添 付 資 料

主要面談者リスト

資料収集リスト

添付資料-1 要請機材仕様及び予算見積（出所：BVK）

添付資料-2 上水道整備計画（出所：BVK）

(Prospective Development Program for the Water Supply System for Belgrade)

添付資料-3 ベオグラード市都市整備計画・
上下水道管理計画（出所：ベオグラード市）
（Integrated Water Management）

添付資料-4 水質関連資料（出所：BVK 水質試験室）

(1) セルビア共和国飲料水水質基準

(2) 地下水及び表流水の水質試験結果

主要面談者リスト

Ministry of Foreign Affairs, Serbia and Montenegro（セルビア・モンテネグロ国外務省）
Mr. Milisav Paic   Minister Plenipotentiary
Ms. Vera Mavric   Minister Plenipotentiary

Ministry of International Economic Relations, Republic of Serbia （セルビア共和国外務経済省）
Ms. Mirjana Jelic

City Assembly of Belgrade（ベオグラード市役所）Executive Board
Mr. Bojan Stanojevic   Vice President of the Executive Board

<Secretariat for Communal and Housing Affairs>
Mr. Ivan Andjelkovic   Director, Office of Water Management

Belgrade Waterworks & Sewrage（ベオグラード上下水道公社）
Mr. Vladimir Tausanovic Managing Director
Mr. Miroslav Cvjetkovic Deputy General Manager
Mr. Mihail Golicin   Executive Director, Makis 2
Mr. Milan Stamenic   Executive Director Assistant for Water Supply system
Mr. Dusan Zimonic   Advisor to the Managing Director
Mr. Mihailo Kovacevic   Department Manager for Telemmatics Department
Mr. Radoslav Babic   Chief of Water Quality Control Department
Mr. Radivojevic Zoran   Director for Developing and Project
Mr. Dragan Jovanovic   Deputy Manager for Treatment Sector
Mr. Djordie Andrejevic Head of Department
Mr. Aleksandar Sotic   Deputy Head of Department
Ms. Ksenija Simunovic   Water Distribution Development

<Crveni Krst Pump station> 1-Apr
Ms. Anna Stosovic   Deputy Head of Pump Station Department

<Banovo Brdo water treatment plant> 1-Apr
Mr. Pavle Jankovic   Head of Banovo Brdo Water Treatment Plant

<Makis water treatment plant> 1-Apr
Dr. Zorka Karklic   (a charge of Water Quality Test)
Ms. Gigana Vasiljevic   (for biochemistry)

<Bezanija water treatment plant> 3-Apr
Mr. Miroslav Savic   Head of Bezanija Water Treatment Plant

University of Belgrade
Dr. Milenko Pusic   Department of Hydrogeology (Technical Advisor to BVK)

European Bank for Reconstruction and Development（EBRD：欧州復興開発銀行）
Mr. Ulf Hindstrom   Senior Banker, Infrastructure
Mr. John Maguire   Principal Banker, Municipal & Environmental Infrastructure

European Agency for Reconstruction (EAR: 欧州復興機関)

Mr. Wout Soer	Local Government and Regional Development

Deuttsche Gesellschaft fur Technische Zusammenarbeit (GTZ:ドイツ技術協力公社) GmbH

Dr. Siegfried Brenke	Team Leader "Modernisation of Municipal Services"
Ms. Svetlana Babic	Deputy Team Leader "Modernisation of Municipal Services"

Kreditanstalt fur Wiederaufbau (KfW: ドイツ復興金融公庫)

Dr. Johannes Feist	Director
Ms. Brankica Dajic	Project Coordinator

United States Agency for International Development (USAID)

Dr. Michael J. Enders	Director, General Development Office
Mr. Arthur Flanagan	General Development Officer
Mr. Mark Pickett	General Development Officer
Mr. Sergej Anagnosti	Program Management Specialist

Mott MacDonald Limited

Mr. Radu Rautu	Team Leader
Mr. Ratko Jankovic	Local Project Coordinator

SETEC Engineering

Mr. Gunther Gutknetcht	Project Manager
Mr. Horst Santner	Project Engineer

Mikrokontrol

Mr. Mile Milanov	Director
Mr. Zoran Soskic	General Manager

在セルビア・モンテネグロ日本国大使館

田邊　隆一	特命全権大使
Mr. Kazumasa Miyazaki	一等書記官
佐野　彰	二等書記官

JICA オーストリア事務所

伏見　勝利	所員
本多　裕美子	企画調整員（環境セクター）

資料収集リスト

平成　　年　　月　　日

主管部長	主管課長	情報管理課長	技術情報課長

地域	東欧	調査名	ベオグラード上水道整備計画	調査の種類	予備調査	作成部課	
国名	セルビア・モンテネグロ国	配属機関名		現地調査期間	2004/3/19 2004/4/18	担当者	

番号	資料の名称	版型	種類	収集先又は発行機関	取扱区分	図書館記入
1	General Urban Plant of Belgrade, 2021 Integrated Water Management 「ベオグラード市総合都市整備計画-2021 年」のうち「上水道管理計画」（2003 年）	A4 20 頁	英訳 CD	ベオグラード市		
2	Prospective Development Program for the Water Supply System for Belgrade ベオグラード上水道整備計画（2004 年 2 月）	A4 67 頁	英訳 CD	BVK		
3	Regulation on Sanitary Requirements for Potable Water セルビア国飲料水水質基準（1998 年 8 月）	A4 8 頁	英訳 コピー	BVK		
4	地下水及び表流水の水質試験結果（2001 年 3 月）	A4 2 頁	英訳 コピー	BVK 中央水質試験室		
5	FIRS CENSUS RESULTS BY MUNICIPALITIES AND SETTLEMENTS OF THE REPUBLIC OF SERBIA, 2002 2002 年セルビア国 国勢調査（2003 年 5 月）（抜粋）	A4 11 頁	コピー	BVK		
6	KfW-Final Report Rehabilitation of Urban Water Supplies and Sanitation in Novi Sad, Nis and Belgrae-Phase I KfW ファイナルレポート（抜粋）（2003 年 12 月）	A4 3 頁	コピー	KfW		
7	The Development of Belgrade waterworks System ベオグラード上水道（抜粋）（1997 年）	A4 8 頁	コピー	BVK		
8	BVK 財務諸表（2003 年度）	A4	CD	BVK		
9	BVK 地図、写真その他	A4 A3	CD	BVK		

10	BVK 本要請プロジェクト B/Q	A4 31 頁	CD	BVK		
11	BVK メンテナンス部　説明ビデオ（動画ファイル）	9 分	CD	BVK		
12	BVK メンテナンス部　説明プレゼンテーション資料 （パワーポイント・ファイル）	A4 40 頁	CD	BVK		
13	BVK　無償援助リスト	A4 1 頁	CD	BVK		
14	BVK　説明プレゼンテーション資料 （パワーポイント・ファイル）	A4 21 頁	CD	BVK		
15	BVK　110 周年記念パンフレット（2002 年）	ｶﾗｰ本 21 頁	コピー	BVK		
16	Program of Construction of Water Treatment Plant Makis 2	A4 9 頁	コピー	BVK		
17	2004　Program Summary	A4 17 頁	コピー	USAID		
18	2nd International Conference on PPP パンフレット	A4 2 頁	コピー	ベオグラード市		

添付資料-1

要請機材仕様及び予算見積

BILL OF QUANTITY

Item No.	Equipment	Q'ty	Specification Sheet	Price (EUR)
1. Well Equipment (97 wells)				
1-1	Aggregate (Pump & Motor)	49	SS-01	1178000
1-2	Frequency Inverter	8	SS-02	75000
1-3	Measuring equioment	8	SS-03	8000
1-4	Valves	100	SS-04	50000
1-5	Flaps	100	SS-04	50000
1-6	Control Cubicle	50	SS-05	578000
1-7	Terminal Equipment hw + sw	50	SS-06	240000
1-8	Telecommunication equipment	97	SS-07	73000
2. Pump Station Equipment (26 PS)				
2-1	Aggregate (Pump & Motor)	28	SS-01	2539000
2-2	Frequency Inverter	53	SS-02	1054720
2-3	Transformer	14	SS-08	230000
2-4	Control Cubicle	44	SS-05	264000
2-5	Flaps	65	SS-04	56100
2-6	Measuring equioment	75	SS-03	37500
2-7	Terminal Equipment hw + sw	23	SS-06	598000
2-8	Telecommunication equipment	24	SS-07	40350
2-9	Local SCADA	14	SS-10	68600
3. Measuring Point Equipment (28 points)				
3-1	Chlorine measurement	28	SS-11	70000
3-2	Control Cubicle	28	SS-05	14000
3-3	Terminal Equipment hw + sw	28	SS-06	140000
3-4	Telecommunication equipment	28	SS-07	28000
4. Reservoir Equipment				
4-1	Chlorine measurement	20	SS-11	50000
4-2	Terminal Equipment hw + sw	20	SS-06	100000
4-3	Telecommunication equipment	20	SS-07	30000
5. Telecommunication Network				
5-1	IP Data network			
5-1-1	Optical cable link 31.1km	1	SS-09	500000
5-1-2	Active components			
5-1-2-1	SHDSL Layer 3 router	30	SS-09	9600
5-1-2-2	Layer 3 switch	4	SS-09	29000
5-1-2-3	Layer 2 switch	12	SS-09	10680
5-2	Wireless data transmission network	8	SS-09	28000
6. Local Control Center Bezanija				
6-1	Domain Controller server (sw + hw)	1	SS-10	3500
6-2	SQL Server (sw + hw)	1	SS-10	6200
7. Local Control Center Banovo Brdo				
7-1	SQL Server (sw + hw)	1	SS-10	6200
7-2	Telecommunication Network Server (sw + hw)	1	SS-10	11500
7-3	Domain Controller server (sw + hw)	1	SS-10	3500
8. Main Control Center Deligradska Street				
8-1	Servers for real time BWS control			
8-1-1	SQL Server (sw + hw)	3	SS-10	74000
8-1-2	Telecommunication Network Server (sw + hw)	1	SS-10	6500
8-1-3	Domain Controller server (sw + hw)	2	SS-10	16500
8-1-4	Master SCADA server	1	SS-10	9300
8-2	Workstation			
8-2-1	Workstation (sw + hw)	3	SS-10	7600
8-3	Voice over IP equipment			
8-3-1	VOIP gateway	1	SS-10	2000
8-3-2	VOIP gatekeeper	1	SS-10	4000
9. Laboratory measuring equipment and instrument				
9-1	Chemical laboratory			
9-1-1	Atomic Absorption Spectrometer(AAS)	1	SS-12	95000
9-1-2	Total Organic Carbon Analyzer(TOC)	1	SS-12	28000
9-1-3	UV-VIS Spectrometer	1	SS-12	19000
9-1-4	HighPerformance Liquid Chromatography(HPLC)	1	SS-12	48000
9-1-5	Ion Chromatography - IC	1	SS-12	48000
9-1-6	Analytical balance, 0.001g	1	SS-12	9000
9-1-7	Glassware Washer	1	SS-12	9000
9-2	Microbiological Laboratory			
9-2-1	Microscope	1	SS-12	10000
9-2-2	Autoclave	1	SS-12	25000
9-2-3	Glassware Washer with drying system	1	SS-12	9000
9-3	Chemical laboratory(waste water)			
9-3-1	Atomic Absorption Spectrometer(AAS)	1	SS-12	80000
9-3-2	Gas Chromatograph, PPC, FID and ECD	1	SS-12	38000
9-3-3	Total Organic Carbon Analyzer(TOC)	1	SS-12	28000
			Total	**8,746,350**

SS-01 / SPECIFICATION OF Pumps & Motor

Item No.	Name of Station	Q'ty	Flow capacity (l/sec)	Head (m)	Motor Output(kW)	rpm	Price (eur)
<< Well Equipment >>							
1-1-01	RW-6m	1	100	75	132	1500	34000
1-1-02	RW-2m	1	100	75	132	1500	34000
1-1-03	RW-8m	1	70	75	90	1500	30000
1-1-04	RW-1m	1	100	75	132	1500	34000
1-1-05	RW-19/1	1	100	75	132	1500	34000
1-1-06	RW-20/1	1	100	75	132	1500	34000
1-1-07	RW-20	1	35	75	45	3000	4000
1-1-08	RW-15/1	1	70	75	90	1500	30000
1-1-09	RW-14/1	1	35	75	45	3000	4000
1-1-10	RW-13/1	1	35	75	45	3000	4000
1-1-11	RW-11/1	1	70	75	90	1500	30000
1-1-12	RW-12/1	1	35	75	45	3000	4000
1-1-13	RW12/2	1	70	75	90	1500	30000
1-1-14	RW-3	1	35	75	45	3000	4000
1-1-15	RW-9	1	35	75	45	3000	4000
1-1-16	RW-7	1	35	75	45	3000	4000
1-1-17	RW22/1	1	130	75	160	3000	16000
1-1-18	RW-2	1	100	75	132	1500	34000
1-1-19	RW-4/1	1	130	75	160	3000	16000
1-1-20	RW-40	1	70	75	90	1500	30000
1-1-21	RW-42	1	100	75	132	1500	34000
1-1-22	RW-43	1	70	75	90	1500	30000
1-1-23	RW-45	1	100	75	132	1500	34000
1-1-24	RW-46	1	100	75	132	1500	34000
1-1-25	RW-49	1	130	75	160	3000	16000
1-1-26	RW-63	1	100	75	132	1500	34000
1-1-27	RW-62	1	100	75	132	1500	34000
1-1-28	RW-72	1	70	75	90	1500	30000
1-1-29	RW-75	1	100	75	132	1500	34000
1-1-30	RW-79	1	70	75	90	1500	30000
1-1-31	RW-81	1	70	75	90	1500	30000
1-1-32	RW-87	1	100	75	132	1500	34000
1-1-33	RW-88	1	100	75	132	1500	34000
1-1-34	RW-90	1	130	75	160	3000	16000
1-1-35	RW-98	1	35	75	45	3000	4000
1-1-36	RW-65	1	70	75	90	1500	30000
1-1-37	RW-66	1	70	75	90	1500	30000
1-1-38	RW-41	1	70	75	90	1500	30000
1-1-39	RW-35	1	100	75	132	1500	34000
1-1-40	RW-29	1	35	75	45	3000	4000
1-1-41	RW-23/1	1	70	75	90	1500	30000
1-1-42	RW-14	1	70	75	90	1500	30000
1-1-43	RW-12/3	1	70	75	90	1500	30000
1-1-44	RE-5m	1	35	75	45	3000	4000
1-1-45	RW-8A	1	130	75	160	3000	16000
1-1-46	RW-10	1	100	75	132	1500	34000
1-1-47	RW-11	1	70	75	90	1500	30000
1-1-48	RW-16/1	1	70	75	90	1500	30000
1-1-49	RW-17	1	35	75	45	3000	4000
<< Pump Station >>							
2-1-01	PS-1a	1	167	160	400	1500	98000
2-1-02	PS-1a	1	167	160	400	1500	98000
2-1-03	PS-1a	1	167	160	400	1500	98000
2-1-04	PS-1b	1	400	90	550	1500	103000
2-1-05	PS-1b	1	400	90	550	1500	103000
2-1-06	PS-1b	1	400	90	550	1500	103000

SS-01 / SPECIFICATION OF Pumps & Motor

Item No.	Name of Station	Q'ty	Flow capacity (l/sec)	Head (m)	Motor Output(kW)	rpm	Price (eur)
2-1-07	PS-1b	1	400	90	550	1500	103000
2-1-08	PS-4	1	300	70	400	1500	102000
2-1-09	PS-18	1	400	65	400	1500	150000
2-1-10	PS-18	1	400	65	400	1500	150000
2-1-11	PS-18	1	400	65	400	1500	150000
2-1-12	PS-18	1	400	65	400	1500	150000
2-1-13	PS-19	1	200	65	200	1500	46000
2-1-14	PS-19	1	200	65	200	1500	46000
2-1-15	PS-19	1	200	65	200	1500	46000
2-1-16	PS-23	1	500	70	600	1500	105000
2-1-17	PS-23	1	500	70	600	1500	105000
2-1-18	PS-23	1	500	70	600	1500	105000
2-1-19	PS-23	1	500	70	600	1500	105000
2-1-20	PS-23	1	500	70	600	1500	105000
2-1-21	PS-17	1	120	80	160	1500	40000
2-1-22	PS-17	1	120	80	160	1500	40000
2-1-23	PS-17	1	120	80	160	1500	40000
2-1-24	PS-21	1	200	65	200	1500	46000
2-1-25	PS-21	1	200	65	200	1500	46000
2-1-26	PS-21	1	200	65	200	1500	46000
2-1-27	PS-20	1	240	150	600	1500	105000
2-1-28	PS-20	1	240	150	600	1500	105000

