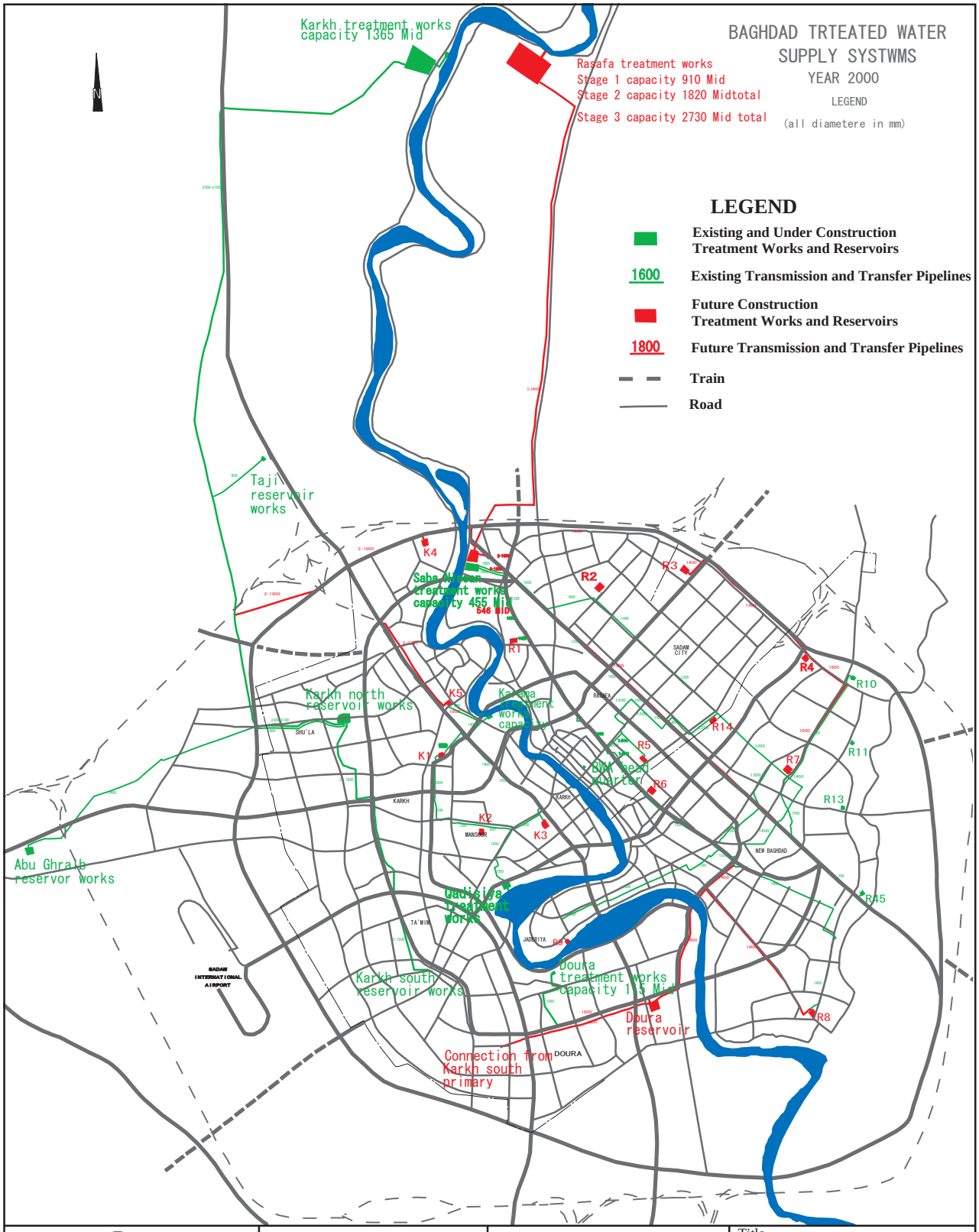
(3) Integration Study of Drinking Water Requirements for The City of Baghdad up to year 2027, The General Company for Water Projects Implementation, January 2003 (Company Report)

(4) Integrated Study on Improvement of The Baghdad Water Supply System (Basic Study Report), The Third Country Training Programme of JICA, March 2005 (JICA Basic Study Report)

(5) Hydraulic Model Potable Water Distribution System Baghdad Water Authority, USAID, Iraq Infrastructure Reconstruction Program, Phase II Potable Water Sector, January 2006 (USAID Report)

The Binnie Master Plan, which was prepared in 1984, provided several water supply schemes intended to address the following problems and facilitate the transfer of water from north to south and from west to east as shown in Figure 5.1.1. Those problems were:

- Deteriorating raw water quality in the Tigris River.
- Lack of water treatment capacity.
- No service reservoirs.
- Lack of transmission pipelines throughout the distribution system.
- Low pressures in some areas of the distribution network.



JICA Japan International Cooperation Agency	The Feasibility Study on Baghdad Water Supply System Improvement Project in the Republic of Iraq	NIPPON KOEI CO.,LTD. Tokyo Engineering Consultants Co., Ltd.	Title: BAGHDAD TREATED WATER SUPPLY SYSTEM YEAR 2000
			Figure 5.1.1

To address the quality, supply, and distribution system problems identified above, BWA initiated the Binnie Master Plan that proposed restructuring of the network system with 20 separate pressure zones or reservoir service areas. The Karkh Water Treatment Plant (WTP) and almost all the existing service reservoirs were constructed in the mid 1980s as described in Chapter 4. After 1986, major construction activities ceased, leaving major portions of the Binnie Master Plan uncompleted, such as the planned service reservoirs in the WSZs, a new water treatment plant (Rasafa WTP) and trunk mains to reinforce the Rasafa distribution network (see Figure 5.1.1).

To date, the above-mentioned Binnie Master Plan was reviewed by the several studies, such as UNICEF, General Company for water projects implementation, JICA training programme and USAID, and various improvement plans for the Baghdad water supply system have been presented. Among the previous studies, the JICA Basic Study Report and USAID Report are considered by BWA as forming the current Baghdad water supply master plan. From the evaluation of the existing water supply system through review of previous studies, the following present problems were identified.

- Chronic water shortage, especially in the Rasafa Side.
- Aged water supply facilities, such as distribution networks, flow meters and WTPs.
- Abnormally high ratio of Unaccounted for Water (UFW) (50%) in the network.
- Water consumption meters in use cover only 23% of the total service connections.
- No establishment of a transmission system in the Rasafa Side.
- Poor meter reading and billing systems
- Deteriorating raw water quality and decreasing flow in the Tigris River.

Among the above problems, which BWA has been faced with, solution of chronic water shortage in the Rasafa side is considered by BWA to be the most urgent and necessary since chronic water shortage causes aggravation of the moral and social order in Baghdad. The water supply system in the Rasafa side has not been improved over the years. The JICA Basic Study Report and USAID Report concluded that improvement of the water supply system in the Rasafa side is a prime requirement.

To solve the water shortage and meet the future water demand, the JICA Basic Study Report and USAID Report recommended enlargement of the water production capacity and UFW reduction. As realizable and effective countermeasures for the problems, by the JICA Basic Study Report and USAID Report proposed: (i) distribution mains replacement for UFW reduction and water saving, (ii) improvement of the distribution system with service reservoirs for stable and safe water supply, and (iii) improvement of WTPs for increasing water production.

Evaluation of the existing water supply system is summarized below and plan formulation was conducted considering the following evaluation:

Table 5.1.1 Evaluation of the Existing Water Supply System

Items	Karkh Side	Rasafa Side	Problems
1. Capacity of WTPs	A	C	Water Shortage
2. Transmission System	A	C	Insufficient Supply (Flow, Pressure, Leakage)
3. Service Reservoirs	B	C	Insufficient Supply (Capacity, Pressure)
4. Distribution Mains	B	C	Water Shortage, Low Pressure, Illegal Connections, Deterioration of Water Quality, High ratio of UFW
5. Distribution Sub-mains	C	C	
6. Water Meter Reading	C	C	High ratio of UFW

(Note) A: Sufficient, B: Moderate C: Poor

5.1.2 Basic Concepts for the Formulations of Plans

The plan was formulated to cover to the year 2027 based on the deficiencies in the existing water supply system. The water resource development potentials for BWA were examined, and the level of urgency of water requirements identified through the study was considered. The target year has been set at 2014 for the mid term plan and 2027 for the long term plan.

The basic concepts for the formulation of the plans are as follows;

1) Targeting water supply system improvement for the area to be selected as the priority area in the feasibility study,
2) Reducing Unaccounted for Water (UFW) in the existing distribution system,
3) Improving the water supply system, considering the chronic water shortage, especially in the Rasafa Side,
4) Reflecting results of the preliminary hydraulic analysis to improve the water supply system,
5) Looking for opportunities to improve the existing meter reading and billing system,
6) Considering the District Meter Areas (DMA),
7) Taking into account the JICA Basic Study Report and USAID Report as being the current Baghdad water supply master plan (These reports are effectively used for planning information).

Based on careful scrutiny of the problems in the existing water supply facilities extracted by the previous studies, the following basic strategies for improvement are recommended for the present and future water supply systems.

1) Aged Asbestos Cement Pipe (ACP), Cast Iron Pipe (CIP) and Polyvinyl chloride Pipe (PVC) pipes, which have been causing water leakage in the distribution network, shall be replaced for leakage prevention and water saving as early as possible.

2) The currently extremely large amount of UFW shall be reduced in stages, not only for supporting economic development and financial strengthening of BWA, but also for conservation of water resources.

3) Considering effectiveness in UFW reduction, replacement of tertiary pipes consisting of aged ACP, CIP and PVC is regarded as a top priority scheme for the distribution networks and in the future the replacement of distribution mains, including secondary shsould follow.

4) According to the hydraulic analysis, all the tertiary pipes should be replaced simultaneously to best augment the existing capacity.

5) Improvement of transmission and distribution mains shall be recommended based on the preliminary network analysis and its implementation will be conducted after replacement of tertiary pipes taking account of the order of priority of the schemes and the BWA budget.

6) Phased construction of WTPs shall be adopted to meet the present and future water requirements.

7) New Service Reservoirs (SRs) shall be constructed at each WSZ, especially in the Rasafa Side. These are urgently required since the present storage capacity is equivalent to only 1.0 hour based on the water requirements.

8) The existing flow meters at WTPs and SRs shall be repaired or replaced for proper management of BWA water works.

9) Water consumption meters shall be replaced or new ones installed as early as possible in order to improve the meter reading and billing system and to determine the exact water consumption rates.

10) The construction plan for pipe replacement works shall be made in consideration of the existing underground structures and application procedures for permission for construction work in roads due to the existence of utility lines, such as water mains, sewers, electric cables and telephone lines (refer to DATA BOOK 2 Drawings of Water Supply Facilities).

5.1.3 Issues and Risks Concerning Plan Formulation

The study for plan formulation has the following issues and risks:

- Plan of the Study was formulated without any field survey in Baghdad city due to security and safety reason in Baghdad city.
- There is no water supply master plan which is involved the latest information of the Baghdad city. Such a plan is scheduled to be formulated by MOB with assistance of the World Bank. Therefore, plan of the Study was formulated based on the existing reliable

reports of JICA Basic Study Report and USAID Report which was prepared in cooperation with counterpart (BWA).

- Population projections in the WSZs were executed based on the above two previous reports and projected population was demarcated uniformly at each Mahalah in the WSZs.
- Water demand was also forecasted based on the above two previous reports and water demand was allocated evenly to each Mahalah in the WSZs since there is no detailed information about land use patterns, type of subscribers or type of buildings.
- It is difficult to determine the exact water production, supply, consumption or UFW at present since almost none of the flow meters are functional.
- It is recommended that the preliminary hydraulic analysis for the future water supply should be reviewed after formulation of a Baghdad city plan since the water supply network was analyzed by this study on the above-mentioned assumptions such as population and water demand projections.
- Pipe length and diameter to meet the future demand should be re-examined since the hydraulic analysis can not be conducted properly without the city master plan.
- As for the plan of pipe replacement schemes, the components pipes in the distribution networks in each Mahalah are assumed to be the same due to lack of detailed information about the ratio of types of pipes and installation age in the existing distribution system.
- The number of water consumption meters that will be required had to be estimated by assuming that the average family size was 12.6 persons per subscriber as proposed by the 2006 USAID Report owing to lack of an updated census.
- There is a lack of information on the existing underground structures, such as sewers, electric cables and telephone lines that need to be protected during construction. It is proposed that an inventory survey of the existing underground structures be carried out during the detailed design stage in order to identify the exact locations of the existing underground structures.