SS−02 / Specification of inverters and soft starters

Item No.	Name of Station	Q'ty	Voltage(V)	Motor Output(kW)	Price (eur)
<< Well Equipment >>					
1−2−01	RW− 3	1	400	45	5000
1−2−02	RW −9	1	400	45	5000
1−2−03	RW−7	1	400	45	5000
1−2−04	RW 46	1	400	132	11000
1−2−05	RW−87	1	400	132	11000
1−2−06	RW−88	1	400	132	11000
1−2−07	RW−35	1	400	132	11000
1−2−08	RW−49	1	400	160	16000
<< Pump Station >>					
2−2−01	PS−1a/FR	1	400	400	79000
2−2−02	PS−1a/ss	1	400	400	8000
2−2−03	PS−1a/ss	1	400	400	8000
2−2−04	PS−1b/FR	1	400	550	103500
2−2−05	PS−1b/SS	1	400	550	12400
2−2−06	PS−1b/SS	1	400	550	12400
2−2−07	PS−1b/SS	1	400	550	12400
2−2−08	PS−4/FR	1	400	400	79000
2−2−09	PS−15/FR	1	400	300	27600
2−2−10	PS−15/SS	1	400	300	7800
2−2−11	PS−15/SS	1	400	300	7800
2−2−12	PS−16/FR	1	400	160	14000
2−2−13	PS−16/SS	1	400	160	5200
2−2−14	PS−16/SS	1	400	160	5200
2−2−15	PS−18/FR	1	400	400	79000
2−2−16	PS−18/SS	1	400	400	8000
2−2−17	PS−18/SS	1	400	400	8000
2−2−18	PS−18/SS	1	400	400	8000
2−2−19	PS−23/FR	1	400	600	103500
2−2−20	PS−23/FR	1	400	600	103500
2−2−21	PS−23/SS	1	400	600	12400
2−2−22	PS−23/SS	1	400	600	12400
2−2−23	PS−23/SS	1	400	600	12400
2−2−24	PS−17/FR	1	400	160	1400
2−2−25	PS−17/SS	1	400	160	5200
2−2−26	PS−17/SS	1	400	160	5200
2−2−27	PS−17A/FR	1	400	250	27600
2−2−28	PS−17A/SS	1	400	250	7800
2−2−29	PS−17A/SS	1	400	250	7800
2−2−30	PS−21/FR	1	400	200	16100
2−2−31	PS−21−SS	1	400	200	5900
2−2−32	PS−21−SS	1	400	200	5900
2−2−33	PS−22/FR	1	400	90	6900
2−2−34	PS−22/SS	1	400	90	2760
2−2−35	PS−24/FR	1	400	110	9200
2−2−36	PS−24/SS	1	400	110	3400
2−2−37	PS−24/SS	1	400	110	3400
2−2−38	PS−20/FR	1	400	600	103500
2−2−39	PS−20/SS	1	400	600	12400
2−2−40	PS−26/FR	1	400	55	5000
2−2−41	PS−26/SS		400	55	2500
2−2−42	PS−26/SS		400	55	2500
2−2−43	PS−3/FR	1	400	315	27600
2−2−44	PS−3/SS	1	400	315	7800
2−2−45	PS−3/SS	1	400	315	7800
2−2−46	PS−6FR	1	400	90	6900
2−2−47	PS−6/SS	1	400	90	2760

SS-02 / Specification of inverters and soft starters

Item No.	Name of Station	Q'ty	Voltage(V)	Motor Output(kW)	Price (eur)
2-2-48	PS-Lesce/FR	1	400	55	5000
2-2-49	PS-Lesce/SS	1	400	55	2500
2-2-50	PS-Lesce/SS	1	400	55	2500
2-2-51	PS-19/FR	1	400	200	16100
2-2-52	PS-19/SS	1	400	200	5900
2-2-53	PS-19/SS	1	400	200	5900

SS-03 / SPECIFICATION OF MEASUREMENT EQUIPMENT (Water Level)

Item No.	Name of Station	Q'ty	Type Pieso	Measuring Span	Depth of well (m)	price(eur)
<< Well Equipment >>						
1-3-01	RW 3	2	Pieso	0-16	0-40	1000
1-3-02	RW 9	2	Pieso	0-16	0-40	1000
1-3-03	RW 7	2	Pieso	0-16	0-40	1000
1-3-04	RW 46	2	Pieso	0-16	0-40	1000
1-3-05	RW 87	2	Pieso	0-16	0-40	1000
1-3-06	RW 88	2	Pieso	0-16	0-40	1000
1-3-07	RW 35	2	Pieso	0-16	0-40	1000
1-3-08	RW 49	2	Pieso	0-16	0-40	1000
<< Pump Station >>						
2-6-01	PS 1A	1	Pieso	0-16		500
2-6-02	PS 1A	1	Pieso	0-16		500
2-6-03	PS 1A	1	Pieso	0-16		500
2-6-04	PS 1B	1	Pieso	0-16		500
2-6-05	PS 1B	1	Pieso	0-16		500
2-6-06	PS 1B	1	Pieso	0-16		500
2-6-07	PS 1B	1	Pieso	0-16		500
2-6-08	PS 4	1	Pieso	0-16		500
2-6-09	PS 4	1	Pieso	0-16		500
2-6-10	PS 4	1	Pieso	0-16		500
2-6-11	PS 15	1	Pieso	0-16		500
2-6-12	PS 15	1	Pieso	0-16		500
2-6-13	PS 15	1	Pieso	0-16		500
2-6-14	PS 15	1	Pieso	0-25		500
2-6-15	PS 15	1	Pieso	0-25		500
2-6-16	PS 15	1	Pieso	0-25		500
2-6-17	PS 15	1	Pieso	0-25		500
2-6-18	PS 16	1	Pieso	0-16		500
2-6-19	PS 16	1	Pieso	0-16		500
2-6-20	PS 16	1	Pieso	0-16		500
2-6-21	PS 16	1	Pieso	0-25		500
2-6-22	PS 16	1	Pieso	0-25		500
2-6-23	PS 16	1	Pieso	0-25		500
2-6-24	PS 16	1	Pieso	0-25		500
2-6-25	PS 18	1	Pieso	0-16		500
2-6-26	PS 18	1	Pieso	0-16		500
2-6-27	PS 18	1	Pieso	0-16		500
2-6-28	PS 18	1	Pieso	0-16		500
2-6-29	PS 18	1	Pieso	0-16		500
2-6-30	PS 19	1	Pieso	0-16		500
2-6-31	PS 19	1	Pieso	0-16		500
2-6-32	PS 23	1	Pieso	0-16		500
2-6-33	PS 23	1	Pieso	0-16		500
2-6-34	PS 23	1	Pieso	0-16		500
2-6-35	PS 23	1	Pieso	0-16		500
2-6-36	PS 23	1	Pieso	0-16		500
2-6-37	PS 25	1	Pieso	0-16		500
2-6-38	PS 25	1	Pieso	0-16		500
2-6-39	PS 25	1	Pieso	0-16		500
2-6-40	PS 25	1	Pieso	0-25		500
2-6-41	PS 25	1	Pieso	0-25		500
2-6-42	PS 25	1	Pieso	0-25		500
2-6-43	PS 28	1	Pieso	0-16		500
2-6-44	PS 28	1	Pieso	0-16		500
2-6-45	PS 28	1	Pieso	0-16		500
2-6-46	PS 28	1	Pieso	0-16		500
2-6-47	PS 28	1	Pieso	0-25		500

SS-03 / SPECIFICATION OF MEASUREMENT EQUIPMENT (Water Level)

Item No.	Name of Station	Q'ty	Type Pieso	Measuring Span	Depth of well (m)	price(eur)
2-6-48	PS 28	1	Pieso	0-25		500
2-6-49	PS 5	1	Pieso	0-25		500
2-6-50	PS 5	1	Pieso	0-25		500
2-6-51	PS 17	1	Pieso	0-16		500
2-6-52	PS 17	1	Pieso	0-16		500
2-6-53	PS 17	1	Pieso	0-16		500
2-6-54	PS 17	1	Pieso	0-16		500
2-6-55	PS 17	1	Pieso	0-16		500
2-6-56	PS 17	1	Pieso	0-16		500
2-6-57	PS 21	1	Pieso	0-16		500
2-6-58	PS 21	1	Pieso	0-16		500
2-6-59	PS 21	1	Pieso	0-16		500
2-6-60	PS 20	1	Pieso	0-25		500
2-6-61	PS 20	1	Pieso	0-25		500
2-6-62	PS 20	1	Pieso	0-25		500
2-6-63	PS 26	1	Pieso	0-25		500
2-6-64	PS 26	1	Pieso	0-25		500
2-6-65	PS 26	1	Pieso	0-25		500
2-6-66	PS 33	1	Pieso	0-40		500
2-6-67	PS 33	1	Pieso	0-40		500
2-6-68	PS 3	1	Pieso	0-16		500
2-6-69	PS 3	1	Pieso	0-16		500
2-6-70	PS 3	1	Pieso	0-16		500
2-6-71	PS 6	1	Pieso	0-16		500
2-6-72	PS 6	1	Pieso	0-16		500
2-6-73	PS Lesce	1	Pieso	0-16		500
2-6-74	PS Lesce	1	Pieso	0-16		500
2-6-75	PS Lesce	1	Pieso	0-16		500

SS-04 / SPECIFICATION OF Valves & Flaps

Item No.	Name of Station	Flaps			Item No.	Valves		
		Q'ty	Diameter (mm)	price (eu)		Q'ty	Diameter	price (eu)
<< Well Equipment >>					<< Well Equipment >>			
1-4-01	1	1	200	500	1-5-01	1	200	500
1-4-02	1m	1	200	500	1-5-02	1	200	500
1-4-03	2	1	200	500	1-5-03	1	200	500
1-4-04	2m	1	200	500	1-5-04	1	200	500
1-4-05	3	1	200	500	1-5-05	1	200	500
1-4-06	3m	1	200	500	1-5-06	1	200	500
1-4-07	3A	1	200	500	1-5-07	1	200	500
1-4-08	4/I	1	200	500	1-5-08	1	200	500
1-4-09	4/III	1	200	500	1-5-09	1	200	500
1-4-10	4m	1	200	500	1-5-10	1	200	500
1-4-11	5	1	200	500	1-5-11	1	200	500
1-4-12	5m	1	200	500	1-5-12	1	200	500
1-4-13	6	1	200	500	1-5-13	1	200	500
1-4-14	6A	1	200	500	1-5-14	1	200	500
1-4-15	6M	1	200	500	1-5-15	1	200	500
1-4-16	7	1	200	500	1-5-16	1	200	500
1-4-17	7M	1	200	500	1-5-17	1	200	500
1-4-18	8A	1	200	500	1-5-18	1	200	500
1-4-19	8M	1	200	500	1-5-19	1	200	500
1-4-20	9	1	200	500	1-5-20	1	200	500
1-4-21	10	1	200	500	1-5-21	1	200	500
1-4-22	10M	1	200	500	1-5-22	1	200	500
1-4-23	11	1	200	500	1-5-23	1	200	500
1-4-24	11/I	1	200	500	1-5-24	1	200	500
1-4-25	12	1	200	500	1-5-25	1	200	500
1-4-26	12/1	1	200	500	1-5-26	1	200	500
1-4-27	12/2	1	200	500	1-5-27	1	200	500
1-4-28	12/3	1	200	500	1-5-28	1	200	500
1-4-29	13/1	1	200	500	1-5-29	1	200	500
1-4-30	14	1	200	500	1-5-30	1	200	500
1-4-31	14/1	1	200	500	1-5-31	1	200	500
1-4-32	15	1	200	500	1-5-32	1	200	500
1-4-33	15/1	1	200	500	1-5-33	1	200	500
1-4-34	16	1	200	500	1-5-34	1	200	500
1-4-35	16/1	1	200	500	1-5-35	1	200	500
1-4-36	17	1	200	500	1-5-36	1	200	500
1-4-37	18	1	200	500	1-5-37	1	200	500
1-4-38	19	1	200	500	1-5-38	1	200	500
1-4-39	19/1	1	200	500	1-5-39	1	200	500
1-4-40	20	1	200	500	1-5-40	1	200	500
1-4-41	20/1	1	200	500	1-5-41	1	200	500
1-4-42	21	1	200	500	1-5-42	1	200	500
1-4-43	22/I	1	200	500	1-5-43	1	200	500
1-4-44	22/II	1	200	500	1-5-44	1	200	500
1-4-45	23/I	1	200	500	1-5-45	1	200	500
1-4-46	23/II	1	200	500	1-5-46	1	200	500
1-4-47	24	1	200	500	1-5-47	1	200	500
1-4-48	25	1	200	500	1-5-48	1	200	500
1-4-49	26	1	200	500	1-5-49	1	200	500
1-4-50	27	1	200	500	1-5-50	1	200	500
1-4-51	28	1	200	500	1-5-51	1	200	500
1-4-52	29	1	200	500	1-5-52	1	200	500
1-4-53	30	1	200	500	1-5-53	1	200	500
1-4-54	35	1	200	500	1-5-54	1	200	500
1-4-55	36	1	200	500	1-5-55	1	200	500

SS-04 / SPECIFICATION OF Valves & Flaps

Item No.	Name of Station	Flaps			Item No.	Valves		
		Q'ty	Diameter (mm)	price (eu)		Q'ty	Diameter	price (eu)
1-4-56	37	1	200	500	1-5-56	1	200	500
1-4-57	38	1	200	500	1-5-57	1	200	500
1-4-58	40	1	200	500	1-5-58	1	200	500
1-4-59	41	1	200	500	1-5-59	1	200	500
1-4-60	42	1	200	500	1-5-60	1	200	500
1-4-61	43	1	200	500	1-5-61	1	200	500
1-4-62	44	1	200	500	1-5-62	1	200	500
1-4-63	45	1	200	500	1-5-63	1	200	500
1-4-64	46	1	200	500	1-5-64	1	200	500
1-4-65	47	1	200	500	1-5-65	1	200	500
1-4-66	48	1	200	500	1-5-66	1	200	500
1-4-67	49	1	200	500	1-5-67	1	200	500
1-4-68	50	1	200	500	1-5-68	1	200	500
1-4-69	51	1	200	500	1-5-69	1	200	500
1-4-70	52	1	200	500	1-5-70	1	200	500
1-4-71	53	1	200	500	1-5-71	1	200	500
1-4-72	59	1	200	500	1-5-72	1	200	500
1-4-73	60	1	200	500	1-5-73	1	200	500
1-4-74	61	1	200	500	1-5-74	1	200	500
1-4-75	62	1	200	500	1-5-75	1	200	500
1-4-76	63	1	200	500	1-5-76	1	200	500
1-4-77	64	1	200	500	1-5-77	1	200	500
1-4-78	65	1	200	500	1-5-78	1	200	500
1-4-79	66	1	200	500	1-5-79	1	200	500
1-4-80	69	1	200	500	1-5-80	1	200	500
1-4-81	72	1	200	500	1-5-81	1	200	500
1-4-82	73	1	200	500	1-5-82	1	200	500
1-4-83	75	1	200	500	1-5-83	1	200	500
1-4-84	78	1	200	500	1-5-84	1	200	500
1-4-85	79	1	200	500	1-5-85	1	200	500
1-4-86	80	1	200	500	1-5-86	1	200	500
1-4-87	81	1	200	500	1-5-87	1	200	500
1-4-88	83	1	200	500	1-5-88	1	200	500
1-4-89	84	1	200	500	1-5-89	1	200	500
1-4-90	85	1	200	500	1-5-90	1	200	500
1-4-91	86	1	200	500	1-5-91	1	200	500
1-4-92	87	1	200	500	1-5-92	1	200	500
1-4-93	88	1	200	500	1-5-93	1	200	500
1-4-94	89	1	200	500	1-5-94	1	200	500
1-4-95	90	1	200	500	1-5-95	1	200	500
1-4-96	92	1	200	500	1-5-96	1	200	500
1-4-97	93	1	200	500	1-5-97	1	200	500
1-4-98	94	1	200	500	1-5-98	1	200	500
1-4-99	95	1	200	500	1-5-99	1	200	500
1-4-100	98	1	200	500	1-5-100	1	200	500
<< Pump Station >>								
2-5-01	PS 1A	1	250	500				
2-5-02	PS 1A	1	250	500				
2-5-03	PS 1A	1	250	500				
2-5-04	PS 1B	1	450	1500				
2-5-05	PS 1B	1	250	500				
2-5-06	PS 1B	1	450	1500				
2-5-07	PS 1B	1	250	500				
2-5-08	PS 4	1	250	500				
2-5-09	PS 4	1	200	500				
2-5-10	PS 4	1	250	500				

SS-04 / SPECIFICATION OF Valves & Flaps

Item No.	Name of Station	Flaps			Item No.	Valves		
		Q'ty	Diameter (mm)	price (eu)		Q'ty	Diameter	price (eu)
2-5-11	PS 15	1	200	500				
2-5-12	PS 15	1	200	500				
2-5-13	PS 15	1	200	500				
2-5-14	PS 16	1	200	500				
2-5-15	PS 16	1	200	500				
2-5-16	PS 16	1	250	500				
2-5-17	PS 18	1	400	1500				
2-5-18	PS 18	1	400	1500				
2-5-19	PS 18	1	350	1000				
2-5-20	PS 18	1	400	1500				
2-5-21	PS 19	1	300	1000				
2-5-22	PS 19	1	300	1000				
2-5-23	PS 19	1	300	1000				
2-5-24	PS 25	1	250	500				
2-5-25	PS 25	1	250	500				
2-5-26	PS 25	1	250	500				
2-5-27	PS 25A	1	200	500				
2-5-28	PS 25A	1	200	500				
2-5-29	PS 25A	1	200	500				
2-5-30	PS 28	1	500	2000				
2-5-31	PS 28	1	500	2000				
2-5-32	PS 28	1	500	2000				
2-5-33	PS 28	1	400	1500				
2-5-34	PS 28	1	400	1500				
2-5-35	PS 28	1	400	1500				
2-5-36	PS 17	1	200	500				
2-5-37	PS 17	1	250	500				
2-5-38	PS 17	1	250	500				
2-5-39	PS 17A	1	300	1000				
2-5-40	PS 17A	1	300	1000				
2-5-41	PS 17A	1	300	1000				
2-5-42	PS 21	1	300	1000				
2-5-43	PS 21	1	150	300				
2-5-44	PS 21	1	150	300				
2-5-45	PS 22	1	300	1000				
2-5-46	PS 22	1	300	1000				
2-5-47	PS 24	1	350	1000				
2-5-48	PS 24	1	350	1000				
2-5-49	PS 24	1	350	1000				
2-5-50	PS 20	1	300	1000				
2-5-51	PS 20	1	300	1000				
2-5-52	PS 20	1	300	1000				
2-5-53	PS 26	1	100	300				
2-5-54	PS 26	1	100	300				
2-5-55	PS 26	1	100	300				
2-5-56	PS 33	1	150	300				
2-5-57	PS 33	1	150	300				
2-5-58	PS 3	1	500	2000				
2-5-59	PS 3	1	500	2000				
2-5-60	PS 3	1	500	2000				
2-5-61	PS 6	1	200	500				
2-5-62	PS 6	1	200	500				
2-5-63	PS Lesce	1	200	500				
2-5-64	PS Lesce	1	200	500				
2-5-65	PS Lesce	1	200	500				