5.2 Service Area and Development Plan

BWA does not have a current land use plan. The Mayoralty of Baghdad (MOB) intends to formulate a Baghdad city plan with the assistance of the World Bank by January of 2007. However, the MOB is not yet able to commence a study for city planning. At present, the BWA service area is about 917.5 km^2. The USAID report identified specific areas within the BWA service area where future growth will most likely occur and presented the concept of the build-out year for the WSZs. The present service area and areas to be served by the water supply system in the future are projected to be as summarized in Table 5.2.1 below:

Table 5.2.1 Water Supply Zones (WSZs)

Water Supply Zone (WSZ)	Total Area (km^2)	Developed Area (km^2)	Potential Area (km^2)	Build-out Year
Rasafa Side				
R1	27.39	20.46	6.93	2014
R2	30.74	22.03	8.71	2015
R3	18.48	16.54	1.94	2008
R4	16.98	10.45	6.53	2020
R5	20.49	19.15	1.34	2006
R6	31.87	30.29	1.58	2006
R7/13	34.55	24.65	9.90	2015
R8	30.09	17.13	12.96	2023
R9	11.96	9.72	2.24	2011
R10 (Ammari)	14.43	11.87	2.56	2011
R11	8.06	4.77	3.29	2022
R12	17.09	16.79	0.30	n/a
R14	16.40	15.49	0.91	2006
R45	7.65	3.90	3.75	2027
Sub-total	286.18	223.24	62.94	
Karkh Side				
K1	13.83	11.02	2.81	2012
K2	21.64	18.78	2.86	2009
K3	14.64	13.44	1.20	2007
K4	14.17	3.81	10.36	2049
K5	8.92	7.19	1.73	2011
K6	106.46	81.49	24.97	2013
K7	127.21	59.41	67.80	2030
K8 (Taji Center)	134.70	75.79	58.91	2024
K9 (Abu Ghraib)	56.67	36.65	20.02	2019
K10	85.33	39.66	45.67	2030
K11 (Airport)	47.72	47.72	0.00	n/a
Sub-total	631.29	394.96	236.33	
Total	917.47	618.20	299.27	

(Source: USAID Report、2006)

At present, the above developed area is served by BWA. Within the Karkh Side, 37% of the service area is undeveloped while 22% of the Rasafa area is undeveloped. About 33% of the BWA service area has a potential for future development. The Karkh Side contains 79% of the total potential development area while the Rasafa Side contains only 21%. Almost all the WSZs, except WSZs R12, K4, K7 and K10, are planned to be developed by 2027.

5.3 Population Projection

5.3.1 Prediction of Population Served

Population in the BWA service area is based on the 1997 census data of the Central Statistical Organization (CSO) obtained from the JICA Basic Study. As BWA service coverage in Baghdad city is 100% and the population served is equal to the population of Baghdad city

and its suburbs, the population served is divided into two areas: Baghdad city and suburban areas as shown in Table 5.3.1.

Table 5.3.1Census Record

Service Area	1977 Census	1987 Census	1997 Census
Baghdad City	2,664,105	3,841,265	4,402,087
a. Rasafa Side	1,797916	2,347,849	2,618,988
b. Karkh Side	866,189	1,493,416	1,783,099
Suburbs (Urban)	66,853		165,956
Total	2,730,958		4,568,043
Planned Service Population in 1997			4,700,000

(Source: JICA Basic Study Report)

The JICA Basic Study Report estimated the population in the BWA service area at 4.7 million as of 1997. While the USAID Report estimated the population according to the 1997 BWA customer base as follows:

Table 5.3.2 1997 Census and BWA Customer Base

Service Area	1997 Census	1997 BWA Customer Base
Baghdad City	4,319,633	4,233,744
a. Rasafa Side	2,530,805	2,495,549
b. Karkh Side	1,788,828	1,738,195
Suburbs (Urban)		247,519
Total	4,319,633	4,481,263

(Source: USAID Report, 2006)

Population difference between Table 5.3.1 and Table 5.3.2 may be attributable to the fact that the population data released by CSO required translation and handling of some duplicate census tract entries and many members of the BWA population included in Table 5.3.2 were excluded because they lived in some census tracts which are not identified on the Baghdad Mahalah Zone Map (see Figure 4.4.6).

The USAID report and the JICA Basic Study Report projected the 2004 BWA population served as 5.3 million and 5.5 million respectively, as shown in Table 5.3.3. Through discussions with BWA, the 2004 population projected by the USAID Report was chosen to be applied for the prediction of BWA population served. For the Feasibility Study, the 1997 population was estimated based on the 2004 projection of the USAID Report and, as will be mentioned later, the annual population growth of the JICA Basic Study Report and estimated population is allocated for each WSZ as presented in Table 5.3.3.

Table 5.3.3 Area and Present Served Population of Year 2004 at Water Supply Zone

Water Supply Zone (WSZ)	Administrative Category of Area	WSZ Area (km^2)*1	WSZ Developed Area (km^2)*1	Build-out Year*1 for Future Development	1997 Population based on Census	2004 BWA Served Population		
						JICA Basic Study Report*2	USAID Report*1	JICA Study Team
Rasafa Side								
R1	City	27.39	20.46	2014	234,045	270,696	270,695	270,695
R2	City	30.74	22.03	2015	307,768	360,859	355,962	355,962
R3	City	18.48	16.54	2008	557,044	680,170	644,273	644,273
R4	City	16.98	10.45	2020	95,019	35,154	109,898	109,898
R5	City	20.49	19.15	2006	189,058	233,195	218,663	218,663
R6	City	31.87	30.29	2006	277,046	241,404	320,429	320,429
R7(/R13*)	City	34.55	24.65	2015	272,056	288,623	314,658	314,658
R8	City	30.09	17.13	2023	115,803	133,939	133,937	133,937
R9	City	11.96	9.72	2011	46,376	121,398	53,638	53,638
R10	City/Suburban	14.43	11.87	2011	35,141	135,662	40,923	40,923
R11	City	8.06	4.77	2022	73,110	103,934	84,559	84,559
R12	City	17.09	16.79	n/a	750		867	867
R13	City	-	-	-	-	24,356	-	-
R14	City	16.40	15.49	2006	426,024	495,972	492,736	492,736
R45	City	7.65	3.90	2027	148	188	171	171
Sub Total		286.18	223.24		2,629,388	3,125,550	3,041,409	3,041,409
Karkh Side								
K1	City	13.83	11.02	2012	125,573	103,776	145,237	145,237
K2	City	21.64	18.78	2009	117,257	196,419	135,619	135,619
K3	City	14.64	13.44	2007	116,479	145,874	134,719	134,719
K4**	City	14.17	3.81	2049	31,878		36,870	36,870
K5	City	8.92	7.19	2011	75,422	61,772	87,232	87,232
K6	City	106.46	81.49	2013	623,132	476,423	720,710	720,710
K7	City	127.21	59.41	2030	529,026	710,178	611,867	611,867
K8**	Taji Center	134.7	75.79	2024	112,453		130,957	130,957
K9**	Abu Ghraib	56.67	36.65	2019	117,105	189,883	136,374	136,374
K10	City	85.33	39.66	2030	258,404	298,869	298,868	298,868
K11	Airport	47.72	47.72	n/a	0	0	0	0
Sub Total		631.29	394.96		2,106,730	2,183,194	2,438,453	2,438,453
TOTAL		917.47	618.20		4,736,118	5,308,744	5,479,862	5,479,862

Source *1: Technical Report Volume 1 Hydraulic Model Potable Water Distribution System
Baghdad Water Authority, USAID, January 2006

* Area and population of R7 include area and population of R13 in case of USAID Projection.

** Population not estimated from census tracts, estimated obtained from BWA (K8, K9) and examination of aerial photography (K4) for USAID Projection.

Source *2: Integrated Study on Improvement of The Baghdad Water Supply System
(Basic Study Report) JICA, March 2005

Table 5.3.4 Population in Each Water Supply Zone in 1997

Water Supply Zone	Type of Area	Area(km^2)	BWA Customer Base* (Person)	Population Density (Persons /km^2)
Rasafa Side				
R1	City	27.39	234,045	8,545
R2	City	30.74	307,768	10,012
R3	City	18.48	557,044	30,143
R4	City	16.98	95,019	5,596
R5	City	20.49	189,058	9,227
R6	City	31.87	277,046	8,693
R7/13	City	34.55	250,998	7,265
R8	City	30.09	115,803	3,849
R9	City	11.96	46,376	3,878
R10 (Ammari)	Suburban/City	14.43	35,141	2,435
R11	City	8.06	73,110	9,071
R12	City	17.09	750	44
R14	City	16.40	426,024	25,977
R45	City	7.65	148	19
Sub Total		286.18	2,629,388	9,188
Karkh Side				
K1	City	13.83	125,573	9,080
K2	City	21.64	117,257	5,419
K3	City	14.64	116,479	7,956
K4	City	14.17	31,878	2,250
K5	City	8.92	75,422	8,455
K6	City	106.46	623,132	5,853
K7	City	127.21	529,026	4,159
K8 (Taji Center)	Suburban	134.7	112,453	835
K9 (Abu Ghraib)	Suburban	56.67	117,105	2,066
K10	City	85.33	258,404	3,028
K11	Airport	47.72	0	0
Sub Total		631.29	2,106,730	3,337
TOTAL		917.47	4,736,118	5,162

(Source: USAID Report, 2006 & JICA Study Team)

Note: * 1997 population was calculated by the JICA Study Team from the 2004 build-out populations of USAID.

The total population of the BWA customer base in the above Table is almost the same as the 1997 population estimated by the JICA Basic Study Report. These estimates of the BWA customer base by the JICA study team are applied to the population projection for the feasibility study.

5.3.2 Annual Population Growth Rate

The annual population growth rates for Iraq and for Baghdad City are as follows:

Table 5.3.5 Annual Population Growth

Time Period	Iraq	Baghdad City
1977 to 1987	3.15%	3.02%
1987 to 1997	3.12%	1.36%
1977 to 1997	3.14%	2.19%

(Source: Company Report 2003 and JICA Basic Study Report)

The 3% of the annual growth rate for Iraq remained fairly constant from 1977 to 1987 and from 1987 to 1997, while Baghdad City population substantially decreased during the 1987 - 1997 time period partially due to the economic sanctions imposed on the Country since the Gulf War in 1990.

For the future population projections, the previous studies applied the following annual population growth rates:

Table 5.3.6Annual Growth Rates

Previous Study Reports	Time Period	Baghdad City	Suburban
JICA Basic Study Report	1997 to 2010	2.10%	2.20%
	2010 to 2020	2.25%	2.20%
	2020 to 2027	2.25%	2.25%
Baghdad University	1997 to 2015	2.10%	
USAID Report	1997 to 2025	2.99%	
UNICEF Report	1997 to 2017	2.99%	

(Source: USAID Report 2006 and JICA Basic Study Report)

Unfortunately, there is no separate data available to indicate the population growth factor within Baghdad city for each individual suburban. However, based on the evaluation of the population growth rates from the censuses, the growth rate between 1977 and 1997 was 2.19% which seems to be more reasonable for the future impact of moderate economic growth. The growth rates as indicated in the JICA Basic Study are proposed considering the economic impact, external restrictions for limiting Baghdad population and social patterns of citizens to limit family size. To determine the future service population, the 1997 BWA customer base as shown in Table 5.3.3 is projected using annual population growth rates proposed by the JICA Basic Study Report.

5.3.3 Projection Results

The estimates of BWA population served in the present and in the future are based on the population in Baghdad city and its suburbans estimated from the 1997 BWA customer base. The population served in the future is presented in DATA BOOK 1 and the population for the target years is summarized below:

Table 5.3.7 Population Projections at Target Years

Year	Rasafa Side	Karkh Side	Total
2005	3,105,320	2,489,928	5,595,247
2014	3,842,650	3,119,815	6,962,464
2027	5,329,742	4,223,161	9,552,903

(Source: BWA & JICA Study Team)

As shown in Table 5.3.7, about 56% of the population served is distributed on the Rasafa side (the left bank of the Tigris River) and 44% on the Karkh side (the right bank). The population and population density in 2005 and the target years are summarized as shown in Table 5.3.8.