SS−05 / SPECIFICATION OF CONTROL CUBICLE

Item No.	Name of Station	Q'ty	Voltage(V)	Installation Indoor / Outdoor	Contro Scheme	Major Component	Price (euro)
<< Well Equipment >>							
1−6−01	98	1	400	indor			6000
1−6−02	95	1	400	indor			6000
1−6−03	94	1	400	indor			6000
1−6−04	93	1	400	indor			6000
1−6−05	92	1	400	indor			6000
1−6−06	90	1	400	indor			6000
1−6−07	89	1	400	indor			6000
1−6−08	88	1	400	indor			6000
1−6−09	87	1	400	indor			6000
1−6−10	86	1	400	indor			6000
1−6−11	85	1	400	indor			6000
1−6−12	84	1	400	indor			6000
1−6−13	83	1	400	indor			6000
1−6−14	81	1	400	indor			6000
1−6−15	80	1	400	indor			6000
1−6−16	79	1	400	indor			6000
1−6−17	78	1	400	indor			6000
1−6−18	75	1	400	indor			6000
1−6−19	73	1	400	indor			6000
1−6−20	72	1	400	indor			6000
1−6−21	69	1	400	indor			6000
1−6−22	62	1	400	indor			6000
1−6−23	61	1	400	indor			6000
1−6−24	60	1	400	indor			6000
1−6−25	59	1	400	indor			6000
1−6−26	66	1	400	indor			6000
1−6−27	65	1	400	indor			6000
1−6−28	64	1	400	indor			6000
1−6−29	63	1	400	indor			6000
1−6−30	51	1	400	indor			6000
1−6−31	50	1	400	indor			6000
1−6−32	49	1	400	indor			6000
1−6−33	48	1	400	indor			6000
1−6−34	47	1	400	indor			6000
1−6−35	46	1	400	indor			6000
1−6−36	45	1	400	indor			6000

SS-05 / SPECIFICATION OF CONTROL CUBICLE

Item No.	Name of Station	Q'ty	Voltage(V)	Installation Indoor / Outdoor	Contro Scheme	Major Component	Price (euro)
1-6-37	44	1	400	indor			6000
1-6-38	43	1	400	indor			6000
1-6-39	42	1	400	indor			6000
1-6-40	41	1	400	indor			6000
1-6-41	40	1	400	indor			6000
1-6-42	38	1	400	indor			6000
1-6-43	37	1	400	indor			6000
1-6-44	36	1	400	indor			6000
1-6-45	35	1	400	indor			6000
1-6-46	22/I	1	400	indor			6000
1-6-47	22/II	1	400	indor			6000
1-6-48	23/I	1	400	indor			6000
1-6-49	23/II	1	400	indor			6000
1-6-50	21	1	400	indor			6000
<< Pump Station >>							
2-4-01	PS 1A	1	400	indor			6000
2-4-02	PS 1A	1	400	indor			6000
2-4-03	PS 1A	1	400	indor			6000
2-4-04	PS 1B	1	400	indor			6000
2-4-05	PS 1B	1	400	indor			6000
2-4-06	PS 1B	1	400	indor			6000
2-4-07	PS 1B	1	400	indor			6000
2-4-08	PS 1A+1B	1	400	indor			6000
2-4-09	PS 18A	1	400	indor			6000
2-4-10	PS 18A	1	400	indor			6000
2-4-11	PS 18A	1	400	indor			6000
2-4-12	PS 18A	1	400	indor			6000
2-4-13	PS 19	1	400	indor			6000
2-4-14	PS 19	1	400	indor			6000
2-4-15	PS 19	1	400	indor			6000
2-4-16	PS 23	1	400	indor			6000
2-4-17	PS 23	1	400	indor			6000
2-4-18	PS 23	1	400	indor			6000
2-4-19	PS 23	1	400	indor			6000
2-4-20	PS 23	1	400	indor			6000
2-4-21	PS 17	1	400	indor			6000
2-4-22	PS 17	1	400	indor			6000

SS-05 / SPECIFICATION OF CONTROL CUBICLE

Item No.	Name of Station	Q'ty	Voltage(V)	Installation Indoor / Outdoor	Contro Scheme	Major Component	Price (euro)
2-4-23	PS 17	1	400	indor			6000
2-4-24	PS 17	1	400	indor			6000
2-4-25	PS 17	1	400	indor			6000
2-4-26	PS 17	1	400	indor			6000
2-4-27	PS 21	1	400	indor			6000
2-4-28	PS 21	1	400	indor			6000
2-4-29	PS 21	1	400	indor			6000
2-4-30	PS 22	1	400	indor			6000
2-4-31	PS 22	1	400	indor			6000
2-4-32	PS 24	1	400	indor			6000
2-4-33	PS 24	1	400	indor			6000
2-4-34	PS 24	1	400	indor			6000
2-4-35	PS 20	1	400	indor			6000
2-4-36	PS 20	1	400	indor			6000
2-4-37	PS 3	1	400	indor			6000
2-4-38	PS 3	1	400	indor			6000
2-4-39	PS 3	1	400	indor			6000
2-4-40	PS 6	1	400	indor			6000
2-4-41	PS 6	1	400	indor			6000
2-4-42	PS Lesce	1	400	indor			6000
2-4-43	PS Lesce	1	400	indor			6000
2-4-44	PS Lesce	1	400	indor			6000
<< Measuring Point >>							
3-2-01		1	400	outdor			500
3-2-02		1	400	outdor			500
3-2-03		1	400	outdor			500
3-2-04		1	400	outdor			500
3-2-05		1	400	outdor			500
3-2-06		1	400	outdor			500
3-2-07		1	400	outdor			500
3-2-08		1	400	outdor			500
3-2-09		1	400	outdor			500
3-2-10		1	400	outdor			500
3-2-11		1	400	outdor			500
3-2-12		1	400	outdor			500
3-2-13		1	400	outdor			500
3-2-14		1	400	outdor			500

SS-05 / SPECIFICATION OF CONTROL CUBICLE

Item No.	Name of Station	Q'ty	Voltage(V)	Installation Indoor / Outdoor	Contro Scheme	Major Component	Price (euro)
3-2-15		1	400	outdor			500
3-2-16		1	400	outdor			500
3-2-17		1	400	outdor			500
3-2-18		1	400	outdor			500
3-2-19		1	400	outdor			500
3-2-20		1	400	outdor			500
3-2-21		1	400	outdor			500
3-2-22		1	400	outdor			500
3-2-23		1	400	outdor			500
3-2-24		1	400	outdor			500
3-2-25		1	400	outdor			500
3-2-26		1	400	outdor			500
3-2-27		1	400	outdor			500
3-2-28		1	400	outdor			500

SS-06 / SPECIFICATION OF TERMINAL EQUIPMENT (hw + sw)

Item No.	Name of Station	Q'ty	Specification	Price HW	Price SW
<< Well Equipment >>					
1-7-01	98	1	PLC with accessories, programing	4000	800
1-7-02	95	1	PLC with accessories, programing	4000	800
1-7-03	94	1	PLC with accessories, programing	4000	800
1-7-04	93	1	PLC with accessories, programing	4000	800
1-7-05	92	1	PLC with accessories, programing	4000	800
1-7-06	90	1	PLC with accessories, programing	4000	800
1-7-07	89	1	PLC with accessories, programing	4000	800
1-7-08	88	1	PLC with accessories, programing	4000	800
1-7-09	87	1	PLC with accessories, programing	4000	800
1-7-10	86	1	PLC with accessories, programing	4000	800
1-7-11	85	1	PLC with accessories, programing	4000	800
1-7-12	84	1	PLC with accessories, programing	4000	800
1-7-13	83	1	PLC with accessories, programing	4000	800
1-7-14	81	1	PLC with accessories, programing	4000	800
1-7-15	80	1	PLC with accessories, programing	4000	800
1-7-16	79	1	PLC with accessories, programing	4000	800
1-7-17	78	1	PLC with accessories, programing	4000	800
1-7-18	75	1	PLC with accessories, programing	4000	800
1-7-19	73	1	PLC with accessories, programing	4000	800
1-7-20	72	1	PLC with accessories, programing	4000	800
1-7-21	69	1	PLC with accessories, programing	4000	800
1-7-22	62	1	PLC with accessories, programing	4000	800
1-7-23	61	1	PLC with accessories, programing	4000	800
1-7-24	60	1	PLC with accessories, programing	4000	800
1-7-25	59	1	PLC with accessories, programing	4000	800
1-7-26	66	1	PLC with accessories, programing	4000	800
1-7-27	65	1	PLC with accessories, programing	4000	800
1-7-28	64	1	PLC with accessories, programing	4000	800
1-7-29	63	1	PLC with accessories, programing	4000	800
1-7-30	51	1	PLC with accessories, programing	4000	800
1-7-31	50	1	PLC with accessories, programing	4000	800
1-7-32	49	1	PLC with accessories, programing	4000	800
1-7-33	48	1	PLC with accessories, programing	4000	800
1-7-34	47	1	PLC with accessories, programing	4000	800
1-7-35	46	1	PLC with accessories, programing	4000	800
1-7-36	45	1	PLC with accessories, programing	4000	800
1-7-37	44	1	PLC with accessories, programing	4000	800
1-7-38	43	1	PLC with accessories, programing	4000	800
1-7-39	42	1	PLC with accessories, programing	4000	800
1-7-40	41	1	PLC with accessories, programing	4000	800
1-7-41	40	1	PLC with accessories, programing	4000	800
1-7-42	38	1	PLC with accessories, programing	4000	800
1-7-43	37	1	PLC with accessories, programing	4000	800
1-7-44	36	1	PLC with accessories, programing	4000	800
1-7-45	35	1	PLC with accessories, programing	4000	800
1-7-46	22/I	1	PLC with accessories, programing	4000	800
1-7-47	22/II	1	PLC with accessories, programing	4000	800
1-7-48	23/I	1	PLC with accessories, programing	4000	800
1-7-49	23/II	1	PLC with accessories, programing	4000	800

SS-06 / SPECIFICATION OF TERMINAL EQUIPMENT (hw + sw)

Item No.	Name of Station	Q'ty	Specification	Price HW	Price SW
1-7-50	21	1	PLC with accessories, programing	4000	800
<< Pump Station >>					
2-7-01	PS 1a Bele vode	1	PLC with accessories, programing	16000	10000
2-7-02	PS 1b Bele vode	1	PLC with accessories, programing	16000	10000
2-7-03	PS 4 Crveni krst	1	PLC with accessories, programing	16000	10000
2-7-04	PS 15 Topcider	1	PLC with accessories, programing	16000	10000
2-7-05	PS 15 Topcider	1	PLC with accessories, programing	16000	10000
2-7-06	PS 16 Vracar	1	PLC with accessories, programing	16000	10000
2-7-07	PS 16 Vracar	1	PLC with accessories, programing	16000	10000
2-7-08	PS 18 Tasmajdan	1	PLC with accessories, programing	16000	10000
2-7-09	PS 19 Bezanija	1	PLC with accessories, programing	16000	10000
2-7-10	PS 23 Stud. grad	1	PLC with accessories, programing	16000	10000
2-7-11	PS 25 Mokr.brdo	1	PLC with accessories, programing	16000	10000
2-7-12	PS 28 Zarkovo	1	PLC with accessories, programing	16000	10000
2-7-13	PS 5 T. Drajzera	1	PLC with accessories, programing	16000	10000
2-7-14	PS 17 Zvezdara	1	PLC with accessories, programing	16000	10000
2-7-15	PS 21 Pionir	1	PLC with accessories, programing	16000	10000
2-7-16	PS 22 Torlak	1	PLC with accessories, programing	16000	10000
2-7-17	PS 24 Kosutnjak	1	PLC with accessories, programing	16000	10000
2-7-18	PS 20 Zeleznik	1	PLC with accessories, programing	16000	10000
2-7-19	PS 26 Ripanj	1	PLC with accessories, programing	16000	10000
2-7-20	PS 33 Avala	1	PLC with accessories, programing	16000	10000
2-7-21	PS 3 Surcin	1	PLC with accessories, programing	16000	10000
2-7-22	PS 6 Dunav	1	PLC with accessories, programing	16000	10000
2-7-23	PS Lesce	1	PLC with accessories, programing	16000	10000
<< Measuring Point >>					
3-3-01	1	1	PLC with accessories, programing	4000	1000
3-3-02	2	1	PLC with accessories, programing	4000	1000
3-3-03	3	1	PLC with accessories, programing	4000	1000
3-3-04	4	1	PLC with accessories, programing	4000	1000
3-3-05	5	1	PLC with accessories, programing	4000	1000
3-3-06	6	1	PLC with accessories, programing	4000	1000
3-3-07	7	1	PLC with accessories, programing	4000	1000
3-3-08	8	1	PLC with accessories, programing	4000	1000
3-3-09	9	1	PLC with accessories, programing	4000	1000
3-3-10	10	1	PLC with accessories, programing	4000	1000
3-3-11	11	1	PLC with accessories, programing	4000	1000
3-3-12	12	1	PLC with accessories, programing	4000	1000
3-3-13	13	1	PLC with accessories, programing	4000	1000
3-3-14	14	1	PLC with accessories, programing	4000	1000
3-3-15	15	1	PLC with accessories, programing	4000	1000
3-3-16	16	1	PLC with accessories, programing	4000	1000
3-3-17	17	1	PLC with accessories, programing	4000	1000
3-3-18	18	1	PLC with accessories, programing	4000	1000
3-3-19	19	1	PLC with accessories, programing	4000	1000
3-3-20	20	1	PLC with accessories, programing	4000	1000
3-3-21	21	1	PLC with accessories, programing	4000	1000
3-3-22	22	1	PLC with accessories, programing	4000	1000
3-3-23	23	1	PLC with accessories, programing	4000	1000
3-3-24	24	1	PLC with accessories, programing	4000	1000
3-3-25	25	1	PLC with accessories, programing	4000	1000
3-3-26	26	1	PLC with accessories, programing	4000	1000
3-3-27	27	1	PLC with accessories, programing	4000	1000
3-3-28	28	1	PLC with accessories, programing	4000	1000
<< Reservoir Equipment >>					
4-2-01	Pionir	1	PLC with accessories, programing	4000	1000
4-2-02	Glavni	1	PLC with accessories, programing	4000	1000
4-2-03	Krainski	1	PLC with accessories, programing	4000	1000
4-2-04	Zeleznik	1	PLC with accessories, programing	4000	1000
4-2-05	Zarkovo	1	PLC with accessories, programing	4000	1000
4-2-06	Umka	1	PLC with accessories, programing	4000	1000
4-2-07	Zvezdara	1	PLC with accessories, programing	4000	1000
4-2-08	Mokrolusko brdo	1	PLC with accessories, programing	4000	1000
4-2-09	Dedinje	1	PLC with accessories, programing	4000	1000
4-2-10	Barajevo	1	PLC with accessories, programing	4000	1000

SS-06 / SPECIFICATION OF TERMINAL EQUIPMENT (hw + sw)

Item No.	Name of Station	Q'ty	Specification	Price HW	Price SW
4-2-11	Petlovo brdo	1	PLC with accessories, programing	4000	1000
4-2-12	Stojcino brdo	1	PLC with accessories, programing	4000	1000
4-2-13	Torlak	1	PLC with accessories, programing	4000	1000
4-2-14	Devojacki grob	1	PLC with accessories, programing	4000	1000
4-2-15	Lipovica	1	PLC with accessories, programing	4000	1000
4-2-16	Water tower Kosutnjak	1	PLC with accessories, programing	4000	1000
4-2-17	Suplja stena	1	PLC with accessories, programing	4000	1000
4-2-18	Kumodraz	1	PLC with accessories, programing	4000	1000
4-2-19	Water tower Lipovica	1	PLC with accessories, programing	4000	1000
4-2-20	Guncati	1	PLC with accessories, programing	4000	1000

SS-07 / SPECIFICATION OF TELECOMMUNICATION EQUIPMENT

Item No.	Name of Station	Q'ty	Specification	Price
<< Well Equipment >>				
1-8-01	1	1	gprs modem, protocol converter	1000
1-8-02	1m	1	gprs modem, protocol converter	1000
1-8-03	2	1	gprs modem, protocol converter	1000
1-8-04	2m	1	gprs modem, protocol converter	1000
1-8-05	3	1	gprs modem, protocol converter	1000
1-8-06	3m	1	gprs modem, protocol converter	1000
1-8-07	3A	1	gprs modem, protocol converter	1000
1-8-08	4/I	1	gprs modem, protocol converter	1000
1-8-09	4m	1	gprs modem, protocol converter	1000
1-8-10	5	1	gprs modem, protocol converter	1000
1-8-11	5m	1	gprs modem, protocol converter	1000
1-8-12	6	1	gprs modem, protocol converter	1000
1-8-13	6A	1	gprs modem, protocol converter	1000
1-8-14	6M	1	gprs modem, protocol converter	1000
1-8-15	7	1	gprs modem, protocol converter	1000
1-8-16	7M	1	gprs modem, protocol converter	1000
1-8-17	8A	1	gprs modem, protocol converter	1000
1-8-18	8M	1	gprs modem, protocol converter	1000
1-8-19	9	1	gprs modem, protocol converter	1000
1-8-20	10	1	gprs modem, protocol converter	1000
1-8-21	10M	1	gprs modem, protocol converter	1000
1-8-22	11	1	gprs modem, protocol converter	1000
1-8-23	11/I	1	gprs modem, protocol converter	1000
1-8-24	12	1	gprs modem, protocol converter	1000
1-8-25	12/1	1	gprs modem, protocol converter	1000
1-8-26	12/2	1	gprs modem, protocol converter	1000
1-8-27	12/3	1	gprs modem, protocol converter	1000
1-8-28	13/1	1	gprs modem, protocol converter	1000
1-8-29	14	1	gprs modem, protocol converter	1000
1-8-30	14/1	1	gprs modem, protocol converter	1000
1-8-31	15	1	gprs modem, protocol converter	1000
1-8-32	15/1	1	gprs modem, protocol converter	1000
1-8-33	16	1	gprs modem, protocol converter	1000
1-8-34	16/1	1	gprs modem, protocol converter	1000
1-8-35	17	1	gprs modem, protocol converter	1000
1-8-36	18	1	gprs modem, protocol converter	1000
1-8-37	19	1	gprs modem, protocol converter	1000
1-8-38	19/1	1	gprs modem, protocol converter	1000
1-8-39	20	1	gprs modem, protocol converter	1000
1-8-40	20/1	1	gprs modem, protocol converter	1000
1-8-41	21	1	gprs modem, protocol converter	500
1-8-42	22/I	1	gprs modem, protocol converter	500
1-8-43	23/I	1	gprs modem, protocol converter	500
1-8-44	24	1	gprs modem, protocol converter	1000
1-8-45	25	1	gprs modem, protocol converter	1000
1-8-46	26	1	gprs modem, protocol converter	1000
1-8-47	27	1	gprs modem, protocol converter	1000
1-8-48	28	1	gprs modem, protocol converter	1000
1-8-49	29	1	gprs modem, protocol converter	1000
1-8-50	30	1	gprs modem, protocol converter	1000
1-8-51	35	1	gprs modem, protocol converter	500
1-8-52	36	1	gprs modem, protocol converter	500
1-8-53	37	1	gprs modem, protocol converter	500
1-8-54	38	1	gprs modem, protocol converter	500
1-8-55	40	1	gprs modem, protocol converter	500
1-8-56	41	1	gprs modem, protocol converter	500
1-8-57	42	1	gprs modem, protocol converter	500

SS-07 / SPECIFICATION OF TELECOMMUNICATION EQUIPMENT

Item No.	Name of Station	Q'ty	Specification	Price
1-8-58	43	1	gprs modem, protocol converter	500
1-8-59	44	1	gprs modem, protocol converter	500
1-8-60	45	1	gprs modem, protocol converter	500
1-8-61	46	1	gprs modem, protocol converter	500
1-8-62	47	1	gprs modem, protocol converter	500
1-8-63	48	1	gprs modem, protocol converter	500
1-8-64	49	1	gprs modem, protocol converter	500
1-8-65	50	1	gprs modem, protocol converter	500
1-8-66	51	1	gprs modem, protocol converter	500
1-8-67	52	1	gprs modem, protocol converter	1000
1-8-68	53	1	gprs modem, protocol converter	1000
1-8-69	59	1	gprs modem, protocol converter	500
1-8-70	60	1	gprs modem, protocol converter	500
1-8-71	61	1	gprs modem, protocol converter	500
1-8-72	62	1	gprs modem, protocol converter	500
1-8-73	63	1	gprs modem, protocol converter	500
1-8-74	64	1	gprs modem, protocol converter	500
1-8-75	65	1	gprs modem, protocol converter	500
1-8-76	66	1	gprs modem, protocol converter	500
1-8-77	69	1	gprs modem, protocol converter	500
1-8-78	72	1	gprs modem, protocol converter	500
1-8-79	73	1	gprs modem, protocol converter	500
1-8-80	75	1	gprs modem, protocol converter	500
1-8-81	78	1	gprs modem, protocol converter	500
1-8-82	79	1	gprs modem, protocol converter	500
1-8-83	80	1	gprs modem, protocol converter	500
1-8-84	81	1	gprs modem, protocol converter	500
1-8-85	83	1	gprs modem, protocol converter	500
1-8-86	84	1	gprs modem, protocol converter	500
1-8-87	85	1	gprs modem, protocol converter	500
1-8-88	86	1	gprs modem, protocol converter	500
1-8-89	87	1	gprs modem, protocol converter	500
1-8-90	88	1	gprs modem, protocol converter	500
1-8-91	89	1	gprs modem, protocol converter	500
1-8-92	90	1	gprs modem, protocol converter	500
1-8-93	92	1	gprs modem, protocol converter	500
1-8-94	93	1	gprs modem, protocol converter	500
1-8-95	94	1	gprs modem, protocol converter	500
1-8-96	95	1	gprs modem, protocol converter	500
1-8-97	98	1	gprs modem, protocol converter	500
<< Pump Station >>				
2-8-01	PS 1a Bele vode	1	gprs,prot.conv.,box, fiber, med.	2400
2-8-02	PS 1b Bele vode	1	gprs,prot.conv., box	1300
2-8-03	PS 4 Crveni krst	1	gprs,prot.conv., box	1300
2-8-04	PS 15 Topcider	1	gprs,prot.conv., box	1300
2-8-05	PS 15 Topcider	1	gprs,prot.conv., switch, box, fiber, med.	3000
2-8-06	PS 16 Vracar	1	gprs,prot.conv., box	1300
2-8-07	PS 16 Vracar	1	gprs,prot.conv., switch, box, fiber, med.	3000
2-8-08	PS 18 Tasmajdan	1	gprs,prot.conv., box	1300
2-8-09	PS 19 Bezanija	1	gprs,prot.conv., switch, box, fiber, med.	3150
2-8-10	PS 23 Stud. grad	1	gprs,prot.conv., box	1300
2-8-11	PS 25 Mokr.brdo	1	gprs,prot.conv., switch, box	1400
2-8-12	PS 28 Zarkovo	1	gprs,prot.conv., switch, box	1400
2-8-13	PS 5 T. Drajzera	1	gprs,prot.conv., switch, box	1400
2-8-14	PS 17 Zvezdara	1	gprs,prot.conv., box	1300
2-8-15	PS 21 Pionir	1	gprs,prot.conv., box	1300
2-8-16	PS 22 Torlak	1	gprs,prot.conv., switch, box, wll subscr.	3200
2-8-17	PS 24 Kosutnjak	1	gprs,prot.conv., switch, box	1400

SS-07 / SPECIFICATION OF TELECOMMUNICATION EQUIPMENT

Item No.	Name of Station	Q'ty	Specification	Price
2-8-18	PS 20 Zeleznik	1	gprs,prot.conv., box	1300
2-8-19	PS 30 Lipovica	1	gprs,prot.conv., box	1300
2-8-20	PS 26 Ripanj	1	gprs,prot.conv., switch, box	1400
2-8-21	PS 33 Avala	1	gprs,prot.conv., switch, box	1400
2-8-22	PS 3 Surcin	1	gprs,prot.conv., switch, box	1400
2-8-23	PS 6 Dunav	1	gprs,prot.conv., switch, box	1400
2-8-24	PS Lesce	1	gprs,prot.conv., switch, box	1400
<< Measuring Point >>				
3-4-01	1	1	gprs modem, protocol converter	1000
3-4-02	2	1	gprs modem, protocol converter	1000
3-4-03	3	1	gprs modem, protocol converter	1000
3-4-04	4	1	gprs modem, protocol converter	1000
3-4-05	5	1	gprs modem, protocol converter	1000
3-4-06	6	1	gprs modem, protocol converter	1000
3-4-07	7	1	gprs modem, protocol converter	1000
3-4-08	8	1	gprs modem, protocol converter	1000
3-4-09	9	1	gprs modem, protocol converter	1000
3-4-10	10	1	gprs modem, protocol converter	1000
3-4-11	11	1	gprs modem, protocol converter	1000
3-4-12	12	1	gprs modem, protocol converter	1000
3-4-13	13	1	gprs modem, protocol converter	1000
3-4-14	14	1	gprs modem, protocol converter	1000
3-4-15	15	1	gprs modem, protocol converter	1000
3-4-16	16	1	gprs modem, protocol converter	1000
3-4-17	17	1	gprs modem, protocol converter	1000
3-4-18	18	1	gprs modem, protocol converter	1000
3-4-19	19	1	gprs modem, protocol converter	1000
3-4-20	20	1	gprs modem, protocol converter	1000
3-4-21	21	1	gprs modem, protocol converter	1000
3-4-22	22	1	gprs modem, protocol converter	1000
3-4-23	23	1	gprs modem, protocol converter	1000
3-4-24	24	1	gprs modem, protocol converter	1000
3-4-25	25	1	gprs modem, protocol converter	1000
3-4-26	26	1	gprs modem, protocol converter	1000
3-4-27	27	1	gprs modem, protocol converter	1000
3-4-28	28	1	gprs modem, protocol converter	1000
<< Reservoir >>				
4-3-01	Pionir	1	gprs protocol converter	1500
4-3-02	Glavni	1	gprs protocol converter	1500
4-3-03	Krainski	1	gprs protocol converter	1500
4-3-04	Zeleznik	1	gprs protocol converter	1500
4-3-05	Zarkovo	1	gprs protocol converter	1500
4-3-06	Umka	1	gprs protocol converter	1500
4-3-07	Zvezdara	1	gprs protocol converter	1500
4-3-08	Mokrolusko brdo	1	gprs protocol converter	1500
4-3-09	Dedinje	1	gprs protocol converter	1500
4-3-10	Barajevo	1	gprs protocol converter	1500
4-3-11	Petlovo brdo	1	gprs protocol converter	1500
4-3-12	Stojcino brdo	1	gprs protocol converter	1500
4-3-13	Torlak	1	gprs protocol converter	1500
4-3-14	Devojacki grob	1	gprs protocol converter	1500
4-3-15	Lipovica	1	gprs protocol converter	1500
4-3-16	Water tower Kosutnjak	1	gprs protocol converter	1500
4-3-17	Suplja stena	1	gprs protocol converter	1500
4-3-18	Kumodraz	1	gprs protocol converter	1500
4-3-19	Water tower Lipovica	1	gprs protocol converter	1500
4-3-20	Guncati	1	gprs protocol converter	1500

SS-08 / SPECIFICATION OF TRANSFORMER

Item No.	Name of Station	Q'ty	Voltage(V)		Capacity(kVA)	Vector Group	Type	Cooling	Installation	Prices (EUR)
			Primary	Secondary			Oil / Dry	Natural / Fan	Indoor / Outdoor	
<< Pump Station >>										
2-3-01	PS - 1A	1	10000	400	2500	DY5	Dry	natural	outdoor	50000
2-3-02	PS - 1B	1	10000	400	2500	DY5	Dry	natural	outdoor	50000
2-3-03	PS - 18	1	10000	400	500	DY5	Dry	natural	outdoor	10000
2-3-04	PS - 18	1	10000	400	500	DY5	Dry	natural	outdoor	10000
2-3-05	PS - 18	1	10000	400	500	DY5	Dry	natural	outdoor	10000
2-3-06	PS - 18	1	10000	400	500	DY5	Dry	natural	outdoor	10000
2-3-07	PS - 19	1	10000	400	250	DY5	Dry	natural	outdoor	5000
2-3-08	PS - 19	1	10000	400	250	DY5	Dry	natural	outdoor	5000
2-3-09	PS - 19	1	10000	400	250	DY5	Dry	natural	outdoor	5000
2-3-10	PS - 23	1	10000	400	800	DY5	Dry	natural	outdoor	15000
2-3-11	PS - 23	1	10000	400	800	DY5	Dry	natural	outdoor	15000
2-3-12	PS - 23	1	10000	400	800	DY5	Dry	natural	outdoor	15000
2-3-13	PS - 23	1	10000	400	800	DY5	Dry	natural	outdoor	15000
2-3-14	PS - 23	1	10000	400	800	DY5	Dry	natural	outdoor	15000

Item No.	Name of Station	Q'ty	Specification	Price (EUR)
5-1 IP data network for tehnical system data transmission				
5-1-1 Optical cable link				
5-1-1-01	Total aprox. 31.1 km	1	single mode	500000
5-1-2 Active components				
<< SHDSL Layer 3 router >>				
5-1-2-1-01	PS 30 Lipovica - PS 20	1	SHDSL Router Layer 3	320
5-1-2-1-02	PS 20 Zeleznik - PS 30	1	SHDSL Router Layer 3	320
5-1-2-1-03	PS 20 Zeleznik - PS 1 A	1	SHDSL Router Layer 3	320
5-1-2-1-04	PS 1A Bele vode- PS 20	1	SHDSL Router Layer 3	320
5-1-2-1-05	PS 1A Bele vode-B.Brdo	1	SHDSL Router Layer 3	320
5-1-2-1-06	B.Brdo-PS 1A Bele vode	1	SHDSL Router Layer 3	320
5-1-2-1-07	B.Brdo-K.Milosa	1	SHDSL Router Layer 3	320
5-1-2-1-08	K.Milosa - B.Brdo	1	SHDSL Router Layer 3	320
5-1-2-1-09	K.Milosa - PS 15 Topcider	1	SHDSL Router Layer 3	320
5-1-2-1-10	PS 15- K.Milosa	1	SHDSL Router Layer 3	320
5-1-2-1-11	K.Milosa - PS 16 Vracar	1	SHDSL Router Layer 3	320
5-1-2-1-12	PS 16- K.Milosa	1	SHDSL Router Layer 3	320
5-1-2-1-13	K.Milosa - PS 4 C Krst	1	SHDSL Router Layer 3	320
5-1-2-1-14	PS 4- K.Milosa	1	SHDSL Router Layer 3	320
5-1-2-1-15	K.Milosa - PS 17 Zvezdara	1	SHDSL Router Layer 3	320
5-1-2-1-16	PS 17- K.Milosa	1	SHDSL Router Layer 3	320
5-1-2-1-17	K.Milosa - PS 18 Tasmajdan	1	SHDSL Router Layer 3	320
5-1-2-1-18	PS 18- K.Milosa	1	SHDSL Router Layer 3	320
5-1-2-1-19	K.Milosa - PS 21 Pionir	1	SHDSL Router Layer 3	320
5-1-2-1-20	PS 21- K.Milosa	1	SHDSL Router Layer 3	320
5-1-2-1-21	K.Milosa - PS 23 S.Grad	1	SHDSL Router Layer 3	320
5-1-2-1-22	PS 23- K.Milosa	1	SHDSL Router Layer 3	320
5-1-2-1-23	PS 19 Bezanija- PS 23	1	SHDSL Router Layer 3	320
5-1-2-1-24	PS 23- PS 19	1	SHDSL Router Layer 3	320
5-1-2-1-25	K.Milosa - Deligradska	1	SHDSL Router Layer 3	320
5-1-2-1-26	Deligradska - K.Milosa	1	SHDSL Router Layer 3	320
5-1-2-1-27	K.Milosa - PS 10 Dedinje	1	SHDSL Router Layer 3	320
5-1-2-1-28	PS 10- K.Milosa	1	SHDSL Router Layer 3	320
5-1-2-1-29	B.Brdo-Makis	1	SHDSL Router Layer 3	320
5-1-2-1-30	Makis - B.Brdo	1	SHDSL Router Layer 3	320
<< Layer 3 switch >>				
5-1-2-2-01	PS 1 A Bele vode	1	Layer 3 + acc	7000
5-1-2-2-02	Banovo Brdo	1	Layer 3 + acc	7500
5-1-2-2-03	Bezanija	1	Layer 3 + acc	7000
5-1-2-2-04	K.Milosa	1	Layer 3 + acc	7500
<< Layer 2 switch >>				
5-1-2-3-01	PS 30 Lipovica	1	Layer 2	890
5-1-2-3-02	PS 20 Zeleznik	1	Layer 2	890
5-1-2-3-03	PS 1B Bele vode	1	Layer 2	890
5-1-2-3-04	PS 4 Crveni krst	1	Layer 2	890
5-1-2-3-05	PS 15 Topcider	1	Layer 2	890
5-1-2-3-06	PS 15 A Topcider	1	Layer 2	890
5-1-2-3-07	PS 16 Vracar	1	Layer 2	890
5-1-2-3-08	PS 16 A Vracar	1	Layer 2	890
5-1-2-3-09	PS 17 Zvezdara	1	Layer 2	890
5-1-2-3-10	PS 18 Tasmajdan	1	Layer 2	890
5-1-2-3-11	PS 23 Studentski grad	1	Layer 2	890
5-1-2-3-12	PS 21 Pionir	1	Layer 2	890
5-2 Wireless data transmission network				
<< Corporative wireless Ethernet 802.11 standard				
5-2-01	Bezanija	1	Site	5000

SS-09 / SPECIFICATION OF TELECOMMUNICATION NETWORK

Item No.	Name of Station	Q'ty	Specification	Price (EUR)
5-2-02	VT Kosutnjak	1	Site	5000
5-2-03	deligradska	1	Bridge	3000
5-2-04	banovo brdo	1	Bridge	3000
5-2-05	makis	1	Bridge	3000
5-2-06	bele vode	1	Bridge	3000
5-2-07	torlak	1	Bridge	3000
5-2-08	zvezdara	1	Bridge	3000

SS-10 / SPECIFICATION OF SERVER

Item No.	Name of Server	Q'ty	Specification	price HW	price SW
<< Pump Station / Local SCADA >>					
2-9-01	PS 4 Crveni krst	1	windows xp, runtime scada	1200	3700
2-9-02	PS 15 Topcider	1	windows xp, runtime scada	1200	3700
2-9-03	PS 16 Vracar	1	windows xp, runtime scada	1200	3700
2-9-04	PS 18 Tasmajdan	1	windows xp, runtime scada	1200	3700
2-9-05	PS 23 Stud. grad	1	windows xp, runtime scada	1200	3700
2-9-06	PS 25 Mokr.brdo	1	windows xp, runtime scada	1200	3700
2-9-07	PS 28 Zarkovo	1	windows xp, runtime scada	1200	3700
2-9-08	PS 27 Makis	1	windows xp, runtime scada	1200	3700
2-9-09	PS 10 Dedinje	1	windows xp, runtime scada	1200	3700
2-9-10	PS 17 Zvezdara	1	windows xp, runtime scada	1200	3700
2-9-11	PS 21 Pionir	1	windows xp, runtime scada	1200	3700
2-9-12	PS 20 Zeleznik	1	windows xp, runtime scada	1200	3700
2-9-13	PS 30 Lipovica	1	windows xp, runtime scada	1200	3700
2-9-14	PS 6 Dunav	1	windows xp, runtime scada	1200	3700
<< Local Control Center Bezanija >>					
6-1	Domain Controller Server	1	windows 2003 standard	3500	
6-2	SQL Server (sw + hw)	1	windows 2003 standard, sql server 10 cal, monitor	4000	2200
<< Local Control Center Banovo Brdo >>					
7-1	SQL Server (sw + hw)	1	windows 2003 standard, sql server 10 cal, monitor	4000	2200
7-2	Telecommunication Network Server (sw+hw)	1	windows 2003 standard, HP open view, visual studio net	3500	8000
7-3	Domain Controller Server	1	windows 2003 standard	3500	
<< Main Control Center Deligradska Street >>					
8-1	Server for real time BWS control				

SS-10 / SPECIFICATION OF SERVER

Item No.	Name of Server	Q'ty	Specification	price HW	price SW
8-1-1	SQL Server (sw + hw)	2	windows 2003 enterprise, sql server enterprise processor monitor, opc serv	24000	50000
8-1-2	Telecommunication Network Server (sw+hw)	1	windows 2003 standard, gprs mediator	3500	3000
8-1-3	Domain Controller Server	2	windows 2003 enterprise, rack box	16500	
8-1-4	Master SCADA server (hw)	1	windows 2003 standard, upgrade version, sql modul	6500	2800
8-2	Workstation				
8-2-1	Workstation (sw+hw)	3	windows xp, monitor 30", office	5500	2100
8-3	Voice over IP Equipment				
8-3-1	VOIP gateway	1		2000	
8-3-2	VOIP gatekeeper	1		4000	