The population and population density of the total area, developed areas and Mahalahs in 2005 are estimated as shown in Table 5.3.9:

Table 5.3.8 Summary of Population Projection at Water Supply Zones for Target Years

Water Supply Zone (WSZ)	WSZ Area (km^2)	WSZ Developed Area in 2005 (km^2)	Present Year: 2005*							Middle-term Target Year: 2014			Long-term Target Year: 2027		
			WSZ			Maharh		Sector at Sadr City		WSZ			WSZ		
			Population	Population Density	Population Density at Developed Area	Number	Population Density at Mharh	Number	Population Density at Sector	Population	Population Density	Population Density at Developed Area	Population	Population Density	Population Density at Developed Area
Rasafa Side															
R1	27.39	20.46	276,380	10,091	13,508	28	9,871			362,382	13,230	13,230	483,938	17,668	17,668
R2	30.74	22.03	363,437	11,823	16,497	21	17,307			440,769	14,339	20,008	648,713	21,103	21,103
R3	18.48	16.54	657,803	35,595	39,770	31	21,219	47	11,738	820,240	44,385	44,385	1,095,379	59,274	59,274
R4	16.98	10.45	112,206	6,608	10,737	17	6,600			136,081	8,014	13,022	208,667	12,289	12,289
R5	20.49	19.15	223,255	10,896	11,658	42	5,316			277,910	13,563	13,563	371,132	18,113	18,113
R6	31.87	30.29	327,158	10,265	10,801	31	10,553			400,471	12,566	12,566	534,803	16,781	16,781
R7/13	34.55	24.65	321,266	9,299	13,033	28	11,474			389,625	11,277	15,806	576,010	16,672	16,672
R8	30.09	17.13	136,750	4,545	7,983	19	7,197			165,847	5,512	9,682	257,169	8,547	8,547
R9	11.96	9.72	54,764	4,579	5,634	12	4,564			70,555	5,899	5,899	94,222	7,878	7,878
R10 (including Ammar	14.43	11.87	41,823	2,898	3,523	6	6,971			53,105	3,680	3,680	70,711	4,900	4,900
R11	8.06	4.77	86,335	10,712	18,100	7	12,334			104,705	12,991	21,951	159,696	19,813	19,813
R12	17.09	16.79	885	52	53	3	295			1,074	63	64	1,434	84	85
R14	16.40	15.49	503,083	30,676	32,478	30	16,769	37	8,611	619,674	37,785	37,785	827,534	50,459	50,459
R45	7.65	3.90	175	23	45	4	44			212	28	54	335	44	44
Sub Total	286.18	223.24	3,105,320	10,851	13,910	279	11,130	84	10,175	3,842,650	13,427	15,942	5,329,742	18,624	18,643
Karkh Side															
K1	13.83	11.02	148,287	10,722	13,456	17	8,723			190,566	13,779	13,779	254,488	18,401	18,401
K2	21.64	18.78	138,467	6,399	7,373	22	6,294			174,406	8,059	8,059	232,908	10,763	10,763
K3	14.64	13.44	137,548	9,395	10,234	15	9,170			170,727	11,662	11,662	227,994	15,573	15,573
K4	14.17	3.81	37,644	2,657	9,880					45,654	3,222	11,983	60,968	4,303	4,303
K5	8.92	7.19	89,064	9,985	12,387	11	8,097			115,692	12,970	12,970	154,499	17,320	17,320
K6	106.46	81.49	735,845	6,912	9,030	56	13,140			962,733	9,043	9,043	1,285,669	12,077	12,077
K7	127.21	59.41	624,716	4,911	10,515	47	13,292			757,643	5,956	12,753	1,011,784	7,954	17,031
K8: Taji Center	134.7	75.79	133,838	994	1,766					162,794	1,209	2,148	248,814	1,847	1,847
K9: Abu Ghraib	56.67	36.65	139,374	2,459	3,803					169,528	2,991	4,626	251,829	4,444	4,444
K10	85.33	39.66	305,144	3,576	7,694	28	10,898			370,073	4,337	9,331	494,209	5,792	12,461
K11: Airport	47.72	47.72	0	0	0					0	0	0	0	0	0
Sub Total	631.29	394.96	2,489,928	3,944	6,304	196	12,704			3,119,815	4,942	7,280	4,223,161	6,690	8,156
TOTAL	917.47	618.20	5,595,247	6,099	9,051	475	11,779			6,962,464	7,589	10,403	9,552,903	10,412	11,886

(Source: BWA & JICA Study Team)

Table 5.3.9 Population and Density in 2005

Service Area	Total Area (km^2) **(A)**	Developed Area: (km^2) **(B)**	Population **(C)**	Population Density in Total Area: **(C)/(A)**	Population Density in Developed Area: **(C)/(B)**	Mahalahs	
						Number	Average Population in Mahalah
Rasafa Side	286.18	223.24	3,105,320	10,851	13,910	272	11,417
Karkh Side	631.29	394.96	2,489,928	3,944	6,304	205	12,146
Total	917.47	618.20	5,595,247	6,099	9,051	477	11,730

(Source: BWA & JICA Study Team)

5.4 Water Demand Projection and Water Requirements

5.4.1 Water Use Condition

(1) Service area and population served

The service area is estimated at 917 km^2 including undeveloped areas of 299 km^2 as described in Section 5.2. The existing population served in 2005 is estimated at 5,595,000 by multiplying the total number of billed domestic connections by the average number of persons per domestic connection (12.6 persons per family from the USAID Report). Targeted population to be served in 2027 is estimated at 9,553,000. Population and population density in the service area are summarized in Table 5.3.8. The present average family size is assumed to be 11.57 for Baghdad City based on an estimation of population and current number of domestic users.

(2) Water consumption

At present, BWA classified their consumers' usage into two major categories, domestic use and non-domestic use based on the billing records. Non-domestic use is classified into two further categories, governmental use and commercial & industrial use. Billed water consists of domestic use at 87% and non-domestic use at 13% (see Tables 4.3.2 and 4.3.4). The UNICEF Report presented the water consumption in 2000 as follows:

Table 5.4.1 Water Consumption in 2000

Description	Amount	Remarks
• Average Daily Water Supplied	1.775 Million m^3/d	WTPs operation records
• Amount Billed	0.860 Million m^3/d	Assumed
• Population Served	4,769,072	Estimated
• Average per Capita Water Supplied	372 lpcd	
• UFW	52%	Assumed
• Average per Capita Water Consumption	180 lpcd	

(Source: UNICEF Report 2003)

The UNICEF Report shows that average per capita water consumption is only 180 lpcd while average per capita water supplied is as much as 372 lpcd due to the large amount of Unaccounted for Water (UFW). However, the above mentioned amounts were estimated based on the assumed factors as shown in the remarks made by the JICA Study Team. After all, actual water consumption is indeterminable since more than 75% of connections have no water meters or meters that are out of service as described in Chapter 4, and therefore, water consumption presented by the previous studies was estimated by adopting the estimated population and unit water demand.

(3) Water production and water use

Water requirements were estimated based on the production data of the existing WTPs (refer to Section 4.4.3). The monthly production records of the WTPs for the past 10 years are classified and summarized in the table below:

Table 5.4.2 Monthly Production of the WTPs

Description	1996	1999	2001	2003	2004	2005*
Max. Monthly Production (MCM/d)	2.324	2.292	2.390	2.186	2.080	2.319
Mean Monthly Production (MCM/d)	2.066	2.101	2.196	1.980	1.991	1.998
Peak Factor (Max. Month/ Mean Month)	1.12	1.09	1.09	1.10	1.04	1.16
Rainy Season Month Production during December to April (MCM/d)	1.955	2.038	2.075	1.895	1.953	1.755
Factor 1 (Rainy Month/ Max. Month)	0.84	0.89	0.87	0.87	0.94	0.76
Factor 2 (Rainy Month/ Mean Month)	0.95	0.97	0.94	0.96	0.98	0.88

(Source: JICA Basic Study Report, March 2005 and *BWA, August 2006)

The amount of production of the WTPs is considered as the water actually supplied through the network. Production had increased over the 10 years up to 2001, however the maximum amount produced reached the actual treatment capacity of 2.3 million m^3/d. Water users in Baghdad city also suffered water shortages and disrupted water supply, not only during the dray season from May to September but also throughout the year since, as shown in the above table, the ratio of maximum month production to mean month production is around 1.1 and the ratio of average month production during December to April to maximum month production was more than 80%.

It was supposed that water shortage and disrupted water supply might be caused by low pressure in the distribution system due to lack of service reservoirs with booster pump stations, especially in the Rasafa side, therefore, individuals were applying private booster pumps directly connected to the pipeline exacerbating the insufficient flow capacity of the distribution mains, especially in peak hours. In dray season, during May to September, the monthly average temperature goes over 30 degrees Celsius; in some cases the temperature exceeds 50 degrees Celsius. Under these circumstances, the water consumption rate becomes

extremely high in summer due to frequent bathing, using the traditional water-cooled air conditioners and for gardening use.

Considering the above mentioned water use conditions, the JICA Basic Study Report assumed that the present peak factor was to be around 1.35 to 1.40 instead of the estimated peak factor ranging 1.06 to 1.10 as shown in the above table.

(4) Future unit water consumption

Iraq standard for classified unit water consumption and unit water demand were provided by the Planning Board Decision in 1977 as shown in the table below. The standard unit water demand is 500 liters per capita per day (lpcd), including UFW which is proposed as 15% of the unit water demand. In 1984, the Binnie Master Plan proposed alternate values than the Iraq standard for the unit water consumption and unit water demand (see Alternative 1 below). Other reports also presented several different unit water demands (Alternatives 2, 3 and 4 below). Table 5.4.3 shows a comparison of unit water consumptions and demands proposed by the previous studies.

Table 5.4.3 Unit Water Consumption and Demand

(Unit: lpcd)

Classification	Iraq Standard	Alternative 1(1		Alternative 2(2	Alternative 3(3	Alternative 4(4
		City	Suburban			
Domestic Use	330	340	275	300		
Industrial & Commercial Use	40	40	30			
Governmental Use	55	35	30			
Unit Water Consumption	425	415	335	400	250	230 to 360
UFW (% of Unit Demand)	75 (15%)	85 (17%)	65 (16.3%)	100 (20%)	(50%)	(50% to 25%)
Projected Unit Water Demand	500	500	400	500	500	480

Source (1: Binnie Master Plan and UNICEF Report

Source (2: Company Report 2003

Source (3: USAID Report 2006

Source (4: JICA Basic Study Report

At present, BWA adopts the unit water demand of 500 lpcd including 75 lpcd of UFW for current planning purposes. In the JICA Basic Study Report, it is designated that the standard unit water demand of 500 lpcd is overestimated compared with the unit water demand of Tokyo at 390 lpcd and Yokohama with 350 lpcd, and also UFW of 15% is not practical. The standard unit water demand of 500 lpcd is proposed as the unit water demand in Alternative 1 of the Binnie Master Plan and UNICEF Report, while in Alternative 2 of the Company Report unit water demand is somewhat revised to 20% of the standard unit water demand. Although in Alternative 3 of the USAID Report unit water demand is 50% of the standard unit water demand and no UFW reduction plan is considered for the future water requirement projection.

The JICA Basic Study Report proposed Alternative 4 in which unit water consumption is expected to increase year by year from 230 lpcd in 2000 to 360 lpcd in 2027. Alternative 4 was accepted by BWA.

As discussed with BWA, the unit water consumption of Alternative 4 is selected from among the above alternatives as the most likely social and economical growth scenario and realistic figures, and recommended for the planning of the future water supply system as shown in Table 5.4.3. Unit water consumption at each target year is summarized below:

Table 5.4.4 Unit Water Consumption

Year	2000	2005	2014	2027
Unit Water Consumption (lpcd)	230	244	280	360

(Source: JICA Basic Study Report)

(5) Unaccounted for Water (UFW)

UNICEF conducted a network efficiency survey at a sub-district level in Baghdad city which resulted in an estimate of UFW of 40% of the total produced. However, during the feasibility study, the UNICEF survey report was not available. UFW in the Baghdad water supply system is reported by BWA to have been 50% in 2000. The JICA Basic Study Report indicated that UFW estimates in 2000 ranged from 40% to 50% because 60% of the pipe network is more than 20 years old and constructed of asbestos cement, cast iron or steel.

The JICA Basic Study Report proposed that the targeted UFW in 2027 is 25% which is half of the present ratio considering the experience of UFW reduction in Japan since steady long term efforts and sufficient funding for the reduction of UFW are needed in order to reduce the amount of UFW to the 15% proposed in the standard. Up to the target year 2027, the annual UFW reduction rate is considered as gradually decreasing as shown in Table 5.4.3 and the proposed UFW ratio at each target year is summarized as follows:

Table 5.4.5 Setting of UFW Reduction

UFW	2000	2005	2014	2027
UFW Ratio (%)	50.0	46.4	38.0	25.0
Annual UFW Reduction Rate (%)	0.925			

(Source: JICA Basic Study Report)

(6) Load factors for water requirement projections

As discussed with BWA, the following load factors were set for water demand projections and hydraulic analysis of the water supply system in Baghdad:

Table 5.4.6 Load Factors

Load Factor	Value	Remarks
Peak Daily Factor	1.40 to 1.25	JICA Basic Study Report (Past record range: 1.06 to 1.4)
Peak Hourly Factor	2.25	Binnie Water Master Plan 1984
Persons per Service Connection	12.60	USAID Report 2006
	11.57	Estimated from billing records and population in 2005

5.4.2 Water Requirements

Future water requirements are forecast based on the above mentioned future populations served and water use conditions from the year 2001 up to the year 2027 as shown in DATA BOOK 1. Classified water demand projections, water requirements and production for target years are summarized as follows.