SS-11 / SPECIFICATION OF Chlorine Measurement

Item No.	Name of Station (check point)	Q'ty	Specification			price (eu)
			chlorine	residual		
<< Measuring Point Equipment >>						
3-1-01	1	1				2500
3-1-02	2	1				2500
3-1-03	3	1				2500
3-1-04	4	1				2500
3-1-05	5	1				2500
3-1-06	6	1				2500
3-1-07	7	1				2500
3-1-08	8	1				2500
3-1-09	9	1				2500
3-1-10	10	1				2500
3-1-11	11	1				2500
3-1-12	12	1				2500
3-1-13	13	1				2500
3-1-14	14	1				2500
3-1-15	15	1				2500
3-1-16	16	1				2500
3-1-17	17	1				2500
3-1-18	18	1				2500
3-1-19	19	1				2500
3-1-20	20	1				2500
3-1-21	21	1				2500
3-1-22	22	1				2500
3-1-23	23	1				2500
3-1-24	24	1				2500
3-1-25	25	1				2500
3-1-26	26	1				2500
3-1-27	27	1				2500
3-1-28	28	1				2500
<< Reservoir Equipment >>						
4-1-01	Pionir	1				2500
4-1-02	Glavni	1				2500
4-1-03	Krainski	1				2500
4-1-04	Zeleznik	1				2500
4-1-05	Zarkovo	1				2500
4-1-06	Umka	1				2500
4-1-07	Zvezdara	1				2500
4-1-08	Mokrolusko brdo	1				2500
4-1-09	Dedinje	1				2500
4-1-10	Barajevo	1				2500
4-1-11	Petlovo brdo	1				2500
4-1-12	Stojcino brdo	1				2500
4-1-13	Torlak	1				2500
4-1-14	Devojacki grob	1				2500
4-1-15	Lipovica	1				2500
4-1-16	Water tower Kosutnjak	1				2500
4-1-17	Suplja stena	1				2500
4-1-18	Kumodraz	1				2500
4-1-19	Water tower Lipovica	1				2500
4-1-20	Guncati	1				2500

SS-12 / SPECIFICATION OF Laboratory Measuring Equipment

Chemical laboratory (drinking water)

	INSTRUMENT	Qty	MODEL PRODUCER	ANALYZED PARAMETERS	PRICE (EUR)
1	Atomic Absorption Spectrometer (AAS)、Autosampler (Flame, Furnace, hydride/ Hg determination, Zeeman background correction)、(Hallow Cathode Lamp: As, Cu, Ni, Zn, K, Na, Ca, Mg, Cr, Sb, Si, Mo, Al; Electrodeless Discharge Lamp: Hg, Se, Cd, Pb)	1	Shimadzu, AA-6800, or Perkin-Elmer AA 800	Metals（As, Cu, Ni, Zn, K, Na, Ca, Mg, Cr, Sb, Si, Mo, Al、Hg, Se, Cd, Pb… ）	95,000
2	Total Organic Carbon Analyzer (TOC), Combustion catalytic oxidation / NDIR PC, Autosampler	1	Shimadzu, TOC-V CPN	Total Organic Carbon（TOC）、 Purgeable Organic Carbon（POC）、 Nonpurgeable OrganicCarbon（NPOC）、 Inorganic Carbon（IC）	28,000
3	UV-VIS Spectrometer,	1	Shimadzu, UV-1601 PC	UV-ext.254nm,nitrates, chlorine, ammonia, nitirites, fluorides, sulfates, sulfides, phosphates, Mn, Fe, Cr^{6+}, Al, detergents, phenols	19,000
4	High Performance Liquid Chromatography (HPLC), Quaternary gradient, Autosampler, PC, DAD, Flou. Det.	1	Shimadzu or Agilent Technologies	Polynuclear aromatic hydrocarbons（PAH）， Carbamate pesticides, Glyphosate herbicide	48,000

5	Ion Chromatography – IC, (Kation, Anion), Ion Suppressor, PC	1	Shimadzu, Agilent Technologies, Dionex	Anion and Kations	48,000
6	Analytical balance, 0.0001g	1			9,000
7	Glassware Washer, general purpose	1	SMEG GW 4050		9,000

Microbiological laboratory

	INSTRUMENT	Qty	MODEL PRODUCER	ANALYZED PARAMETERS	PRICE (EUR)
1	Microscope, Digitally	1	Olympus, BX 51		10,000
2	Autoclave	1	Systec 5075 ELV/MLM 1601		25,000
3	Glassware Washer with Drying System	1	SMEG GW 4050		9,000

Chemical laboratory (waste water)

	INSTRUMENT	Qty	MODEL PRODUCER	ANALYZED PARAMETERS	PRICE (EUR)
1	Atomic Absorption Spectrometer (AAS)、Autosampler (Flame, Furnace, hydride/ Hg determination, Zeeman background correction)、(Lamp: Hg, Cd, As, Pb, Se, Cu, Fe, Mn, Ni, Cr, Al, Zn)	1		Metals	80,000
2	Gas Chromatograph, PPC, FID and ECD	1			38,000
3	Total Organic Carbon Analyzer (TOC)	1			28,000

添付資料-2

上水道整備計画（英訳）

BELGRADE WATERWORKS AND SEWAGE SYSTEM

PROSPECTIVE DEVELOPMENT PROGRAM
FOR THE WATER SUPPLY SYSTEM FOR BELGRADE

Belgrade,
February 2004.

Contents:

CONTENTS

INTRODUCTORY INFORMATION

In 2002 the Belgrade Waterworks System celebrated 110 years of existence of a modern waterworks. In the past eleven decades the construction of a modern Belgrade Waterworks System was closely connected with the development of our city during that period.

Belgrade dates back nearly two-and-a-half thousand years and numbers among the oldest cities in Europe. In that period it was destroyed and rebuilt around forty times. On the other hand, Belgrade is a young city: the majority of its buildings (houses, industrial and sports facilities) were built in the past fifty years. Table 1 presents the development of the City of Belgrade in the period 1940-2002 by citing the number of apartments.

Table 1: Number of Apartments

Year	1940.	1944.	1954.	1964.	1973.	1981.	1991.	2002.
No. of Apartm.	105.395	89.663	110.785	175.262	281.728	460.000	545.383	522.039

Table 2 presents the development of the waterworks system of Belgrade.

Table 2: Development of the Waterworks System in Belgrade

year	number of consumers in Belgrade	annual water production 10^6 m^3	capacity of facilities l/s	length of waterw. netw. km	territory covered by system ha
1892.	50.000	1,87	33	46	
1950.	430.000	27,00	960	466	5.000
1960.	600.000	49,57	1.200	673	
1970.	950.000	104,03	3.950	1.217	13.500
1980.	1.120.000	178,40	6.500	1.615	15.000
1990.	1.260.000	203,55	10.500	1.962	18.000
1995.	1.376.880	222,36	10.580	2.257	20.500
2000.	1.346.216	235,61	11.580	2.503	22.000
2003.	1.320.000	233,50	11.640	2.654	

These materials point to the technical problems of supplying the city with water whose present stoppage could significantly reflect on regular supply and development of the City in the coming period. The development of the waterworks system cannot take place “from time to time”, because that results in stoppage. The development of the waterworks system must be constant and a function of the City’s development.

Economic improvement and current changes in the economic system during the drafting and adoption of this long-term development strategy for the waterworks system of Belgrade represent a necessary precondition for its realization. Given this situation it is not possible to provide the financing particulars per proposed key facility, but it is possible to establish the basic sources of financing:

- Agency for Building Land and Construction (land development contribution, construction land use contribution and general interest resource use contribution)
- Budget of the City of Belgrade (through the Secretariat for Community Residential Services)
- Domestic and foreign bank credits
- Own income – from price of water (assuming that the Enterprise becomes economically viable)
- Donations.

After more than one hundred years of existence the Belgrade Waterworks System today represents a complex waterworks system with a series of significant hydro-technical facilities. The objective of this report is to prepare an assessment of the current state of the City’s water supply, as well as to establish which key facilities need to be built with the objective of successfully realizing the functional operation of the system for supplying the City with water.

Successful supplying of the City with water can be realized under the following conditions:

- if there is persistent and concerted effort on prospective development of the system

- if effort is invested in rational exploitation of the system (reduction of losses)
- if effort is invested in protecting water sources
- if key systems facilities are constructed in timely fashion.

The subject of these analyses is prospective development through timely reconstruction, but with prior analysis of development of sources and key facilities in the waterworks system. Of course, this is a proposal for establishing the orientation for supplying Belgrade with water in the coming period.

1. CURRENT CONDITIONS AND DEVELOPMENT UP TO NOW

The modern Belgrade Waterworks System was established in 1892. The period from its establishment to today is characterized by intense development and expansion of Belgrade which made the reconstruction of the waterworks system an imperative with a view to regular supplying of the City with water.

Today the Belgrade Waterworks System is a complex technical system which provides the services of supplying citizens in the central territory of the City and in a large number of suburban settlements with water that meets sanitary hygienic standards.

1.1. DEVELOPMENT OF THE WATERWORKS SYSTEM AS A FUNCTION OF CITY DEVELOPMENT

The development of the Belgrade Waterworks is closely associated with intense development of the City on a long term basis. The development of the waterworks system cannot take place from time to time, for that results in stoppages – that is to say, irregular water supply in the City. A series of years of intense construction is necessary to make up for lost time. Unfortunately such periods occurred in the development of the waterworks system.

The following can be observed in the more than ten past decades of the Belgrade Waterworks System:

- the number of residents increased by more than 25 times, while the amount of water produced increased by 110 times,
- in the last 20 years capacities increased by an amount that is equivalent to the capacity increases during the previous 80 years,
- in the period following World War II 91% of the total water sources capacities were built and 85% percent of the total length of the waterworks network.

In the past ten decades of the Belgrade Waterworks the concept of supplying the City with water changed four times in order for adequate amounts of water to be secured for the City's consumers.

The first concept was based on the groundwater sources at Makis (1892).

Because of inadequate amounts of groundwater, **the second concept** was based on the use of surface water – Sava river water which was purified at the Bele vode facility (1927).

The third period begins in 1953 – a concept based on groundwater sources – on a system of capturing facilities which draw groundwater using horizontal drains (Reni system, with Proisage also beginning to be developed). Up to now 99 wells have been built with horizontal drains (Reni and Proisage).

The fourth period is again a period of developing surface waters – connecting of Makis (1986).

To summarize, by considering the presented information on the development of the Belgrade Waterworks System the following can be observed:

Belgrade is one of four cities in the world which are located on two large water faring rivers, but is one of a few large European cities which in the past decades experienced water supply problems. In order to improve water supply in Belgrade in the past twenty years a large number of scientists and experts in the area of water supply have been engaged. A series of consultations were organized:

- Supplying Belgrade With Water – consultation related to the General Urban Plan of Belgrade entitled: Battle for Healthy Drinking Water (1972).
- Supplying Belgrade With Water – held in the Municipal Parliament (November 1983).
- Current State of Supplying Belgrade With Water – scientific speakers platform organized by the Association of Engineers and Technicians (December 1983).

- Supplying Belgrade With Water in the Near and Distant Future – with the Association of Engineers and Technicians (June 1985).
- Supplying Belgrade With Water – organized by the Association of Engineers and Technicians (June 1987).
- One Hundred Years of Belgrade's Waterworks and Sewage Systems 1892-1992 (1992).

As part of the general urban plans of Belgrade as official long-term documents for the City general solutions for Belgrade were also prepared:

a) General Solution for Belgrade's Waterworks (1950)
б) General Solution for Belgrade's Waterworks (1977, part of Belgrade's 1972 General Urban Plan)

There were also changes and extensions to Belgrade's General Urban Plan (1987) in which the basic concept for Belgrade's Waterworks was proposed.

In 2003 the new General Urban Plan for Belgrade was prepared. Unfortunately and contrary to established practice, as part of the new General Urban Plan no new general solution for the waterworks has been prepared.

An overview of the development of the waterworks system is presented in Table 3.

Table 3. BWS Capacities Over Time

	1970.	1980.	1990.	1994.	2000.	2001.
1. WATER PRODUCTION						
a) annual production m^3/yr. ($\times 10^6$)	104	178	203	222	245	243
b) average spec.consum. l/hr/day	369	423	442	443	393	376
c) max. daily consumption l/hr		6.486	7.034	7.323	8.330	8.417
1.1. Capacity of Facilities						
a) groundwater	3.150	7.100	8.000	8.000	8.000	8.000
b) surface water	500	500	2.500	2.580	3.580	3.580
c) total	3.650	7.600	10.500	10.580	11.580	11.580
1.2. Reni Wells						
a) number of wells	26	55	93	95	99	99
b) tapped water l/hr	2.990	5.060	5.045	4.859	4.797	4.510
2. DISTRIBUTION SYSTEM						
2.1. Consumption accord. to Zones (%)						
a) Zone I 75-125 m.a.s.l.	56,1	53,5	52,5	56,1	54,1	52,16
b) Zone II 125-175 m.a.s.l.	35,7	33,5	33,2	23,8	24,2	25,08
c) Zone III 175-225 m.a.s.l.	7,9	12,4	13,2	18,0	19,4	20,48
d) Zone IV 225-310 m.a.s.l.	0,2	0,6	1,1	2,1	2,3	2,28
2.2. Waterworks Network						
a) length of waterworks network (km)	1.217	1.615	1.979	2.257	2.510	2.534
b) number of connections (units)	50.939	74.616	86.467			
2.3. Reservoirs						
a) volume of reservoirs (10^3 м^3)	190	194	196	206	219,5	208,6
b) max.daily.prod.of reserv.(%)						
2.4. Source Stations (clean water)						
a) number of Source Stations	16	17	20	25	28	28
b)installed capacities (l/s)	17.850	19506	21.591	21.591	21.780	21.780
c)installed capacities (kW)	23.178	24.643	27.378	27.378		
3. SYSTEM LOSSES (%)	23,29	20,87	20,62	26,22		

1.1.1. WATER SOURCES, PRODUCTION AND CONSUMPTION

Belgrade is being supplied with water from sources on the Sava river for decades already. Today the principal source of water is the riverfront of the Sava river where capture of groundwater is mostly conducted (filtration of river water). The amount of treated water which is taken directly from the Sava river is around 40% of the total water produced. All water that enters the distribution system is previously treated in purification facilities.

The available water (consumption) used for supplying the city is limited by two fundamental capacities:

- the capacities of active water sources and
- the capacities of water purification facilities.

This is the reason why this section deals separately with water sources and with production capacities for consumption.

1.1.1.1. Water Sources

The existing water sources of the Belgrade Waterworks include the riverfront of the Sava river, from the right bank of the Mouth to Ostruznica, and on the left bank all the way to Kupinovo. The captured groundwater is a filtrate of river water.

For ten decades now Belgrade is being supplied with water from groundwater sources on the riverfront of the Sava. For the first five pipe wells activated in 1892 groundwater was captured "below the Bele vode source" (according to the project by Oscar Smrecker, an engineer from Munchen).

In the period between 1899-1914 another fifteen pipe wells were built on the Bele vode location (except that one number of wells were constructed jurisdictionally toward the Sava – toward Makis).

In the period between 1930-1936 measures were taken for increasing groundwater capacities with the building of 30 pipe wells – "southern and northern sources".

Very extensive hydrologic testing was carried out at the beginning of 1940 (before the beginning of World War II) under the direction of academician prof. Miladin Pecinar. These tests served as the basis for preparing the Project for Supplying Belgrade With Water from Ada Ciganlija and Part of Makis (1943). Academician M. Pecinar's fundamental idea was to tap the groundwater along the riverfront of the Sava river using pipe wells.

The change in conception in the development of the waterworks system was the decision that Belgrade should be supplied with water captured from groundwater sources in the alluvial area of the Sava river. This concept was adopted in the 1950 General Urban Plan with the note that pipe wells will be used for capturing of water.

In the early fifties the realization of the new concept for supplying Belgrade with water began using a new capturing facility with branching horizontal drains (Reni type). The first Reni well was built on the left bank of the Sava and began operation at the end of 1953.

In the period between 1953 and today 99 Reni type well were built according to the chronology presented in the following table. The total installed power of pumps in these wells is 13 MW.

Table 4. Chronology of Well Construction

year	1960	1965	1970.	1975.	1980.	1985.	1990.	1995.	2000.	2003
number of wells in use	6	14	26	38	55	83	93	96	97	99
aver.capac. of Reni wells in l/s	182	158	115	115	92	69	54	52	56	51

As can be seen from the above table, for a period of 30 years it is possible to see the ratio between the increase in the volume of tapped water and the increase in the number of wells. The average capacity per well of 182 l/s has been reduced to 51 l/s, that is to say 3.6 times smaller, while the number of wells increased by 16.5 times.

The projection of source volumes given in the General Plan from 1977 is based on testing and studies carried out at the time. All studies up to that time gave optimistic projections on water supplies from groundwater sources.

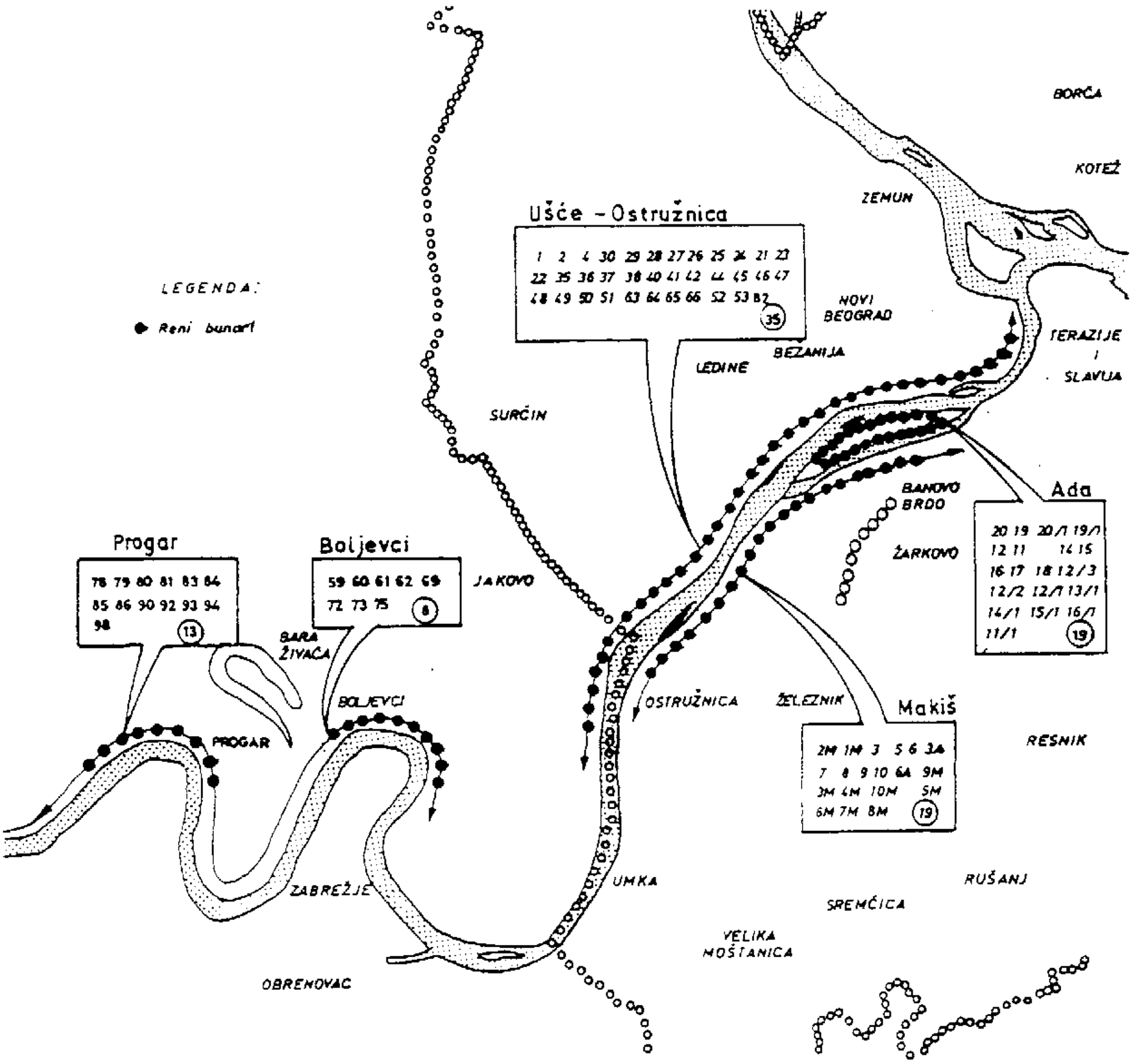


Image 1. Sources of the Belgrade Waterworks

With a volume of water of around 5 m3/sec., which is the amount of tapped groundwater (at the time the General Plan was prepared), it was estimated that a total of 22 m3/sec. could be tapped from groundwater sources. However, even though a planned water source was not engaged (for instance Obedska bara), the actual conditions are as follows:

a) The existing water source along the riverfront of the Sava river has three locations: Mouth – Ostruznica, Boljevac and Progar. 5,300 l/s are currently captured there with a tendency toward reduction.
b) The War Island as a source (decision by the Municipal Parliament of Belgrade) cannot be realized as a potential water source for supplying the City with water.
c) Right bank of the Danube – in recent years the subject of extensive testing.

Based on these facts it can be observed that the planned assumptions were not realized, that is to say that there is evident difference between what was planned and realized, with the result that Belgrade is facing a shortage in terms of water supplies from groundwater sources.

The future use of existing water sources of river filtrates using capturing facilities – Reni wells is one of the most difficult problems faced by the Belgrade Waterworks. The problem lies in the reduction of capacities of groundwater sources.

Many years of work on regenerating the drainage of Reni wells indicate that the problem does not lie in the drop in water capturing capacities, but in the drop in the capacities of the sources themselves. The cause is the reduction in infiltration from the Sava river to groundwater sources.

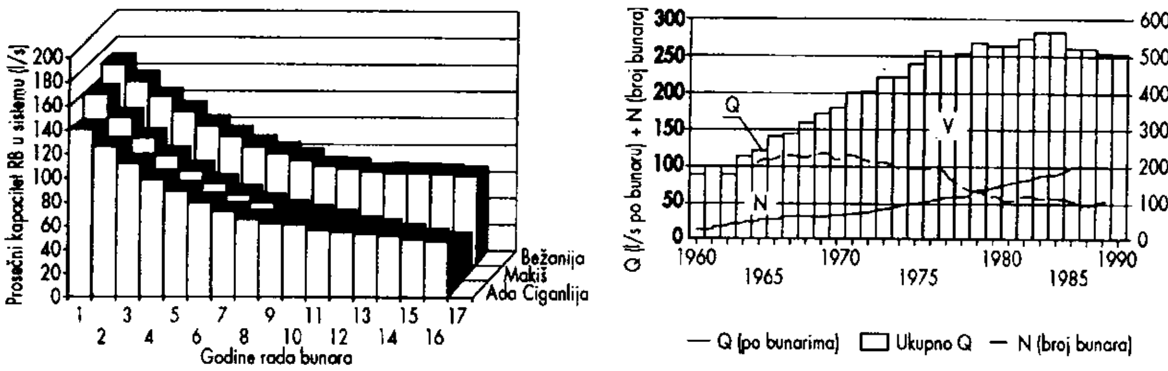


Image 2. Reduction in Capacities of Water Sources

Data on groundwater levels at existing source locations indicates that there is a constant trend of reduction in groundwater capacities which is a classic indicator of “overexploitation” of sources, and which results in small capacities per well (today around 52 l/sec., and in 1960, 182 l/sec.).

1.1.1.2. Water Purification Facilities

All water that is delivered to consumers is previously purified in appropriate facilities. Today in Belgrade such facilities are located in five places: “Bele vode”, “Banovo brdo”, “Bezanija”, “Makis” and “Vinca”.

Water supplying of Belgrade began from a modern waterworks system in 1892 with the construction of a system of pipe wells on the location of Bele vode. Already in March of 1893 a provisional installation was deployed for removing iron from water. This installation consisted of four drums filled with coke and two slow filters (from sand and gravel, height 80 cm), according to Smrecker’s project.

In the period between 1926-1927 a facility was built for purifying water from the Sava river at Bele vode, and in 1936 a new installation was built for purifying groundwater.

Capacities before World War II amounted to 53,000 m^3/day.

In 1959 the construction of a new waterworks system began (the “Banovo brdo” facility; tunnel from Banovo brdo to Tasmajdan) on the right bank of the Sava river. The Banovo brdo water purification facility with its capacity of 1,000 l/sec. began operating at the end of 1961, with the second stage at the beginning of 1966, and the third, at the end of 1974.

In 1963 the construction of a system on the left bank of the Sava (New Belgrade and Zemun) began. The Bezanija facility was also built as part of this system (stage one in 1966, stage two in 1974, and stage three in 1985).

The construction of new facility for treatment of river water, “Makis I” with capacity 2 m^3/sec., began in 1984. This facility began operation in 1987.

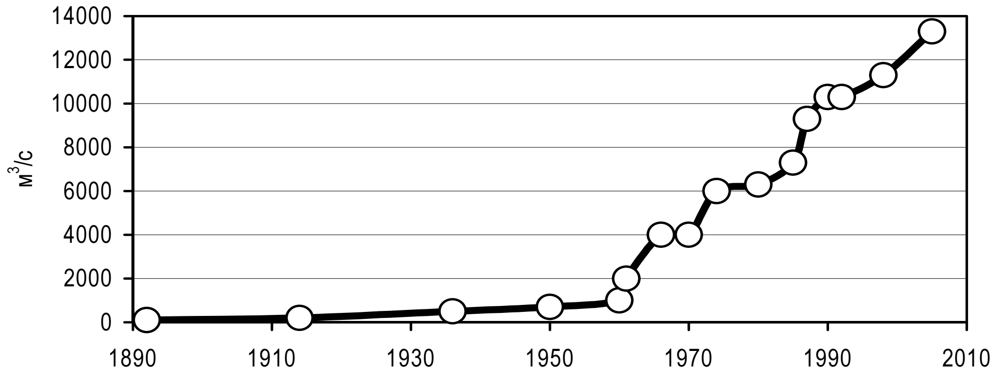


Image 3. Capacity of Facilities

Installed capacities of water purification facilities in Belgrade are:

Groundwater:

Bele vode	600 l/sec.	43.200 m^3/day
Banovo brdo	4.200 l/sec.	362.800 m^3/day
Bezanija	3.200 l/sec.	276.480 m^3/day
Total groundwater	*8.000* l/sec.	*682.560 m^3/day*

River water:

Bele vode	500 l/sec.	43.200 m^3/day
Makis 1	2.000 l/sec.	172.800 m^3/day
Jezero	1.000 l/sec.	86.400 m^3/day
Vinca	80 l/sec.	6.912 m^3/day
Makis 2	2.000 l/sec.	172.800 m^3/day
Total river water	*5.580 l/sec.*	*482.112 m^3/day*
Total groundwater and river water	*13.580 l/sec*	*988.872 m^3/day*

At the beginning of 1998 the pretreatment facility "Jezero" began operation as part of a system of modern treatment of Sava river water. Until the construction of the filter installation "Jezero" this facility had three uses:

– for treated water to be directed to the Bele vode facility,
– for treated water to be directed for artificial replenishing of the groundwater source through infiltration,
– to fill the Sava Bay (tr. Jezero) with clear water.

With the construction of the "Jezero" facility pretreatment became part of the technological line for treatment of river water with a capacity of 1 m^3/sec.

In 2003 with a 20 million € credit from the EBRD the construction of phase two of the facility for river water treatment "Makis 2", with a capacity of 2 m^3/sec., began.

The key structures of the groundwater treatment facilities (at Bele vode, Banovo brdo and Bezanija) are: aerators with retention pools, filters, water disinfection stations and reservoirs for accumulating pure water. The "Bele vode" and "Makis" facilities for purifying surface water differ in terms of technical schemes. While the "Bele vode" is a classical, but also very dilapidated, the "Makis" facility is modern and uses modern technology. The Makis system includes tapping and a source station of raw water from the Sava river (capacity 7 m^3/sec.) with a thrusting channel to the facility. The facility includes:

– a pretreatment facility with high efficiency in clearing water,
– ozonation (preozonation of raw water and main ozonation of cleared water before the GAU filter),
– water filtration in fast gravitational multi-layer filters and active carbon filters,

– final chlorination (prior to the pure water reservoir),
– mud treatment is carried out in a separate facility.

The purified water from the pure water pool (two hour reserve) is sent into the distribution system to consumers via the source station.

1.1.1.3. Water Production and Consumption

Water production depends on the capacities of an active source and the capacities of the purification facility, as well as on the source of the water (groundwater or surface water).

Water production is constantly increasing because it must meet the demands of new consumers, besides current ones. Table 5 presents the increase in water production.

Table 5. Water Production

Year	Amount of Water Produced		
	annua. 10^6 m^3	daily m^3	average l/s
1982	1,0	2.800	32
1903	1,5	4.040	47
1910	1,8	5.019	58
1914	3,1	8.000	93
1920	3,4	9.348	108
1930	10,2	27.915	323
1940	19,6	53.830	623
1950	29,7	81.277	991
1960	49,6	135.814	1.572
1970	104,0	285.005	3.299
1981	178,4	486.849	5.635
1985	188,2	515.616	5.968
1990	203,6	557.671	6.455
1995	227,3	612.771	7.208
2000	245,4	670.455	7.635
2001	242,8	665.291	7.700
2002	231,2	663.420	7.331
2003	233,5		

Table 6 presents quantities by years according to source of produced water:

Table 6. Source of Water

Source of Water	Year										
	1939	1960	1970	1975	1980	1985	1990	1995	2000	2001	2002
groundwater (%)	50	70	96,2	94,3	89,7	92,1	78,1	69,7	61,3	58,7	59,2
surface water (%)	50	30	3,8	5,7	10,3	7,9	21,9	30,3	38,7	41,3	43,8
average. product.(л/с)	323	1567	3298	4526	5642	5967	6455	7208	7635	7700	7331

The term production means the amount of water directly used by consumers as registered by water meters (households, industry and municipal consumption: cleaning of streets and watering of plants).

Consumption means the difference between the produced water and “losses in the system”. Over the past 16 years the average index of increased consumption is 2.5%.

Table 7. Production, Consumption and Loss

Amount of water	Year									
	1960	1965	1970	1975	1980	1985	1990	1995	2000	2003
production in mill. m^3/year	49,6	72,8	104,0	142,7	178,4	188,2	203,8	227,3	245,4	233,5
consumption in mill. m^3/year	38,0	59,5	79,8	105,3	141,1	142,4	161,8	167,0	163,3	162,0
loss in system in %	23,5	18,4	23,3	26,2	20,9	24,3	20,6	26,5	29,5	26,5

Specific consumption (annual median) represents a consumption norm as an element of calculation in the waterworks system. Table 8 presents realized specific consumption.

Table 8. Specific Consumption

Year	1892	1930	1950	1960	1970	1980	1985	1990	1995	2000	2003
spec.cons. l/consm./day	56	140	189	229	369	423	426	442	443	359	356

In Belgrade the distribution system is divided into four elevation zones, with their corresponding consumption being as follows:

Table 9. Consumption by Zones (%)

Year	Elevation Zone (m.a.s.l.)			
	I	II	III	IV
from	75	125	175	225
to	125	175	225	275
1965	63,0	32,0	4,5	0,5
1970	56,9	35,0	7,9	0,2
1975	56,9	33,6	9,2	0,3
1980	53,5	33,6	12,4	0,6
1985	52,0	36,0	11,4	0,6
1990	52,5	33,2	13,2	1,1
1994	56,1	23,8	18,0	2,1
2000	54,1	24,2	19,4	2,3
2001	52,2	25,1	20,5	2,3

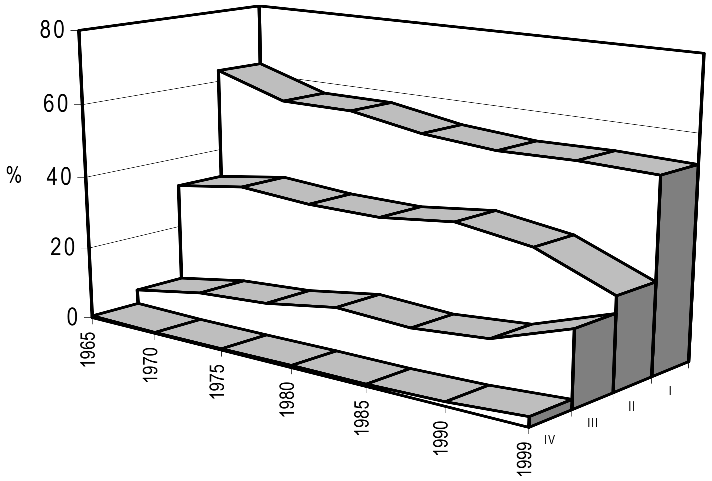


Table 10 presents an overview of electrical energy consumption from the source to the consumer in kW/m³:

Table 10. Consumption of Electrical Energy

year	**1978**	**1979**	**1980**	**1981**	**1982**	**1983**	**1984**	**1985**	**1986**	**1987**	**1990**	**1995**	**2000**	**2001**
kWh/m³	0,74	0,76	0,74	0,79	0,83	0,82	0,86	0,89	0,92	0,91	1,04	0,94	0,99	0,90

This table indicates a constant rise in electrical energy consumption per m³ of water. This problem was observed and arose because of the reduction in the capacities of Reni wells, over pumping of water from remote sources and because of the structure of new consumers (disposition according to elevation zones).

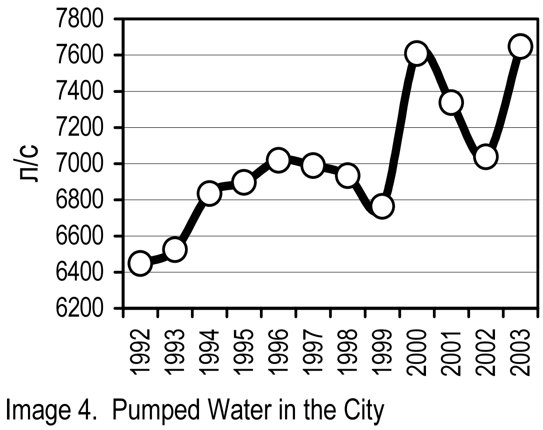


Image 4. Pumped Water in the City

Image 4 presents the amounts of pumped water in the City for the period 1992-2003. A slight drop is observed in the last three years. This can be explained by the reduction in consumption which arose as the result of an end in operation of large consumers, which above all refers to industrial consumers. The sudden rise in the last year of this series is ascribed to the change to measuring pumped quantities of water, which clearly differ from estimated quantities thus far.

1.1.1.4. Water Quality

With the conception of a modern waterworks in Belgrade and its activation in 1892 the greatest attention was given to water quality (establishment of expert teams which controlled water quality). This is the reason why already in 1893 the first installation for water purification began operating, even though at that time many large cities in Europe did not have such facilities. However, even at that time (as today) the public was not well informed, leading prof. N. Stamenkovic at the Upper School to observe in 1894 that: "Every claim that water is unclean or unhealthy stems either from ignorance or from laziness."

The laboratory for chemical and biological testing was established in 1929 when river water participated with a little over 50% in the overall water production, i.e. when water quality control had to be raised to a higher level.

The function of the laboratory through various organizational forms remained unchanged, where it must be stressed that now it has modern equipment and a staff with the highest expert qualifications.

One of the most significant activities in the process of supplying the City with water is control of water quality which determines its degree of sanitary-hygienic safety. Drinking water is a staple product and its control is subject to special, very clear and strict legal regulations (Rule Book on Hygienic Safety of Drinking Water, Official Gazette of the SFRY 33/87 and 13/91; Rule Book on Conditions That Must Be Fulfilled by Drinking Water, Official Gazette of FRS 26/77). Water quality control is practically carried out in three sages. The first stage of control is carried out in three shifts, in on site laboratories, the second stage of control is carried out in the Service for Sanitary Water Control, and the third stage of control is carried out in the Municipal Institute for Health Protection.