(1) Water demand projections

As described in Section 5.4.1, unit water consumption has four alternative sets of values depending on the concept of the UFW ratio and UFW reduction plan. The difference in the unit water demand between Alternative 4 and other alternatives is 20 lpcd or the equivalent to 4% of the Iraq standard. For planning the future water supply system, Alternative 4 is thought to present a reasonable unit consumption and realistic UFW reduction rate and therefore, is recommended for adoption, since such a small difference can be taken care of by flexible operation of water supply facilities and, more importantly, social stability and economy of construction are of primary concern for the present projects, especially the improvement project for the water supply system for the Rasafa side. The WSZ improvement projects with aging water supply facilities are supposed to be completed by the year 2014 and then social stability and economy of construction will be developed gradually.

The classified water demand projection at each target year is shown in Table 5.4.7 and summarized in Table 5.4.8.

Table 5.4.7 Classified Water Demand Forecast

Classification \ Year	Unit	2000	2004	2005	2014	2027
		Former Benchmark	Benchmark	Present	(Medium Term)	(Long Term)
1 Service Area (km2)	km2	917.47	917.47	917.47	917.47	917.47
1.1 Existing Developed Area		-	618.20	618.20	669.27	803.70
1.2 Area to be Newly Developed		-	299.27	299.27	248.20	113.77
2 Projected Population	1000 persons	5,042	5,480	5,595	6,962	9,553
3 Percentage of Population Served	%	100	100	100	100	100
4 Water Use Condition						
4.1 Unit Water Consumption	lpcd	230	241	244	280	360
4.2 UFW Ratio	%	50.0	47.1	46.4	38.0	25.0
4.3 Number of Subscribers	connections	400,130	434,910	555,600	601,769	825,661
(JICA Basic Study Report)			567,551			
4.4 Family Size: Persons per Connection	persons	12.60	12.60	11.57	11.57	11.57
5 Average Daily Water Demand	m3/d	1,159,575	1,322,995	1,366,839	1,949,490	3,439,045
5.1 Average Flow	l/s	13,421	15,312	15,820	22,564	39,804
5.2 Yearly Water Demand	MCM/y	423	483	499	712	1,255
6 Daily UFW Amount	m3/d	1,159,575	1,179,969	1,184,595	1,194,849	1,146,348
7 Effective Water Ratio	%	50.0	52.9	53.6	62.0	75.0
8 Seasonal Load Factor	%	71	73	73	77	80
(Peak Day Factor)	-	1.400	1.372	1.365	1.292	1.250
9 Average Daily Water Requirement	m3/d	2,319,151	2,502,964	2,551,433	3,144,339	4,585,394
9.1 Average Flow	l/s	26,842	28,969	29,530	36,393	53,072
9.2 Yearly Water Requirement	MCM/y	846	914	931	1,148	1,674
9.3 Yearly Water Production Amount	MCM/y	840	840	913	-	-
10 Saving Water	m3/d	-	71,513	91,122	377,321	1,146,348
10.1 (Losses in case of 50 % of UFW)	MCM/y	-	26	33	138	418
10.2 Percentage of Average Water Requirement	%		2.9	3.6	12.0	25.0
11 Maximum Daily Water Requirement	m3/d	3,246,879	3,434,106	3,482,731	4,062,562	5,731,797
11.1 Maximum Flow	l/s	37,580	39,747	40,309	47,020	66,340
11.2 Yearly Maximum Water Requirement	MCM/y	1,185	1,253	1,271	1,483	2,092
12 Peak Hourly Water Requirement	m3/d	5,218,089	5,631,670	5,740,725	7,074,762	10,317,136
12.1 Peak Hourly Flow	m3/h	217,420	234,653	239,197	294,782	429,881
12.2 (Peak Hourly Factor: 2.25)	l/s	60	65	66	82	119
13 Proposed Water Production	m3/d	2,334,000	2,379,040	2,514,040	3,678,540	5,257,500
	MCM/y	852	868	918	1,343	1,919
13 Unit Water Demand per capita per day	lpcd	460	457	456	452	480

(Source: BWA & JICA Study Team)

Table 5.4.8 Water Demand Projection at Each Target Year

Classification	2000	2005	2014	2027
1. Water Use Condition				
1.1 Unit Water Consumption (lpcd)	230	244	280	360
1.2 Planned UFW Ratio (%)	50.0	46.4	38.0	25.0
1.3 Peak Day Factor	1.400	1.365	1.292	1.250
2. Average Water Requirements				
2.1 Average Water Requirements (MCM/d)	2.320	2.551	3.144	4.585
2.2 UFW Amount (MCM/d)	1.185	1.185	1.195	1.146
2.3 Unit Average Water Demand per capita (lpcd)	460	456	452	480
3. Maximum Water Requirements				
3.1 Max. Daily Water Requirements (MCM/d)	3.247	3.483	4.063	5.732
3.2 Unit Max. Water Demand per capita (lpcd)	644	622	583	600
4. Reference Index				
4.1 UFW Reduction Rate at Target Year (%)	-	3.6	8.4	13.0
4.2 Effective Ratio of Water Requirements (%)	50.0	53.6	62.0	75.0

(Source: BWA & JICA Study Team)

(2) Forecast Water Requirements

Based on the projected water demand, water requirements are estimated as shown in Table 5.4.7 from the year 2000 to the year 2027 for the future Baghdad water supply system. The estimated water requirements assume that the land use pattern in the existing service areas will not change significantly. Water requirements in the service area are summarized in Table 5.4.9. Annual water requirements at each target year are estimated based on average daily water supply of 931 MCM/y in 2005, 1,148 MCM/y in 2014 and 1,674 MCM/y in 2027 as shown in Table 5.4.10.

Table 5.4.9 Summary of Water Requirements

Description	2000	2005	2014	2027
1. Rasafa Side				
1.1 Population (10^3)	2,799	3,105	3,843	5,330
1.2 Average Water Demand ($10^3m^3/d$)	644	759	1,076	1,919
1.3 Average Daily Requirement ($10^3m^3/d$)	1,287	1,416	1,735	2,558
1.4 Max. Daily Requirement ($10^3m^3/d$)	1,802	1,933	2,242	3,198
2. Karkh Side				
2.1 Population (10^3)	2,243	2,490	3,120	4,223
2.2 Average Water Demand ($10^3m^3/d$)	516	608	874	1,520
2.3 Average Daily Requirement ($10^3m^3/d$)	1,032	1,135	1,409	2,027
2.4 Max. Daily Requirement ($10^3m^3/d$)	1,444	1,550	1,820	2,534
3. Total of Baghdad				
3.1 Population (10^3)	5,042	5,595	6,962	9,553
3.2 Average Water Demand ($10^3m^3/d$)	1,160	1,367	1,949	3,439
3.3 Average Daily Requirement ($10^3m^3/d$)	2,319	2,551	3,144	4,585
3.4 Max. Daily Requirement ($10^3m^3/d$)	3,247	3,383	4,063	5,732

Table 5.4.10 Projected Water Demand and Water Requirement at Water Supply Zone

(Target Years of 2005, 2014 and 2027)

Water Supply Zone (WSZ)	2005						2014						2027					
	Served Population	Water Demand (m^3/d) (Unit Water Demand) 244 lpcd	UFW (m^3/d) 46.4%	Average Daily Requiement (m^3/d)	Maximum Daily Requirement (m^3/d) (Peak Day Factor) 1.365	Peak Hourly Flow (m^3/h) 2.25	Served Population	Water Demand (m^3/d) (Unit Water Demand) 280 lpcd	UFW (m^3/d) 38.0%	Average Daily Requirement (m^3/d)	Maximum Daily Requirement (m^3/d) (Peak Day Factor) 1.292	Peak Hourly Flow (m^3/h) 2.25	Served Population	Water Demand (m^3/d) (Unit Water Demand) 360 lpcd	UFW (m^3/d) 25.0%	Average Daily Requirement (m^3/d)	Maximum Daily Requirement (m^3/d) (Peak Day Factor) 1.250	Peak Hourly Flow (m^3/h) 2.25
Rasafa Side																		
R1	276,380	67,516	58,514	126,029	172,030	11,815	362,382	101,467	62,189	163,656	211,444	15,343	483,938	174,218	58,073	232,290	290,363	21,777
R2	363,437	88,783	76,945	165,727	226,218	15,537	440,769	123,415	75,642	199,057	257,182	18,662	648,713	233,537	77,846	311,382	389,228	29,192
R3	657,803	160,692	139,266	299,958	409,443	28,121	820,240	229,667	140,764	370,431	478,597	34,728	1,095,379	394,336	131,445	525,782	657,227	49,292
R4	112,206	27,410	23,756	51,166	69,841	4,797	136,081	38,103	23,353	61,456	79,401	5,761	208,667	75,120	25,040	100,160	125,200	9,390
R5	223,255	54,538	47,266	101,804	138,963	9,544	277,910	77,815	47,693	125,508	162,156	11,766	371,132	133,607	44,536	178,143	222,679	16,701
R6	327,158	79,920	69,264	149,184	203,636	13,986	400,471	112,132	68,726	180,858	233,668	16,955	534,803	192,529	64,176	256,706	320,882	24,066
R7/R13	321,266	78,481	68,017	146,497	199,969	13,734	389,625	109,095	66,865	175,960	227,340	16,496	576,010	207,363	69,121	276,485	345,606	25,920
R8	136,750	33,406	28,952	62,358	85,118	5,846	165,847	46,437	28,462	74,899	96,769	7,022	257,169	92,581	30,860	123,441	154,301	11,573
R9	54,764	13,378	11,594	24,973	34,088	2,341	70,555	19,755	12,108	31,864	41,168	2,987	94,222	33,920	11,307	45,226	56,533	4,240
R10*	41,823	10,217	8,855	19,071	26,032	1,788	53,105	14,869	9,114	23,983	30,986	2,248	70,711	25,456	8,485	33,941	42,426	3,182
R11	86,335	21,090	18,278	39,369	53,738	3,691	104,705	29,317	17,969	47,286	61,094	4,433	159,696	57,490	19,163	76,654	95,817	7,186
R12	885	216	187	404	551	38	1,074	301	184	485	626	45	1,434	516	172	688	860	65
R14	503,083	122,896	106,510	229,406	313,139	21,507	619,674	173,509	106,344	279,853	361,570	26,236	827,534	297,912	99,304	397,217	496,521	37,239
R45	175	43	37	80	109	7	212	59	36	96	124	9	335	121	40	161	201	15
Sub-total	3,105,320	758,585	657,441	1,416,026	1,932,900	132,752	3,842,650	1,075,942	659,448	1,735,390	2,242,200	162,693	5,329,742	1,918,707	639,569	2,558,276	3,197,900	239,838
Karkh Side																		
K1	148,287	36,224	31,394	67,619	92,300	6,339	190,566	53,358	32,704	86,062	111,192	8,068	254,488	91,616	30,539	122,154	152,693	11,452
K2	138,467	33,826	29,315	63,141	86,187	5,919	174,406	48,834	29,930	78,764	101,763	7,384	232,908	83,847	27,949	111,796	139,745	10,481
K3	137,548	33,601	29,121	62,722	85,615	5,880	170,727	47,803	29,299	77,102	99,616	7,228	227,994	82,078	27,359	109,437	136,797	10,260
K4	37,644	9,196	7,970	17,166	23,431	1,609	45,654	12,783	7,835	20,618	26,638	1,933	60,968	21,949	7,316	29,265	36,581	2,744
K5	89,064	21,757	18,856	40,613	55,437	3,807	115,692	32,394	19,854	52,248	67,504	4,898	154,499	55,620	18,540	74,159	92,699	6,952
K6	735,845	179,756	155,789	335,545	458,019	31,457	962,733	269,565	165,217	434,783	561,739	40,761	1,285,669	462,841	154,280	617,121	771,401	57,855
K7	624,716	152,609	132,261	284,871	388,848	26,707	757,643	212,140	130,021	342,161	442,073	32,078	1,011,784	364,242	121,414	485,656	607,070	45,530
K8 (Taji Center)*	133,838	32,695	28,335	61,030	83,306	5,722	162,794	45,582	27,938	73,520	94,988	6,892	248,814	89,573	29,858	119,431	149,288	11,197
K9 (Abu Ghraib)*	139,374	34,047	29,508	63,555	86,752	5,958	169,528	47,468	29,093	76,561	98,917	7,178	251,829	90,658	30,219	120,878	151,097	11,332
K10	305,144	74,542	64,603	139,146	189,934	13,045	370,073	103,620	63,509	167,130	215,931	15,668	494,209	177,915	59,305	237,220	296,525	22,239
K11 (Airport)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sub-total	2,489,928	608,254	527,153	1,135,407	1,549,831	106,444	3,119,815	873,548	535,400	1,408,949	1,820,362	132,089	4,223,161	1,520,338	506,779	2,027,117	2,533,897	190,042
Total	5,595,247	1,366,839	1,184,594	2,551,433	3,482,731	239,197	6,962,464	1,949,490	1,194,849	3,144,339	4,062,562	294,782	9,552,903	3,439,045	1,146,348	4,585,394	5,731,797	429,881
Annual Water Requirement (MCM/year)		499		931	1,271			712		1,148	1,483			1,255		1,674	2,092	

(Source : BWA & JICA Study Team)

5.4.3 Proposed Water Production

(1) Water treatment capacity projections

For the potable water supply in Baghdad, raw water is drawn from the Tigris River and treated by the existing eight WTPs and 34 CU sites as described in Section 4.4.3. The water production is estimated at around 2.3 MCM/d in 2004 and 2.5 MCM/d in 2005. Production of the WTPs is more than 93% of total production. Based on the above-mentioned water demand projections, BWA required 2.5 MCM/d in 2004 and 2.6 MCM/d in 2005 on an average daily supply basis. It is supposed a deficit exists in the present water supply system, not only in terms of the maximum daily supply but also the average daily supply. It is, therefore, necessary that BWA improve the existing WTPs and develop new treatment plants.

Water treatment capacity projections were provided by BWA as shown in Table 5.4.11. As for the proposed WTPs implementation schedule, the JICA Basic Study Report was referred to and the year of implementation of the existing WTP comes from the USAID Report. Capacity of the existing plants, including Shark Dijla WTP Expansion-1, is estimated at the present actual capacity base and capacity of on-going/proposed plants is presented with the design capacity base.

Table 5.4.11 Water Treatment Capacity Projection

Name of Treatment Plant		First Year of Operation	Capacity (m^3/d)			Remarks
			Total	Rasafa Side	Karkh Side	
1	Existing Plants					
	8 WTPs		2,208,000	678,000	1,530,000	Actual Capacity
	16 CU Sites Connected with Network		125,280	118,000	7,280	
	18 CU Sites Isolated from Network		55,465	39,905	15,560	Actual Capacity
2	On-going/Currently Constructed Plants					
	Shark Dijla WTP Expansion-1	2005	135,000	135,000		USAID, Actual Capacity
	Sadr City WTP	2006	90,000	90,000		USAID, Design Capacity
	Sadr City 27 CU Sites (Isolated)	2006	405	405		USAID, Design Capacity
	19 CU Sites (Isolated)	2007	85,500	76,500	9,000	JICA, Design Capacity
3	Proposed Plants					
	Shark Dijla Expansion-2	2009	315,000	315,000		Design Capacity
	Rasafa WTP Stage-1	2011	600,000	600,000		Design Capacity
	Rasafa WTP Stage-2	2015	600,000	600,000		Design Capacity
	Rasheed WTP Abandon	2015	-50,000	-50,000		to be abandoned
	Rasafa WTP Stage-3	2019	600,000	600,000		Design Capacity
	Half of Existing 16 CU Sites Removal	2019	-62,640	-59,000	-3,640	to be removed
	Rasafa WTP Stage-4	2023	600,000	600,000		Design Capacity
	Half of Existing 16 CU Sites Removal	2023	-62,640	-59,000	-3,640	to be removed
Total			5,239,370	3,684,810	1,554,560	

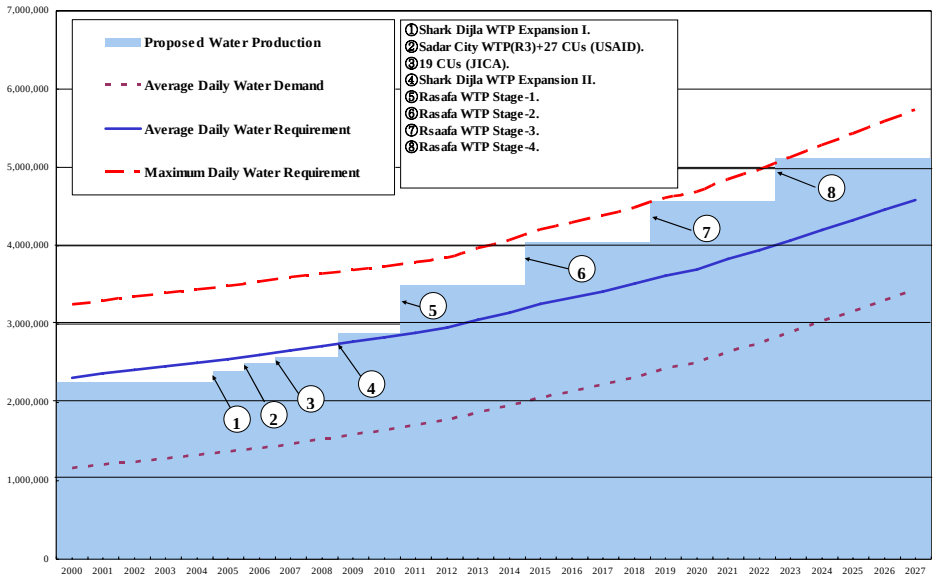
(Source: BWA & JICA Study Team)

As shown in Table 5.4.11, the existing deteriorated Rasheed WTP will be demolished after completion of Rasafa WTP stage-3. A half of the existing 16 CU sites connected with the distribution network are to be removed in the year 2019, and the remaining half in 2023. According to the JICA Basic Study Report, CUs under implementation by the assistance of international agencies, such as JICA and USAID, are not included in the plan for stepwise construction of plants provided by the JICA Basic Study Report.

(2) Water requirements and production

Water requirements and water production are projected in chronological order as shown in DATA BOOK 1 and Figure 5.4.1. Figure 5.4.1 shows the balance of forecast demand and treatment capacity. The JICA Basic Study Report recommended that a balancing quantity of about 520,000 m^3/d might be transmitted from the Rasafa side to the Karkh side in the target year of 2027. For this water transmission, the existing river crossing trunk mains of 1600 mm and 1400 mm in diameter will be used as they have sufficient conveying capacity and pressure.

Although the water treatment capacity projection is to improve the water supply condition in Baghdad, it is noteworthy that the maximum daily supply has never been met as shown in Figure 5.4.1. Shark Dijla expansion-2 allows the average daily supply to be met in the year 2009. Based on the BWA standard design, the WTPs are typically to be designed to fulfil the maximum daily supply with on-line distribution storage providing peak hourly supply. From a practical standpoint regarding the existing facilities, the actual treated water through the WTPs, as mentioned in Section 4.4.3, is well below the design capacity so that average daily supply is not being met.



(Source: BWA & JICA Study Team)

Figure 5.4.1 Water Requirements and Proposed Water Production

5.5 Priority Project Areas

5.5.1 Selection of the Priority Areas

(1) Results of preliminary hydraulic analysis

The preliminary hydraulic analysis was carried out using a simplified computer model as described in Appendix A. The results of the preliminary analysis are summarized below:

- For present and future average daily flow, distribution mains on the Karkh side are sufficient. They are not sufficient on the Rasafa side, especially in R3 and R14.
- For future peak hourly flow, almost all distribution mains and sub-mains are in a critical condition with more than 7 m/km of head loss gradient.
- For the present peak hourly flow, in the Karkh side WSZs K1, K5, K6, K10 and in the Rasafa side WSZs R1, R2, R3, R14, R7/13, R4, R5, R6, R11 are in a critical condition with more than 7 m/km of head loss.
- Several pipes of the existing trunk and distribution main and sub-mains capacity in R3 and R14 need to be improved since some networks in the zones are showing low pressure problems due to insufficient pipe capacity.
- Minimum water pressures in R3, analyzed at sub-mains consisting of secondary and tertiary, are between 0 m and 10 m. These figures do not meet BWA's minimum criteria of 10 m.
- Results suggest that WSZs on the Rasafa side should be improved urgently by means of improvement of the distribution network to provide proper pipe capacity and a service reservoir at each WSZ.

(2) Priority area ranking and selection

From the above mentioned examination and analyses of the Baghdad water supply system, distribution network improvement, UFW reduction and augmentation of water production are ascertained to be required as the most urgent and fundamental measures for the present and future water supply system improvement. The BWA service area shall be improved in order of priority based on evaluation of the water supply condition in each WSZ. Twenty five WSZs rated as priority improvement projects were ranked to determine implementation priority by applying three factors; number of beneficiaries, population density, urbanization rate of the area in 2005 (see Table 4.2.1 of Chapter 4) and necessity of network improvement. The following table shows the relative priority among the WSZs to improve water supply conditions in Baghdad.

Table 5.5.1Priority Area Ranking

WSZs	Population		Population Density		Urbanization		Necessity of Network Improvement	Priority Ranking
Rasafa	3,105,320		10,851		78.00%			
R1	276,380	B	10,091	B	74.70%	B	A	7
R2	363,437	A	11,823	A	71.70%	B	A	3
R3	657,803	A	35,595	A	89.50%	A	A	1
R4	112,206	B	6,608	B	61.50%	B	B	12
R5	223,255	B	10,896	A	93.50%	A	B	6
R6	327,158	A	10,265	B	95.00%	A	B	4
R7/13	321,266	A	9,299	B	71.30%	B	A	5
R8	136,750	B	4,545	C	56.90%	C	C	15
R9	54,764	C	4,579	C	81.30%	A	C	17
R10	41,823	C	2,898	C	82.30%	A	C	18
R11	86,335	C	10,712	A	59.20%	C	B	16
R12	885	C	52	C	98.20%	A	C	23
R14	503,083	A	30,676	A	94.50%	A	A	2
R45	175	C	23	C	51.00%	C	C	24
Karkh	2,489,928		3,944		62.60%			
K1	148,287	B	10,722	A	79.70%	A	B	9
K2	138,467	B	6,399	B	86.80%	A	C	10
K3	137,548	B	9,395	B	91.80%	A	C	11
K4	37,644	C	2,657	C	26.90%	C	C	22
K5	89,064	C	9,985	B	80.60%	A	B	14
K6	735,845	A	6,912	B	76.50%	A	A	8
K7	624,716	A	4,911	C	46.70%	C	C	13
K8	133,838	B	994	C	56.30%	C	C	21
K9	139,374	B	2,459	C	64.70%	B	C	20
K10	305,144	B	3,576	C	46.50%	C	A	19
K11	Airport						-	-
Baghdad	5,595,247		6,099		67.40%			

(Remark) A: High, B: Medium, C: Low

WSZs R3, R14 and R2 are ranked as the highest priority followed by WSZs R6, R7 and R5. There are large populations living in these WSZs, which are located in the heart of the Rasafa side. Water consumption and UFW ratio are high and the projects for water supply system improvement are urgently required to meet basic human needs and to generate a large saving in unaccounted for water. As discussed with BWA, WSZs R2, R3 and R14 within Shaab and Sadr 1 and Sadr 2 administrative municipalities on the Rasafa side were selected as the most urgent zones for improving the water supply system. The water supply system improvement plan for WSZs R2, R3 and R14 is to be formulated as a proposed project.

5.5.2 Outline of Priority Areas

(1) Service areas and population served

The selected priority areas consist of three WSZs R2, R3 and R14 which are located on the Rasafa side. WSZ R2 belongs to Shaab Municipality and WSZs R14 and R3 belong to Sadr City Municipality. Sadr City, which is one of the urban centres in Baghdad, is divided into two municipalities: Sadr-1 and Sadr-2. Areas of R2, R3 and R14 are 30.74 km^2, 18.48 km^2 and 16.40 km^2 respectively and the existing urban developments in the Shaab and Sadr City districts are summarized as shown in Table 5.5.2.

The service area to be improved and the population served in the priority area were determined based on the results of the population projections described in Section 5.3. The present population and population density for the Project areas in 2005 are summarized below:

Table 5.5.2 Population and Density of Priority Areas in 2005

WSZ	Area (km^2)	Developed Area (km^2)	Population	Population Density:	Population density in Developed Area
R2	30.74	22.03	363,437	11,823	16,497
R3	18.48	16.54	657,803	35,595	39,770
R14	16.40	15.49	503,083	30,676	32,478
Total of Priority Area	65.62	54.06	1,524,323	23,230	28,197
Baghdad	917.47	618.20	5,595,247	6,304	9,051
Proportion (%)	7%	9%	27%	-	-

(Source: BWA & JICA Study Team)

WSZs R2, R3 and R14 are divided into 21, 31 and 30 administrative districts or Mahalahs respectively and WSZs R3 and R14 are further divided by BWA into 46 sectors and 37 sectors respectively as given in Table 5.5.3

Table 5.5.3 Population and Density Classified by Mahalah and Sector in 2005

Project Area (WSZ)	Administrative District: Mahalah				BWA Sector	
	Number	Population per Mahalah	Mahalah without Sectors	Mahalah with Sectors	Number	Population Density per Sector
R2	21	17,307	21	-		
R3	31	21,219	4	27	46	11,738
R14	30	16,769	12	18	37	8,611
Total/Average	82	18,589	37	45	83	10,175

(Source: BWA & JICA Study Team)

The future land use developments in the priority area are assumed to be the same as the existing land use patterns and therefore, new development areas in the priority area are planned for residential and commercial use as follows:

- In WSZ R14, undeveloped area of 0.91 km^2 is to be built up by the year of 2006,
- In WSZ R3, undeveloped area of 1.94 km^2 is to be built up by the year of 2008,
- In WSZ R2, undeveloped area of 8.71 km^2 is to be built up by the year of 2015.