The sampling program is conducted according to an established scheme and covers 160 tap water locations divided into 18 groups. 14,000 samples are tested annually for various parameters. The following institutions are also involved in testing water quality: "Dr. Dragoslav Karajovic" Institute (radioactivity) and "Virusology Institute Torlak" (water testing for viruses).

The results of physical-chemical and bacteriological-biological testing of drinking water from the Belgrade Waterworks obtained by the Sanitary Control Service and the laboratory of the Municipal Institute for Health Protection indicate that the results are within legally prescribed limits, from which it can be concluded that the residents of Belgrade drink water that is sanitarily-hygienically safe.

1.1.2. DISTRIBUTION SYSTEM

The water supply process consists of continuous supplying of hygienically safe water through the distribution system to all consumption points. Essentially, the objective of a water supply system is:

- supplying of settlements with drinking water (households),
- supplying water for industrial purposes,
- supplying of water for public and municipal consumption.

The supplying of Belgrade with water is realized through, from an engineering point of view, a very developed complex of hydro-technical facilities. The distribution system of the Belgrade Waterworks consists of structures of the waterworks network (principal lines and distribution network), source stations (in the system) and reservoirs.

The concept of supplying Belgrade with water through a distribution system can be reduced to the following:

A) *Water distribution on the right bank of the Sava* – more complex and with greater problems; supplying of water is carried out through three facilities:

a) From the “Bele vode” production facility water is piped to consumers through source stations SS-1a and SS-16.
   Source Station 16 supplies the first elevation zone of the territory of Cukarica and part of Rakovica and fills the “Zeleznik” reservoir, from where water is piped further on in the direction of Sremcica, Rusanj, Velike Mostanice and Barajevo.
   SS-1a is used for supplying a part of the second elevation zone of Cukarica and for piping water to the “Dedinje” reservoir.

b) All the water from the “Banovo brdo” production facility is distributed through the existing tunnel (T1) and the three source stations in it in the following way:
   The Topcider source station pipes water from the tunnel to the first and second elevation zones, at the same time filling the “Principal”, “Krajinski” and “Dedinje” reservoirs. The “Vracar” source station re-pumps water from the tunnel (T1) for the consumption of the first and second zones, toward the “Zvezdara” reservoir. The “Tasmajdan” source station directs water to the “Pionir” reservoir and the territory of zone one, including the settlements on the left bank of the Danube. From the above listed reservoirs water is piped to hither zones through the “Pionir”, “Principal” and “Zvezdara” source stations, with distribution being carried out thus.

c) Purified water from the “Makis” facility enters the first tunnel line through the “Banovo brdo” system, while the other portion is piped in the direction of the “Zarkovo” reservoir, and further on into regional systems toward Mladenovac (once when the construction of this part of the system is completed). Water from the “Bele vode” is directed today toward Zeleznik and Barajevo, and toward the center of the City, Topcider and Mostar.

B) Territory of Belgrade on the left bank of the Sava – is supplied from the “Bezanija” production facility. Water is piped through a tunnel and source stations “Studentski grad” and “Bezanija” to consumers in New Belgrade and Zemun who are in the first elevation zone.

The pipeline on the bridge across the Sava supplies the connection for the distribution network between the left and right banks of the Sava.

Distribution system facilities are located on the territory of ten municipal and partly on the territory of two suburban municipalities. Because of ground configurations, the territory of the city is divided into four elevation zones, from 70 to 300 m above sea level. The whole of zone one is connected in a ring network into a single system; it extends from Batajnica to Kaludjerica; from Umka to Ovca; from Surcin to Visnjica, etc. Zone two is for the biggest part connected into a single whole, except for parts of the Barajevo system and upper parts of Umka. Zones three and four supply the highest points in the city. Re-pumping between zones is carried out through source stations, where each zone has reservoirs for its gravitational area. The development of the distribution system is in the service of production capacities, which is presented in Table 11.

Table 11. Development of the Distribution System

	1892	1950	1960	1970	1980	1990	2000	2001	2003
no. of consumers ($\times$ 1000)	50	430	600	950	1.120	1.200	1.720	1.768	1.320
length of network in km	46	466	673	1.217	1.615	1.963	2.510	2.534	
reserv. vol. in m^3 ($\times$ 1000)	5,0	78,0	82,0	176,7	181,5	196,2	219,5	208,5	208,5
installed SS strength, MW	0,35	10,26	13,00	21,24	22,71	25,33	28,00	28,00	28,00

1.1.2.1. Water Supply Network

A significant role in supplying Belgrade with water is occupied by water distribution, while the primary role in the distribution of water is occupied by the water supply network.

Balgrade’s water supply network represents the transportation highways for water and the direct link between the producer and the consumer. It must be pointed out that the water supply network represents the last segment of the waterworks system in supplying water, and in it consumers observe all operational faults. Because of size and operating method the water supply network represents the biggest investment and exploitation cost.

The Water supply network of the Belgrade Waterworks covers an enormous expanse of around 2,000 ha (from Umka to Borca and Ovca and from Dobanovci to Veliko Selo).

The transportation of water from sources to production facilities and after treatment to consumers is realized through the water supply network in twofold fashion: pipelines for raw water (from sources to purification facilities, length of around 200 km) and main distribution pipelines, together with the distribution network (for pure water, length around 2,300 km).

The water supply network is very diversified and multifarious, both in terms of diameters and types of materials, as well as length of use. Pipeline diameters range from one inch (25 mm) to 1,500 mm, while tunnel intakes have diameters up to 2,000 mm.

Differences in dimensions of the pipeline are technically justified and necessary, but only to a certain degree beyond which there is neither technical, nor economic justification. Such is the "white" network (zinc coated pipes) which presently extends to 221 km in the system and which is slow to be replaced, even though it is dilapidated and technically inadequate, therefore presenting a constant problem both for the waterworks enterprise and for consumers.

Table 12. Water Supply Network According to Years

year	total length (km)	number of valves	number of outlets	number of hydrants	number of connections
1960	533	2.990	260	3.885	42.326
1970	1.217	6.580	310	8.169	50.939
1980	1.615	8.730	436	10.839	74.616
1983	1.785	9.216		11.443	79.066
1987	1.872	9.880	525	12.260	83.531
1988	1.956	10.500	547	12.540	85.326
1989	1.948	10.600	586	12.650	85.474
1990	1.963	11.117	586	12.920	86.467
1995	2.257	11.766	703	14.150	92.500
1999	2.263	11.808	590	14.012	103.000
2000	2.510	11.925	591	14.074	106.320
2001	2.534	11.974	592	14.079	113.254

Information on the raw water pipeline is as follows:

a) total length 200 km
b) number of valves 435 pcs.

Intensive development of the city in the post war era necessitated the development of the water supply network. In the past thirty years the length of the water supply network and number of valves increased by around 100%, while the number of connections increased by 120%.

Table 13 presents information on street pipelines according to types of materials used in their construction.

Table 13. Pipelines According to Types of Material

type of material	% represented					
	1980	1990	1994	1999	2000	2001
1. iron cast	56,72	57,8	59,4	63,1	63,3	63,1
2. modular cast		0,1	2,2	2,2	2,2	2,2
3. steel piles (with zinc coated)	20,2	20,0	18,1	16,6	16,3	16,2
4. asbestos-cement	22,0	21,0	17,8	16,2	15,2	15,1
5. plastic	0,6	0,7	2,2	3,1	2,8	3.0
6. armored concrete	0,5	0,4	0,3	0,3	0,3	0,3

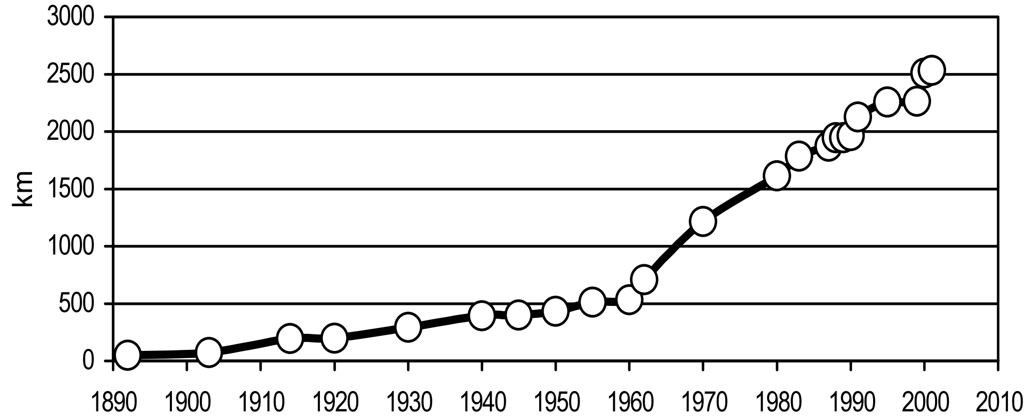


Image 5. Length of Water Supply Network

Age of pipes is one of the significant characteristics of the network. Table 14 presents the situation at the end of 2002.

Table 14. Age of Pipes

Age (years)	Length (km)	%
up to 10	425,2	16,0
from 10 to 20	555,8	20,9
from 20 to 30	551,9	20,8
from 30 to 40	644,7	24,3
from 40 to 50	236,6	8,9
from 50 to 100	240,3	9,1
TOTAL	2,654,4	100,0

Table 15 presents the frequency of disruptions in the network as an element for assessing the choice of material for pipes, while the types of disruption are listed in Table 15a.

Table 15. Frequency of Disruptions

year	length km	annual no. of disruptions	no. of disrupt. per km
1980	1.615	2.590	1,6
1985	1.827	1.897	1,0
1988	1.956	2.147	1,4
1991	2.128	2.802	1,3
1993	2.245	11.172	4,9
1995	2.257	12.622	5,6
1999	2.300	13.475	5,9
2000	2.510	12.737	5,1
2001	2.534	11.958	4,7

Table 15a. Types of Disruption

Type of disrupt.	%
With consumer	68,5
Street pipes	17,8
Valves	8,9
Hydrant	4,8

1.1.2.2. Distribution System Facilities

Besides the water supply network, the distribution system of the City also consists of pump stations and accumulation reservoirs. Because of the disposition of the ground the territory of the City is divided into four elevation zones. These zones have their own distribution system facilities (pump stations and reservoirs).

Pump Stations

Water supply system pump stations in the Belgrade Waterworks System represent hydro-technical engineering facilities whose role is to increase the energy of the water, making possible the supply of water to settlements and industries in the higher areas of the City.

The disposition of these installed capacities according to zones is presented in Table 16.

Table 16. Pump Stations According to Elevation Zones

zone	no. of PS	water consump. in %	installed capacities in %	installed strength in %
I	8	55,0	47,4	53,3
II	6	25,0	31,9	26,8
III	6	17,7	17,5	17,5
IV	3	2,4	3,2	2,4

Installed capacities of pump stations (zone specific pump stations) amount to 27,585 l/s, wile the installed strength is around 28 KW.

Reservoirs

These hydro-construction facilities are used in the water supply system for accumulating water, while at the same time making up for all changes in consumption with available amounts of water. They are the fundamental facilities of rationalization of the distribution system in terms of economics and exploitation.

The total volume of (accumulation) reservoirs amounts to 221.724 m^3, which with a further 61,256 m^3 in the water purification installations amounts to a total of 283.000 m^3.

The distribution of reservoir volumes according to zones is presented in Table 17.

Table 17. Reservoirs According to Elevation Zones

zone	zone I	zone II	zone III	zone IV	total
number of reservoirs	6	5	5	3	19
elevation point of reservoirs m.a.s.l.	150	200	250	300	
volume in m^3	95.132	91.375	29.467	5.750	221.724
water consumption in zone in %	52,1	25,0	20,4	2,6	100
amount of reservoir volume in zone in %	42,9	41,2	13,3	2,6	100

During days of maximum consumption (for instance June 5, 2000, 713.364 м^3) the volume of distribution reserves was to around 31%, which can only be assessed as unsatisfactory.

Analysis of water consumption according to elevation zones on the day of maximum consumption (June 1999) is presented in Table 18.

Table 18. Reservoir Space on the Day of Maximum Consumption

zone	zone I	zone II	zone III	zone IV
volume of reservoirs m^3	95.132	91.375	29.467	5.750
water consump. in zone (June 1999.)	390.016	171.455	132.525	16.368
water consumption in %	54,7	24,0	19,0	2,3
degree of secured* supply in %	24,4	53,3	21,7	35,1

*) Percentage of coverage of maximum daily consumption (8,646 l/s)

The previous analysis indicates that it is necessary to make certain corrections (expansion of reservoir volumes) with the objective of achieving the same degree of supply for all zones in order to successfully deliver water to the City.

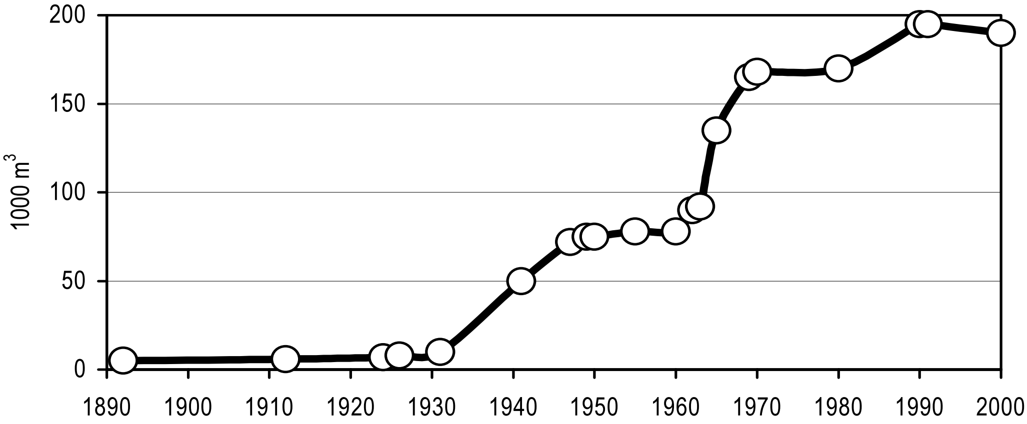


Image 7. Volume of Reservoirs

1.1.3. ANALYSIS OF INVESTMENTS

The fundamental characteristic of the modern world is accelerated technological development, but one that results in damage to the environment. In order to supply settlements with water this tendency of the modern world is conditioned by technical-sanitary measures in order that drinking water can be secured within required limits. The consequence of such a situation is an increase in investments.

The development of investment activities can best be seen in a comparative overview of development of capacities (Table 19) and realized investments (Table 20) for the period 1971-1993. In order to make the information readily comparable, in view of inflation, realized investments are expressed in US dollars. In comparing data it should be kept in mind that certain waterworks facilities require prior investments.

Table 19. Development of Waterworks Capacities

Period	Annual production m^3		Increase	Increase in period
	initial year	final year	production in %	l/s
1950-1960	29.666.000	49.572.000	67,1	737
1960-1970	49.572.000	104.027.000	109,8	1.592
1970-1981	104.027.000	178.398.000	71,5	2.362
1981-1990	178.398.000	203.550.000	14,1	5.988
1991-2001.	203.550.000	242.831.460	19,3	1.245

The previous data indicates that Belgrade is currently in a phase of relatively moderate increase in consumption, which in fact suggests slower development of the City. This is a rule observed in all large cities in the world.

Table 20. Realized Investment for Waterworks Facilities

year	in US $
1971	3.260.438
1973	1.326.697
1974	5.654.270
1976	7.945.769
1977	13.288.641
1978	21.678.924
1979	28.678.333
1980	19.378.566
1981	24.506.535
1982	22.661.516
1983	22.311.072
1984	21.316.234
1985	19.244.506
1986	44.130.044
1987	35.419.393
1988	13.381.857
1989	8.490.770
1990	7.738.418
1991	15.726.752
1992	3.409.693
1993	7.000.000
1994	10.458.283
1995	11.051.578
1996	13.030.000
1997	14.411.000
1998	23.954.000
1999	12.200.000
2000	5.900.000
2001	12.200.000
2002	50.000.000

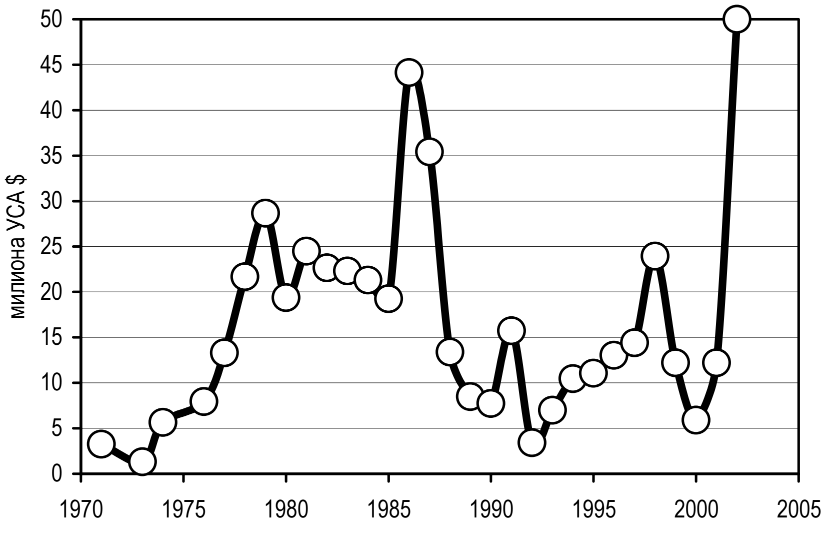


Image 8. Realized Investments for Waterworks Facilities

1.2. ASSESSMENT OF CURRENT CITY WATER SUPPLY CONDITIONS

The more than ten decades of the Belgrade Waterworks System indicate that the development of a modern waterworks system is directly connected with the development of Belgrade. This development of the waterworks system made possible the successful supply of water to the City in the previous period.

During its existence the Belgrade Waterworks System changed its concept of water supply on four occasions with the objective of securing sufficient amounts of safe drinking water.