The future populations are projected considering the above mentioned future land use developments and land use patterns. The forecast population served in the priority areas for each target year are summarized below:

Table 5.5.4Population Projection for Priority Areas

Year	R2	R3	R14	Total
2005	363,437	657,803	503,083	1,524,323
2014	440,769	820,240	619,674	1,880,683
2027	648,713	1,095,379	827,534	2,571,626

(Source: BWA & JICA Study Team)

(2) Water requirements of the priority areas

The projection of water demands and water requirements for the BWA service areas was conducted as described in Section 5.4 and the results are presented in Table 5.4.7. The projected water demands and water requirements of the priority areas are summarized for each WSZ as follows:

Table 5.5.5Water Demand and Requirement Projections for Project Areas

WSZ	2005			2014			2027		
	Water Demand (m^3/d)	Average Daily Requirement (m^3/d)	Maximum Daily Requirement (m^3/d)	Water Demand (m^3/d)	Average Daily Requirement (m^3/d)	Maximum Daily Requirement (m^3/d)	Water Demand (m^3/d)	Average Daily Requirement (m^3/d)	Maximum Daily Requirement (m^3/d)
R2	88,783	165,727	226,218	123,415	199,057	257,182	233,537	311,382	389,228
R3	160,692	299,958	409,443	229,667	370,431	478,597	394,336	525,782	657,227
R14	122,896	229,406	313,139	173,509	279,853	361,570	297,912	397,217	496,521
Total	372,370	695,091	948,800	526,591	849,341	1,097,348	925,785	1,234,381	1,542,976

(Source: BWA and JICA Study Team)

In the priority areas, the projected average daily water supply in 2005 is classified by Mahalahs and sectors as presented in Table 5.5.6.

Table 5.5.6 Water Requirement of Project Area in 2005

WSZ	Average Daily Supply (m^3/d)	Mahalah		Sector	
		Number	Average Daily Supply at Each Mahalah	Number	Average Daily Supply at Each Sector
R2	165,727	21	7,892	-	-
R3	299,958	31	9,676	46	6,976
R14	229,406	30	7,647	37	9,176
Total	695,091	82	8,477	83	8,275

(Source: BWA and JICA Study Team)

(3) Physical condition, topography and geology

The priority areas are located in the northern part of Baghdad City. Total area is about 66 km^2 and population was estimated at 1.5 million in 2005. The elevation varies from 33 m to 37 m above mean sea level. The area slopes down to the south with an inclination of less than 0.1%. The service area is quite flat land with an average slope of about 0.08 %.

A geotechnical investigation was recently conducted by MOB for Sadr sewerage system improvement in October 2005. For determining the subsoil properties, eighty bore holes were drilled in Sadr City. Results of the investigation are summarized as follows:

1) Sub Soil Structure	
1st Layer (0 m to 1.0 m or 2.0 m):	Medium or soft silty clay
2nd Layer (1.0 m to 2.0 m or 5.0 m):	Soft sandy silty clay
2) Soil Bearing Capacity	
N-Value	2 to 10
Shear Strength of Soft Soil	Less than 2 N-Value (20 kPa)
Allowable Soil Bearing Capacity	50 kPa
3) Groundwater	
Groundwater Level	0.2 m to 0.6 m below the ground surface
Transmissivity	0.189 m^2/d
Average Recovery Time	15 min.
Volume of Water Recovered	5.89 m^3/d

The soil structure in the priority areas generally comprises soft sandy silty clay with low shear strength and high level of groundwater. The groundwater level at R2 is presumed to be more than 1.0 m below the ground surface.

(4) Present condition of the water supply system

The priority area is supplied directly from Shark Dijla WTP through a distribution main of DN1600 mm since there are no service reservoirs at present. Total length of the distribution mains ranging from 75 mm to 1600 mm in diameter is around 1,300 km. Distribution mains and secondary are mostly made of ductile iron pipe and their diameters vary between 300 mm and 1600 mm and distribution tertiary consist of ACP, CIP and PVC with diameters ranging 75 mm to 250 mm. Distribution mains are provided with a total of 1,965 control and sectionalizing valves for optimizing distribution network operations. There are a total 2,500 fire hydrants with a four inch bore. The hydrants are typically located above ground. Water consumption meters are individually installed for subscribers, however more than 50% of the subscribers are not so equipped.

The average daily flow rate as estimated in this study is 695,091 m^3/d (8.1 m^3/s) consisting of 165,722 m^3/d (1.9 m^3/s) for R2, 299,958 m^3/d (3.5 m^3/s) for R3 and 229,406 m^3/d (2.7 m^3/s) for R14. As for water use patterns, peak water consumption occurs from 7 am to 2 pm and again from 6 pm to 9 pm. All households with storage reservoirs use them regardless of the season. Normal capacity of individual household reservoirs ranges from 1 m^3 to 2 m^3.

The results of flow analysis indicate that the instantaneous maximum flow velocity in most pipelines of WSZs R3 and R14 is more than 2.0 m/s, while in the distribution main for R2 it is less than 2.0 m/s. In the WSZs R3 and R14, water pressure in water mains varies from 10 m to 28 m and in R2 water pressure of more than 30 m is estimated. Minimum water pressures in R3, analyzed at sub mains, are between 0 m and 10 m. These figures do not meet BWA's minimum criteria of 10 m. Head loss gradient in R2 is acceptable at less than 3 m/km, while in WSZs R3 and R14 it is mostly more than 4 m/km. Head loss gradient of the main connected between R2 and R3 is in a critical condition with a head loss of more than 7 m/km.

(5) On-going and planned water supply system improvement

The projects related to water supply system improvement in the priority areas are on-going or planned by BWA in assistance with international organizations as descried below.

1) Water treatment compact units (CUs)

USAID has been providing Sadr City with water treatment compact units with total capacity of 405 m^3/d as follows:

- 25 CU sites in R3 for schools and a hospital (to be completed within 2006)
- 2 CU sites in R14 for schools and a hospital (completed)

JICA also will install the following CUs in R3 by early 2007:

- 1 CU site with capacity of 4,500 m^3/d located at Orfall, Orfall
- 1 CU site with capacity of 4,500 m^3/d located at Hay Al-Montadher

Those CUs are to be isolated from the BWA distribution network.

2) Sadr Water Treatment Plant (WTP)

Sadr WTP with a capacity of 90,000 m^3/d is under construction with the assistance of USAID. The raw water for Sadr WTP will be transferred using the existing raw water network with a raw water line extension of 2 km. Sadr WTP will be completed by the beginning of September this year.

3) Service Rervoirs (SRs)

BWA reports WSZs R3 and R14 to be the ones most urgently requiring water supply system improvement and WSZs R2 and R7 are the second priority since service reservoirs do not exist in those WSZs. The service reservoirs for R2, R3 and R14 have already been designed by BWA. BWA intends to construct the reservoirs for R3 and R14 and their project cost is estimated at US$80 million in total. The reservoirs for R3 and R14 are planned to get their water from the Shark Dijlah WTP. The cost of trunk mains from Shark Dijlah WTP to R3 reservoir is estimated at about US$ 50 million.

4) Distribution tertiary and service pipes

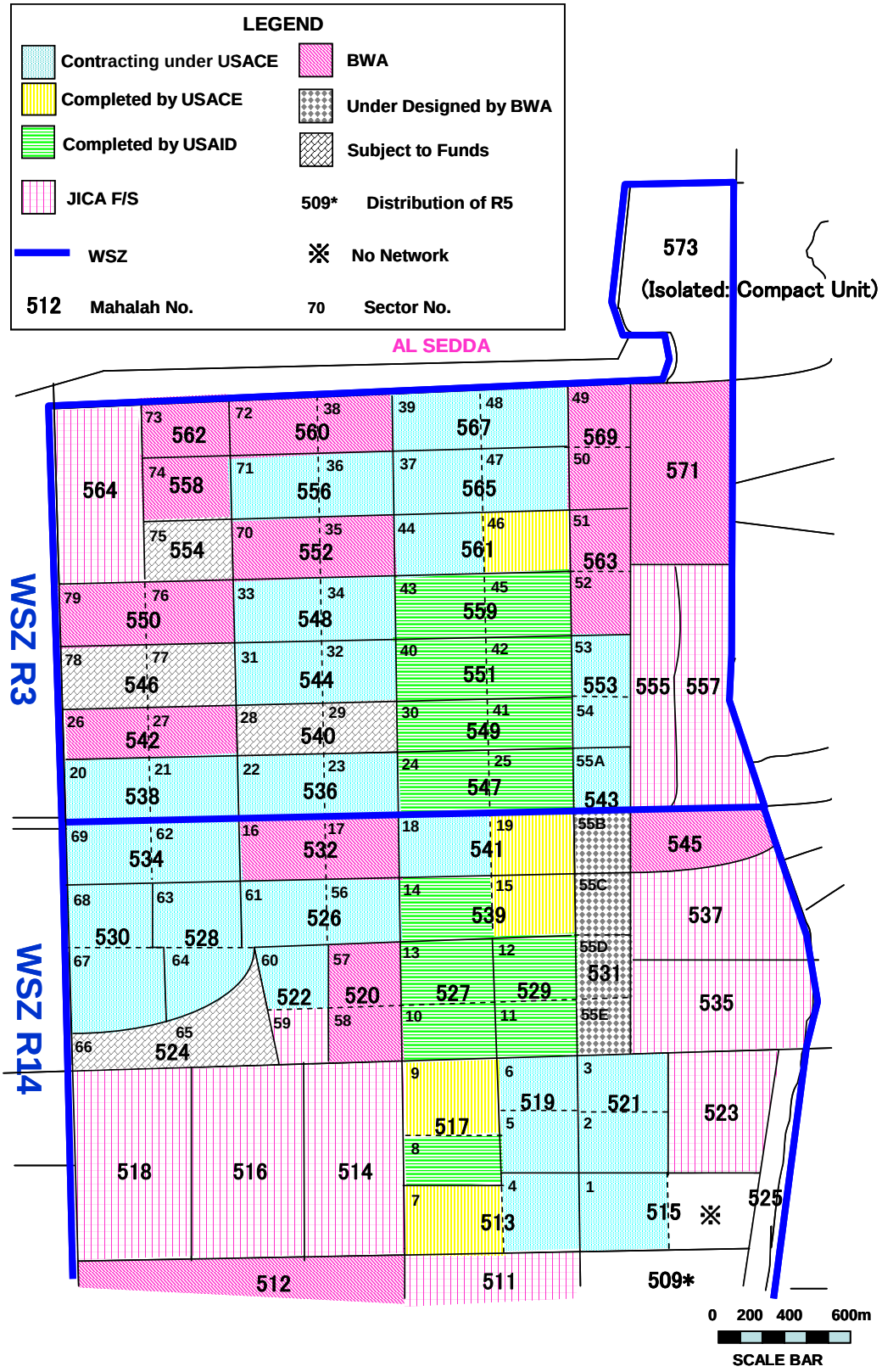
Distribution tertiary for WSZs R3 and R14, which were selected as priority areas, have been greatly improved by the pipe replacement works as a part of USAID Sadr City Water Supply Projects as shown in Figure 5.5.1 and Table 5.5.8. Within R2, distribution tertiary was improved only in Mahalah No. 357 by BWA. The present pipe replacement works in Mahalahs and sectors in the priority area are listed in Table 5.5.7.

Table 5.5.7 Summary of Pipe Replacement Works in WSZs R2, R3 & R14

Replacement Area			Total Length of Replaced Pipe (m)		Total (m)
WSZ	Mahalah	Sector	DIP	PVC	
R2	357		n/a	n/a	n/a
Sub Total					
R3	547	24		7,227	7,227
		25		7,175	7,175
	549	30		2,920	2,920
		41		6,333	6,333
	551	40		6,334	6,334
		42		7,157	7,157
	552	76	7,850		7,850
		79	7,850		7,850
	559	43		2,823	2,823
		45		3,294	3,294
Sub Total			15,700	43,263	58,963
R14	517	8	7,321		7,321
	527	10		6,335	6,335
		13		6,960	6,960
	529	11		6,361	6,361
		12		6,874	6,874
	539	14		7,247	7,247
		15		7,247	7,247
	541	19	7,200	7,247	7,247
Sub Total			14,521	48,271	55,592
Total (m)			30,221	91,534	114,555

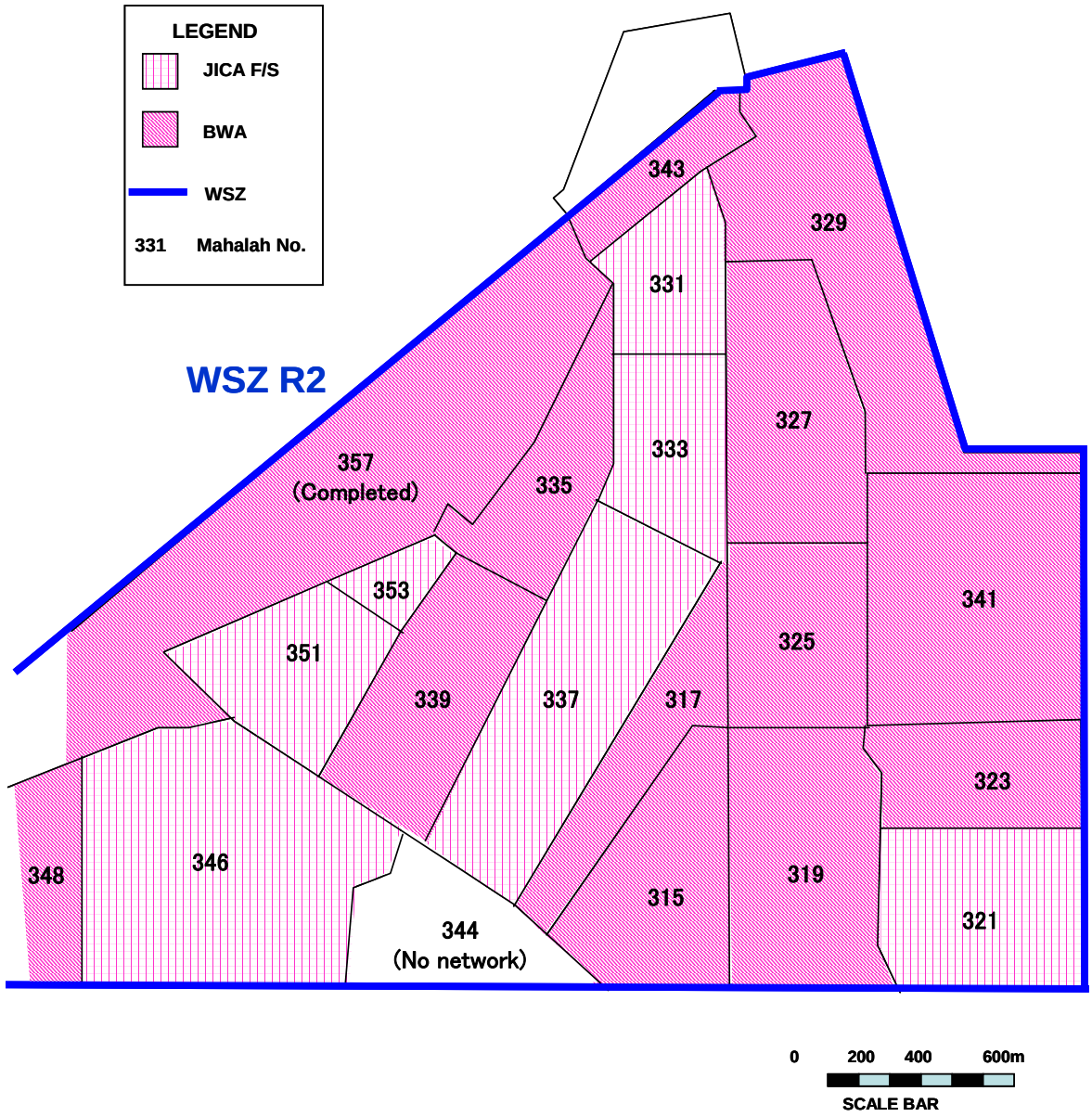
(Source: BWA & USAID)

Replaced pipes range from 150 mm to 300 mm in diameter. Length of replaced pipelines per sector is estimated at 6 km on average. Not many water consumption meters were installed by USAID.



(Original Source: BWA and GRD-PCO)

Figure 5.5.1 On-going pipe Replacement Works (1/2)



(Original Source: BWA and GRD-PCO)

Figure 5.5.1 On-going pipe Replacement Works (2/2)

Table 5.5.8 Pipe Replacement Work at Mahalahs and Sectors in the Feasibility Study Area

Water Supply Zones (WSZs)	Maharah Number	Sector	Completed	On-going	Contracted	Planning	Remaining	Others	Remarks
R2	315					1			by BWA
Total Numbers Mahalah Sector	317					1			by BWA
21	319					1			by BWA
Completion Numbers Mahalah Sector	321						1		
1	323					1			by BWA
Ongoing/contracted Numbe Mahalah Sector	325					1			by BWA
0	327					1			by BWA
Planning Numbers Mahalah Sector	329					1			by BWA
12	331						1		
Remaining Numbers Mahalah Sector	335					1			by BWA
7	339					1			by BWA
Area (km2):	341					1			by BWA
30.74	343					1			by BWA
Developed Area (km2):	344							1	No Network
22.03	346						1		by BWA
Undeveloped Area (km2):	348					1			by BWA
8.71	351						1		
	353						1		
	357		1						by BWA
	333						1		
	337						1		
R3	543	55A			1				by GRD-PCO
Total Numbers Mahalah Sector	536	22 23			2				by GRD-PCO
31 46	538	20 21			2				by GRD-PCO
	540	28 29				2			by GRD-PCO
Completion Numbers Mahalah Sector	542	26 27				2			by BWA
17	544	31 32			2				by GRD-PCO
	546	78 77				2			by GRD-PCO
Ongoing/contracted Numbe Mahalah Sector	548	33 34			2				by GRD-PCO
18	547	24 25	2						by USAID
	549	30 41	2						by USAID
Planning Numbers Mahalah Sector	550	79 76	2						by BWA
1 11	551	40 42	2						by USAID
Remaining Numbers Mahalah Sector	552	70 35	2						by BWA
3 0	553	53 54			2				by GRD-PCO
	554	75 -				1			by GRD-PCO
	555	- -					1		
Total Area (km2):	556	71 36			2				by GRD-PCO
18.48	557	- -					1		
Developed Area (km2):	558	74 -				1			by BWA
16.54	559	43 45	2						by USAID
Undeveloped Area (km2):	560	72 38				2			by BWA
1.94	561	44 46	1		1				by GRD-PCO
	562	73 -				1			by BWA
	563	51 52	2						by BWA
	564	- -					1		
	565	37 47			2				by GRD-PCO
	567	39 48			2				by GRD-PCO
	569	49 50	2						by BWA
	571	- -				1			by BWA
	573	- -						1	Supplied by CUs
	329	-						1	Located at Shaab (R2)
R14	509	- -						1	Supplied from R5
Total Numbers Mahalah Sector	511	- -					1		
30 39	512	- -				1			by BWA
	513	7 4	1		1				by GRD-PCO
Completion Numbers Mahalah Sector	514	- -					1		
10	515	1 -			1				by USAID
	516	- -					1		
Ongoing/contracted Numbe Mahalah Sector	517	8 9	2						by USAID & GRD-PCO
18	518	- -					1		
	519	5 6			2				by GRD-PCO
Planning Numbers Mahalah Sector	520	57 58			2				by BWA
2 10	521	2 3			2				by GRD-PCO
	522	59 60			1		1		by GRD-PCO
Remaining Numbers Mahalah Sector	523	- -					1		
8 1	524	66 65				2			by GRD-PCO
	525	- -				1			No Network
Total Area (km2):	526	61 56			2				by GRD-PCO
16.4	527	10 13	2						by USAID
Developed Area (km2):	528	63 64			2				by GRD-PCO
15.49	529	11 12	2						by USAID
Undeveloped Area (km2):	530	67 68			2				by GRD-PCO
0.91	531	55C, 55D, 55E				3			by BWA
	532	16 17				2			by BWA
	534	69 62			2				by GRD-PCO
	535	- -					1		
	537	- -					1		
	539	14 15	2						by USAID & GRD-PCO
	541	18 19	1		1				by GRD-PCO
	545	- -				1			by BWA
	543	55B				1			by BWA

(Source: BWA, USAID & GRD-PCO)

5.6 Baghdad Water Supply System Improvement Plan

5.6.1 Selection of Priority Projects

Several projects have been proposed by the previous studies to improve the existing water supply conditions and to meet future water demands and the following priority projects related to the selected priority areas consisting of the WSZs R2, R3 and R14 were determined from viewpoints of the degree of urgency based on social needs and benefits, and economic viability.

In the JICA Basic Study Report, priority projects for the Baghdad water supply system improvement were contemplated and selected as given below:

First priority projects:	Improvement of WTP (Shark Dijla WTP expansion-2) Replacement of ACP and CIP in WSZs R3 and R14 Installation of water consumption meters with service pipes in WSZs R3 and R14
Second priority projects:	Implementation of new WTP (Rasafa WTP stage-1) Replacement of ACP and CIP in WSZs R2 and R7 Installation of water consumption meters with service pipes in WSZs R2 and R7

The USAID Report also formulated priority projects in the water and sanitation sectors and the following projects have been implemented or are on-going at present:

Implemented projects:	Shark Dijla WTP expansion-1 Rehabilitation of CUs in Sadr City Replacement of distribution tertiary in Sadr city (14 sectors in WSZs R3 and R14) Hydraulic Analysis of Baghdad water supply system for the years 2004, 2010 and 2015
On-going projects:	Replacement of distribution tertiary in Sadr city (21 sectors in WSZs R3 and R14) Sadr WTP Construction of service reservoir for R3 had been stopped and R14 had been announced for bidding.

Some of the proposed projects have been selected as priority projects because they will require further study to scope out details at the feasibility stage and time constraints make it imperative to proceed as quickly as possible. Other projects, classified as either rehabilitation or improvement projects, are not priority projects because they can proceed directly to the basic design stage without a feasibility study. Generally, projects are identified as a priority if they satisfy the following criteria:

1) The project reduces UFW losses,
2) The project is urgently required for public health or operational reasons, and
3) The scale of project makes it relatively easy to proceed within the given time constraints.

A preliminary selection of priority projects includes a District Meter Area (DMA) system to assist in leakage detection efforts, the replacement of old distribution tertiary and replacement of defective meters or installation of new water consumption meters. Although the Shark Dijla WTP expansion-2, Rasafa WTP project and service reservoirs project for WSZs R2, R3 and R14 were initially selected as priority projects, they are omitted from the JICA feasibility study because they were already planned and designed by BWA in cooperation with USAID.

In conclusion, the following improvements in the priority areas are required immediately for the implementation of the water supply system improvement project for the present and future water supply system.

1) Replacement of aged ACP, CIP and PVC.
2) Replacement of distribution tertiary pipes to meet the present and future water flow.
3) Installation of water consumption meters.
4) Introduction of a DMA for reduction of the extremely large amount of UFW, which is currently at 50%.

5.6.2 Improvement Plan and Implementation Schedule

The proposed projects are summarized below and their implementation schedules for Baghdad water supply system improvement are presented in Figure 5.6.1. Locations of the Priority Projects are shown in Figure 5.6.2. Among the following proposed projects, some projects have been conducted by BWA with assistance from international agencies.

(1) Rehabilitation and improvement program for the distribution network

1) Distribution tertiary replacement

At present, the total length of distribution pipelines ranging from 75mm to 1600mm in diameter is estimated at about 1,300 km in the priority areas. A variety of materials have been used over the years. In general, the older mains are ACP and CIP, and the newer mains are ductile iron pipes (see Chapter 4.2).

The total length of distribution tertiary ranging from 75mm to 250mm is estimated at 1,166 km and tertiary consists mainly of ACP and CIP as shown in Table 5.6.1. The CIP, most of which are 30 years old, have inferior lead joints which are susceptible to high leakage rates. Leakage for these lines is also high at connection points and valves in comparison to other pipe materials. ACP also has been in use for more than 20 years and a large portion of the leaks are suspected to be from the pipe body because of their fragile structure. Therefore, replacement of old pipes is one of the measures proposed to effectively reduce water losses in the water supply system. The total length of ACP is estimated at about 658 km and CIP is about 142 km at present. Additionally, DIP was installed in the 1990s. Although these pipes are considered to be relatively new and do not need to be replaced, these pipes should be replaced to meet the future water demand flow. Except for the areas covered by projects of BWA with assistance of USAID and GRD-CPO as described in Section 5.5, all the distribution tertiary should be replaced. The implementation schedule for the distribution tertiary replacement program is shown in Figure 5.6.1. Replacement works required in the priority areas are summarized in Table 5.6.1.

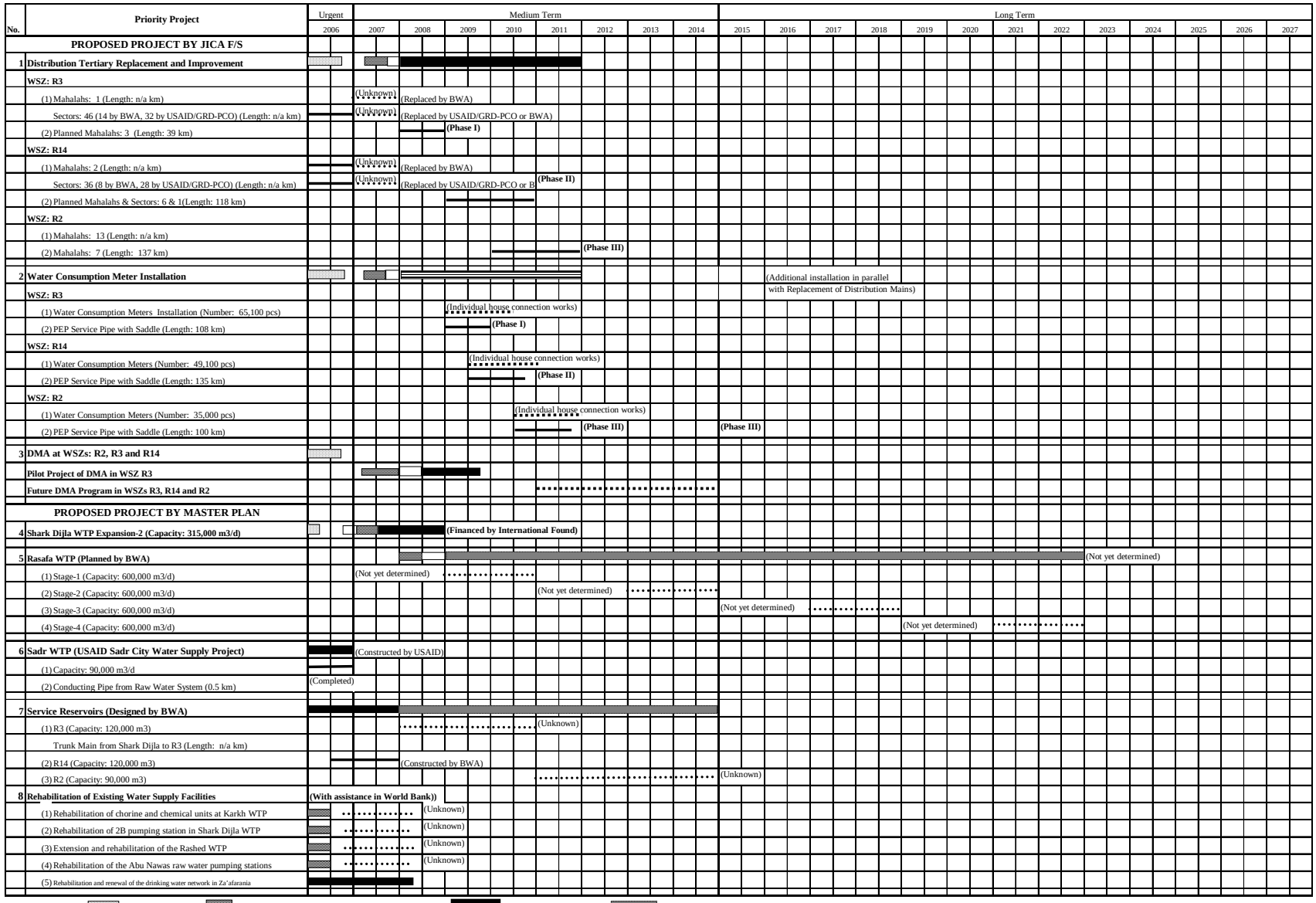


Figure 5.6.1 Overall Implementation Schedule of Priority Projects

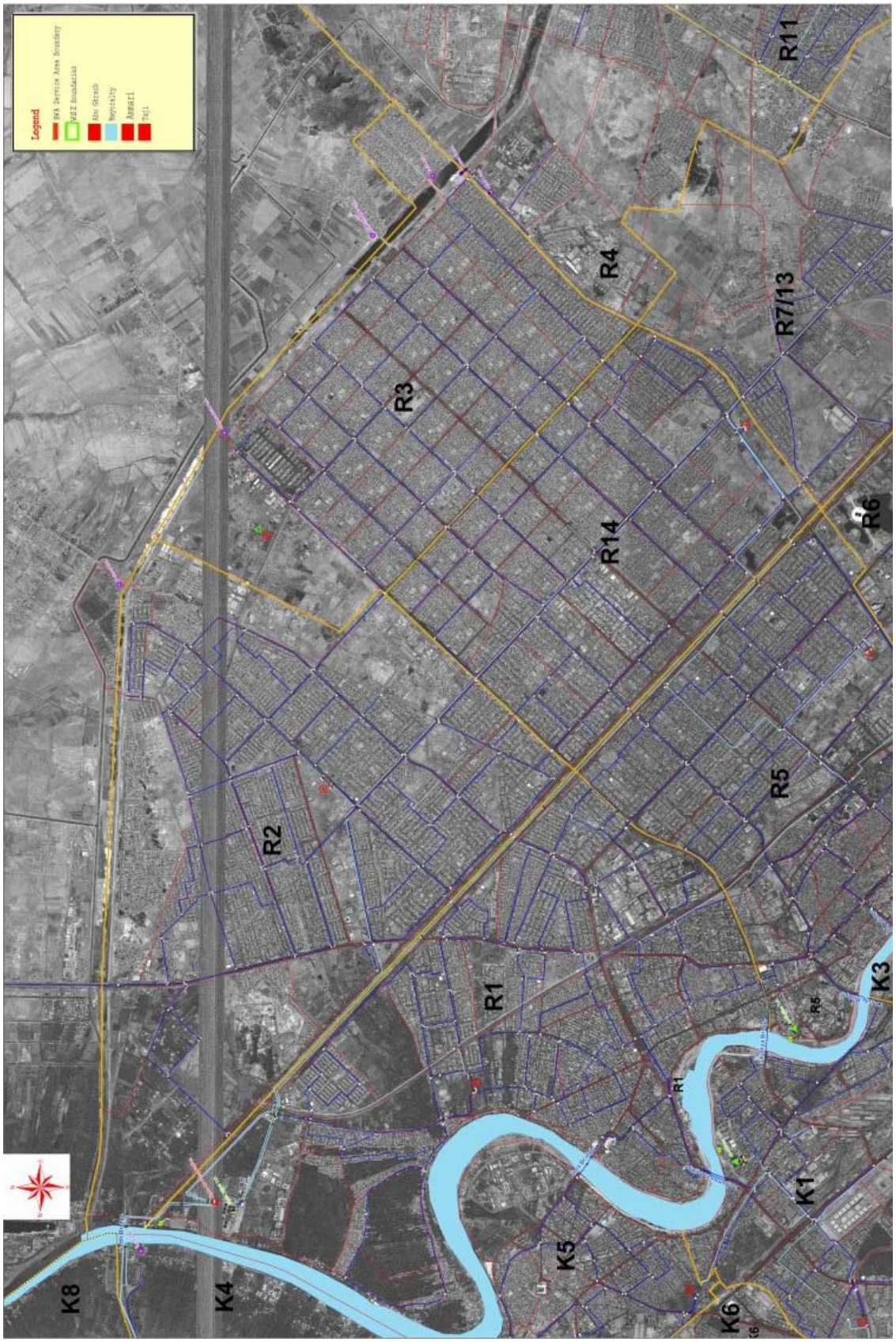


Figure 5.6.2 Location of Priority Projects

Source: USAID Report, 2006

Table 5.6.1 Required Distribution Tertiary Replacement

(Unit: km)

Pipe Length	R2	R3	R14	Total
1. Length of Existing Distribution Tertiary: D ≦250mm	420	372	374	1,166
a) ACP	237	210	211	658
b) CIP	51	45	46	142
c) Others (DIP/PVC)	132	117	117	366
2. Pipe Length Covered by Projects of BWA, USAID & GRD-PCO	283	333	256	842
3. Pipe Length Required by F/S	137	39	118	294

(Source: BWA and JICA Study Team)

2) Water consumption meter installation

In the BWA service area, about 48% of the 483,478 house connections are equipped with water consumption meters. However, there is a huge backlog of defective or unreadable water consumption meters waiting to be repaired or replaced (more than 129,000 or 55% of the house connections) and a substantial amount of revenue is being lost due to malfunctioning meters. Only 23% of the total number of service connections are metered properly and water consumption of the remaining 77% connections in the BWA service area are not known by BWA. In the Project area, functional water consumption meters for house connections are suspected to be less than 10%. For water meter reading and a proper billing system, meters installation is required urgently.

The required number of water consumption meters for domestic use is estimated based on the projected population and family size as given below.

Table 5.6.2 Water Consumption Meter Installation

Description	R2	R3	R14	Total
Number of Water Consumption Meters	35,000	65,100	49,100	149,200
a) 12 mm (1/2') Meters (set)	28,700	53,400	40,300	122,400
b) 18 mm (3/4') Meters (set)	3,200	5,800	4,400	13,400
c) 25 mm (1') Meters (set)	3,100	5,900	4,400	13,400

(Source: BWA and JICA Study Team)

It is recommended that imported foreign made rotary piston type meters, which have a high degree of accuracy of +/- 1.5% at minimum flow, be used. The rotary piston meter facilitates installation in the horizontal or vertical plane, which is seen as an advantage. Based on technical and economic evaluations it is recommended that existing water consumption meters be replaced with more reliable and accurate rotary piston type meters. Additionally, a meter testing and repairing system shall be developed since there is a large backlog of meters waiting for repair.

(2) DMA system

The implementation of District Meter Areas (DMA) is an essential requirement for an effective leakage control strategy as mentioned in Section 6.2. Without any information on district flows, it is impossible to determine accurate leakage levels or pin-point where maintenance and leakage personnel should focus their efforts. The DMA system is required to reach the targets for reduction of system leakage. The installation of a DMA system is proposed to optimize water distribution and facilitate leakage control. Integration with BWA's WSZ system to be implemented is also taken into consideration for planning the DMA. Because the WSZ system focuses on the transmission mains, service reservoirs and distribution mains, the DMA system is designed in two layers. The first layer contains transmission pipelines that connect reservoirs and distribution mains. These are grouped as a WSZ block. The second layer consists of small blocks which define each sector area. In R2, a total of 21 medium blocks of 21 Mahalahs were further subdivided into 36 small blocks according to administrative boundaries, roads, elevation and pressure stabilization criteria determined by network analysis.

Priorities for implementation of DMA system blocks were determined by evaluation factors, such as population served, water demand, water saved and ratio of ACP in the system from a viewpoint of necessity of leakage detection and control. The areas with the highest priority are the small blocks located in R3, R14 and R2. The proposed DMA system is summarized below:

Table 5.6.3 Proposed DMA System

Classification of Block	R3	R14	R2	Number of Blocks
i) Large Block System without medium blocks	1	1	1	3
ii) Small Block System	67	68	47	182
iii) Total Number of Proposed Blocks	68	69	48	185

(3) Water production improvement

The Shark Dijla water treatment plant is under re-development and Sadr WTP is newly constructed with the assistance of USAID to up-grade water sources for Baghdad. Rasafa WTP planned by BWA shall be constructed in stages to meet water demand during peak demand months. The other existing WTPs are to be renovated for securing proper operation. The CUs isolated from the distribution network shall be used for rural water supply even if Rasafa WTP is established. The following WTPs are proposed for water production improvement:

Table 5.6.4 Proposed Construction of Water Treatment Plants

	Name of Treatment Plant	Operation Year	Capacity (m^3/d)
1	Shark Dijla Expansion-2	2009	315,000
2	Rasafa WTP Stage-1	2011	600,000
3	Rasafa WTP Stage-2	2015	600,000
4	Rasafa WTP Stage-3	2019	600,000
5	Rasafa WTP Stage-4	2023	600,000
Total			2,715,000

(Source: JICA Basic Study Report)

(4) Service reservoir development

According to the Binnie Master Plan, each WSZ needs a service reservoir with proper storage capacity. The service reservoirs for R2, R3 and R14 are planned and designed by BWA as follows and the land required for the service reservoirs has been secured by BWA as shown in Figure 5.6.2.

Table 5.6.5 Proposed Service Reservoirs

Name of Service Reservoir	Capacity (m^3)	Status
R2	90,000	Designed by BWA
R3	120,000	Designed by BWA
R14	120,000	Financed by BWA

The service reservoirs are to be supplied from Shark Dijlah WTP through the trunk main. R14 service reservoir is planned by BWA to be implemented within this year. Implementation of R2 and R3 is not yet determined by BWA. All the reservoirs for R2, R3 and R14 need to be constructed by the year of 2014.

(5) Rehabilitation of water supply facilities

BWA is planning to conduct the following schemes for rehabilitating the existing water supply facilities under the "Water Supply and Sanitation Project" financed by the World Bank. Schemes are summarized in Table 5.6.6.

Table 5.6.6 WB Grant Aid Water Supply Projects

Components	Status		Revised Costs (US$ million)
1. Rehabilitation of chlorine and chemical units at Karkh WTP	Detailed design stage	By June 2006	4.1
2. Rehabilitation of 2B pumping station in Shark Dijla WTP	Detailed design stage	By June 2006	5.62
3. Extension and rehabilitation of the Al-Rasheed WTP	Detailed design stage	By June 2006	17.0
4. Rehabilitation of the Abu Nawas raw water pumping stations	Detailed design stage	By June 2006	3.95
5. Rehabilitation and renewal of the drinking water network in Al-Zufraniya	Construction stage	In Progress (by March 2008)	15.3

(Source: WB)