For more than hundred years Belgrade has been supplied from groundwater sources. In the last forty years tapping of groundwater sources is conducted through capturing facilities – Reni wells along the Sava riverfront. Until 1975 the City was for the most part supplied with water successfully, but today it has been concluded that this concept is outdated. Through technical and interventionist measures in the sense of artificial replenishment of water sources, the capacities of existing groundwater sources need to be maintained at optimal capacity levels (from 6-8 m^3/sec.).

Given the new geopolitical location of the Sava river, and keeping in mind that 83.5% of the river basin is located in newly created, independent states, it is necessary to reassess the concept of supplying Belgrade with water.

The applied technologies of the water purification facilities is different, depending on the source of the treated water: groundwater and surface water. River water purification facilities are necessary to ensure reliability of the City's water supply. They must meet the highest technical standards. "Makis" is one such facility.

The capacities of the groundwater facilities are adequate. The captured quantities of water are around 5,500 l/s, while the capacities of the facilities are 8000 l/s. These facilities also need to be modernized.

Analysis of realized investments in the period 1976-1995 show that investments were irregular (1986 – 44 million dollars, 1993 – 2.9 million dollars), which clearly indicates that stable sources of financing must be found in order for successful water supplying to be achieved.

Construction of new capacities for surface water is a necessary condition for regular water supply in the near future.

Future supplying of Belgrade with water requires urgent measures to be taken with regard to protection of localities in terms of sanitation (especially where potential water sources for Belgrade are concerned).

1.2.1. SOURCES AND FACILITIES

The Belgrade Waterworks is still far from fulfilling all requirements and securing all needs, including reserve quantities of water.

The groundwater sources consist of 99 well constructed in the period between 1953 and 1993.

Under current conditions the capacities of the existing sources from which water is captured at Makis, Ada Ciganlija and the riverfront area of the Sava from its Mouth to Kupinski kut, are currently at 5,500 l/s. Besides this an additional 3.0 m^3/sec. of river water from Sava are also available through the "Makis" facility.

The capacities of the wells is objectively decreasing over time. In order to soften these negative natural effects and at least to make up for lost capacities of the water sources it is necessary to build new wells each year or, by taking technical measures, to replenish existing water sources (opening up contacts between Sava rivers – porous environment and infiltration lakes).

With the objective of maintaining and improving the quality of existing water sources, both of groundwater and directs use of river water from the Sava, it is necessary to secure sanitary protection from numerous polluters of the Sava river along its entire length and to take protective measures in order to ensure successful supplying of the City with water.

1.2.2. DISTRIBUTION SYSTEM

Water is distributed from water purification facilities to consumers through a series of pump stations, reservoirs, main intakes and the distribution network.

The distribution system on the left bank of the Sava (New Belgrade and Zemun) is relatively simple as the entire area of consumption belongs to the first elevation zone. The key facility of this system are the pump stations "Bezanija", "Studentski grad" and the tunnel intake Bezanija-Studentski grad.

In the coming period it is necessary to complete the new pump station "Bezanija" with a pumping pipeline to the area of consumption and to reconstruct the pump station "Studentski grad" in order to ensure the water supply of residential settlements in New Belgrade and Zemun.

The distribution of water from the water purification facility to the consumers in the territory of the City on the right bank of the Sava is associated with numerous problems and will be facilitated through the construction of the second tunnel intake (T2), through the reconstruction of the existing tunnel intake (T1) with facilities for connections to consumers (pump stations, reservoirs and pipelines), and through construction of the regional water supply system toward Mladenovac.

The construction of the following important facilities is planned for transporting water from the tunnels to areas of consumption:

- Reconstruction of the PS "Topcider"
- PS Vracar (new) which will pump water into the newly built pipeline ∅900-800 mm in the Mokri lug valley and a planned pipeline ∅700-500 mm on the Vracar plateau.

As there is considerable delay in the realization of certain of the mentioned facilities which are supposed to ensure a better water supply and provide conditions for residential development, *certain problems are already felt in the supply of water of central City municipalities because of bottlenecks in the distribution system.*

The problem of old pipelines of raw water has not been pointed out here **–** intakes to facilities which are outdated and require urgent reconstruction in some parts.

Pump stations which are operating are overburdened, without reserves, and need to be reconstructed as soon as possible. Capacities are not the only critical factor, but also the rundown equipment.

An overview of the pump stations is provided with the objective of attaining better insight into the condition of the pump stations in the system and the need for their reconstruction:

- PS "Bele vode 16" is operating constantly with all four groups which are in very poor condition; equipment is fully depreciated. Reconstruction is planned and is the only solution, but no funds are available,
- PS "Studentski grad" is operating with four of the five installed pumps, hydraulic protection is not resolved,
- PS "Bezanija" is operating with two, often with tree of the three installed groups which are in poor condition,
- PS "Topcider" is operating with three large groups; the only reserve is a small group, all of them are in poor condition
- PS "Vracar 2" is operating constantly with all four pumps, there are no reserves, and the pumps have been exploited for a very long time and are in poor condition,
- PS "Bele vode 1a" is operating with all three groups; there are no reserves; they are in poor condition,
- PS "Dedinje" is operating constantly with three groups; the reserve is one outdated group, they are operating according to a schedule which is not favorable.

The reservoir space in the BWS amounts to a little over 30% of average daily consumption. This is unsatisfactory because it represents only a half of the smallest recommended reservoir space in the literature, and is smaller by many times from reservoir space in a developed system. There is a need for increasing reservoir space in all zones, with the most critical situation being in the first elevation zone. The project for the second tunnel intake includes the construction of a large number of new reservoirs in all elevation zones.

Reconstruction of the water supply network

Besides expanding the waterworks system with new facilities it is necessary to carry out successive reconstruction of the old rundown water supply network with a view to reducing losses and ensuring a more stable water supply.

The water supply network is very diverse and multifarious, both in terms of diameters and types of materials, as well as in terms of age. The oldest part of the network is in the old part of the City, where defects are most common. Thus of all the disruptions in the water supply network in 1987, 52.8% occurred on the territory of Vracar, Palilula and Stari grad (tr. Old town). The highest percentage of water loss also occurs there.

By replacing this network not only would the problem of a reliable water supply be solved, but also the loss of water in the system would be reduced. Up to now more attention was given to constructing new facilities and, as a rule, very little funding was secured for replacing rundown and poor parts of the network.

Around 100 km of pipelines were replaced in the period 2001-2003 as part of the reconstruction of the water supply network. This was financed from donations, the City budget and the Agency for Development of Belgrade.

1.2.3. WATERWORKS SYSTEM MAINTENANCE

Maintenance of the Belgrade Waterworks System assumes the exploitation of the system under functional and technically adequate conditions.

Given that for a series of years investments were very poor, it has become essential and important for the Enterprise to use the available funds with maximum efficiency. There are two essential ways of activating resources with a view to realizing such a set objective and they are:

- the first is based on significant investments (material-economic and other resources),
- the second is based on realizing greater results by improving maintenance with smaller investments.

The analysis of losses indicates that it is economically far more acceptable, rational and productive to improve maintenance of the water supply system with increased investments.

The first condition for advancing maintenance of the water supply system is good business-technical organization. One of the fundamental objectives of new organization is increased efficiency in the basic activity and successful control of working business processes, and this boils down to successful functioning and maintenance of the system.

The equipment used for maintaining the waterworks facilities is outdated and inadequate.

1.3. SUPPORTING DOCUMENTS FOR FORMULATING A DEVELOPMENT STRATEGY

The work program on drafting a development strategy for the Belgrade Waterworks is for the best part based on documents issued from 1970 to today.

The following can be observed in the analysis of the state of planning:

a) The General Urban Plan up to 2010 has been adopted, although it does not include the General Solution to Supplying and Channeling.
b) Numerous obligations from the development plan, as well as water deficiency at the current time required a slightly faster trend of development in the initial period.

The following documents are singled out among the usual literature as a basis for a prospective development plan for the Belgrade Waterworks System in the period until 2010:

1. Water Source for Supplying Belgrade With Water in the Urban Plan Until Year 2000 (published in 1972)

The Association of Engineers of Serbia organized this Consultation with the intention of providing an answer to key problems in the City's water supply.

2. General Urban Plan 1972

This is a report based on general supporting documents which establishes the basis for the development and territorial organization of the City. Prepared by the Urbanism Institute, 1972.

3. The Problem of Supplying the Population and the Industry in the Socialist Republic of Serbia With Water Beyond SAP Until Year 2000

This study considers the condition and disposition of the water supply, functioning of the municipal water supply system; the basic elements of the water source crisis in supplying the population with water; the conditions for securing required water needs – future needs and protection of the water source area for supplying cities and settlements in Serbia with water. Prepared by the Waterworks Institute "Jaroslav Cerni", 1974.

4. Belgrade 1976 - 1985

Document on the development of Belgrade within a planning period as a basis for long-rage prospective development with appropriate actions for realizing the plan. Prepared by the Municipal Parliament, 1977.

5. Study on the Optimal Conditions of Exploitation of the BWS System

Draft study for optimizing the operation of the BWS water supply system (second Mirjevo zone). Prepared by "Mihajlo Pupin" Institute, 1974.

6. General Solution for Belgrade's Water Supply System

Besides an analysis of the existing water supply system the solution offers a concept of the water supply until year 2000. The study is in three volumes (12 booklets). Prepared by "Energoprojekt", 1978.

7. Previous Study – Supplying Suburban Municipalities of Belgrade With Water Until Year 2000

In analyzing the current condition of the water supply, possible variant solutions are offered with technical and economic indicators (in three volumes). Prepared by "Energoprojekt", 1978.

8. The Condition of Local Waterworks Facilities on the Territory of Priority Municipalities and Proposed Measures

Prepared by the Municipal Institute for Health Protection, 1981.

9. Territorial Plan for the City of Belgrade

Elements of long-term social and economic development of Belgrade in the period between 1980 and 2000, with a special part of the land development plan for the period 1981-1985. Prepared by the Institute for Development Planning of the City of Belgrade, 1980.

10. Development of the Belgrade Waterworks and Sewage Systems Between 1976-1982

By analyzing the condition and development of the waterworks and sewage systems of Belgrade their assessment and specific characteristics are established, with planned development up to 1985 being offered. Prepared by the "Belgrade Waterworks and Sewage System", 1983.

11. Study on the Development of the Belgrade Waterworks System for the Period 1981 to 1990

On the basis of prior literature and analysis of the operation of the BWS from the perspective of the production distribution system in space and time. Prepared by "Energoprojekt", 1983.

12. Expert Analysis – Analysis of the possibility of applying measures for increasing the capacity of existing groundwater sources of the Belgrade Waterworks

Prepared by the "Jaroslav Cerni" Institute, 1984.

13. Preliminary Report on Testing the Technological Process of Purification of River Water at the "Bele Vode" Installations

The objective of this research is the advancement of the current state and defining of conditions for water purification to be always hygienically safe. Prepared by the Municipal Institute for Health Protection, 1984.

14. Study on the Long Range Effects of the Slowing Down of the Danube and the Sava on the Territory of the City of Belgrade

The construction of the hydro electrical dam "Djerdap 1" slowed down accumulation, changing the flow of the Danube and the Sava on the territory of Belgrade. This situation should provide an answer to the influence of the hydro electrical dam "Djerdap 1" on the groundwater sources of Belgrade for new conditions of flow and water levels. Prepared by Institute "Jaroslav Cerni", 1985.

15. General Urban Plan of the City of Belgrade "Belgrade 2000", Changes and Additions

The purpose of land is changed (from 43,904 to 29,147 ha), the ratio between developed and free land is also changed (Article 4) which resulted in changes and additions to the plan from 1972. Prepared by the Institute for Development Planning of the City of Belgrade, 1985.

16. Testing of the Possibility of Using Water From the Lake at Ada Ciganlija for Purification at the "Banovo Brdo" Facility

In the interest of controlling water shortages the Enterprise is forced to conduct testing for the possibility of increasing water supply capacities through occasional use of limited quantities of water from the lake at Ada Ciganlija to be purified at the "Banovo Brdo" facility. Prepared by the Municipal Institute for Health Protection, 1985.

17. The Basis of Water Resource Management in the Republic of Serbia

The Basis of Water Resource Management in the Republic of Serbia takes a unified view of water regimens and protection of water from pollution, as well as waterworks solutions that are applicable to the territory of the Republic. Prepared by the "Jaroslav Cerni" Institute, 1995.

18. Long-term Projection of Sava River Water Quality From the Perspective of a Safe Water Supply for Belgrade

The scientific research project includes three fundamental possibilities:

- Scanning of the ambient water characteristics of the Sava river and mouths of tributaries from Ljubljana to Belgrade
- Collection and processing of information on social-economic factors on the river basin of the Sava river.
- Collection and processing of past tests of water quality with the preparation of a computer model and processing of the water quality of the Sava river.

Prepared by the "Jaroslav Cerni" Institute

19. Report on Hydraulic Model Testing of Facilities for Introducing Water Into the Tunnel System of the Belgrade Waterworks

The hydraulic model testing had the objective of solving the problem of increasing the capacity of the system. Prepared by the "Jaroslav Cerni" Institute

20. Preliminary Design of the Second Water Tunnel Intake

On the basis of the "Analysis of the Role and Position of the Second Water Intake Tunnel" prepared by "Hidroprojekat" in 1983 and following expert opinions from professional committees, the preliminary design of the second water tunnel intake was prepared. Prepared by "Hidroprojekat" and "Jaroslav Cerni" Institute, 1986/1987.

21. Hydraulic Bases for Reconstructing Pipe Stations of the Intake System of the Belgrade Waterworks

Previous measuring of pressure losses along the tunnel system, as well as hydraulic conditions for PS operation on the tunnel are the fundamental subjects of research. Prepared by "Jaroslav Cerni" Institute 1984-1987.

22. Study on Securing Water for Long Term Needs of Belgrade

The study defines Belgrade's future needs for high quality water, availability of sources for their supply, as well as bases for long term supplying of the city with water. Prepared by "Jaroslav Cerni" Institute 1987-1988.

23. Continual Measurement of Levels and Pressure in the Belgrade Waterworks System as a Precondition for Managing the System and Rational Water Consumption

A mathematical simulation of the BWS was carried out with the objective of modernizing the management of the Belgrade Waterworks as a precondition for reliable establishment of the condition of the system, as well as creation of the bases for designing a new BWS. Prepared by the Civil Engineering Faculty and BWS Sector, 1989.

24. Development of the Belgrade Waterworks and Sewage System for the Period 1983-1989

A Belgrade Waterworks and Sewage System Enterprise publication whose purpose is to present the development of this municipal function for the seven years in question. Prepared by Ph.D. Dusan Cuzovic, 1989.

25. Future Supplying of Belgrade With Water

Essentially this publication presents the bases for preparing a new General Waterworks Project, dealing with strategic issues that need to be resolved with the objective of future successful operation of the water supply system. Prepared by Ph.D. Dusan Cuzovic, 1990.

26. General Solution to Belgrade's Hydro Network and Riverfronts

The objective of the study is to prepare variant solutions as bases for development of the riverfront area of the Sava and Danube within the preparation of the new General Urban Plan for Belgrade. Prepared by "Jaroslav Cerni" Institute, "Energoprojekt" and Institute for Planning of the City of Belgrade, 1990.

27. Expert Analysis Defining Locations for Building New Wells in the Belgrade Water Source Zone

The analysis includes testing of the existing Belgrade water sources and definition of realistic possibilities of tapping certain quantities of water for the needs of the Belgrade Waterworks on the territory of the left bank of the Danube and in the wider area of the Pancevo Marsh. Prepared by "Balby International", 1991.

28. Study on Mixing Water from Different Sources in the Belgrade Waterworks

The objective of the study is to establish the effects of mixing surface wager and groundwater after treatment in the existing facilities (Makis – Banovo Brdo) in certain proportions and under different seasonal conditions. Prepared by the Municipal Institute for Health Protection, 1992.

29. Documentation on Contacts with the International Bank

30. Annual Report on the Operation of the Waterworks in the Period 1971-1999

31. One Hundred Years of the Belgrade Waterworks and Sewage 1892-1992

Collection of papers from the expert consultation on the occasion of the hundredth anniversary of the Enterprise. Prepared by the Enterprise and a Group of Authors, 1992.

32. Long Term Program for the Development of the Enterprise

a) Waterworks and Sewage, Development Plan in Stages 1975-1985
b) Medium Range Development Plan 1976-1980
c) Medium Range Production and Consumption Plan 1979-1980
d) Plan Analysis 1980-1985 and 1986-1990
e) Medium Range Plan 1991-1195

33. General Plan for Belgrade Until 2021

This is a general documentation basis which establishes the foundations for development and territorial organization of the city. Prepared by the Urbanism Institute 2002.

2. DEVELOPMENT OF THE BELGRADE WATERWORKS SYSTEM UNTIL 2005

The foundations for preparing this document on development are: comprehensive analysis of development thus far and the types of problems associated with it, expressed needs and the possibilities of fulfilling them, as well as objectives of land development of the city until year 2005.

The General Urban Plan as the basis for long term development and the General Solution for the Waterworks were supposed to represent the basis for preparing this document-strategy of development of the water supply for the period 1995-2005. The 1972 General Urban Plan has been surpassed and the procedure has been initiated for preparing the new General Urban Plan until 2010. Because of the unrealized territorial concept for the City according to the General Urban Plan and because of considerable differences in the assessment of capacities of water sources, the General Solution for the Waterworks is not realistic and does not permit the realization of all phases. The conditions in which the prospective plan for waterworks facilities is being adopted are different from those when previous development plans were being adopted – the biggest disadvantages are in the economic and technical aspects.

Even though this development plan is considered necessary as well as restrictive, great effort is required for it to get realistic characteristics, which was the target during its preparation.

Many years of practice confirm that prospective investment plans represent general plans for realizing investment activities in which approximate investment numbers are considered, while actual definition is scheduled to take place in lower order plans (medium-term and annual plans).

2.1. DEVELOPMENT OBJECTIVES, PROGRAMMING FOUNDATIONS AND PLANNING ASSUMPTIONS

The Belgrade Waterworks exists for hundred years already, but it only had the issue of water sources resolved for brief periods of time, so that this issue is considered a long term problem of supplying the City with water.

According to the General Solution to the Waterworks, the City is exclusively supplied from water sources along the Sava (whether through infiltration of groundwater or exploitation of surface water).

The vigorous development of the City in the past 50 years was accompanied by very intense development of all functions of the water supply system: capacities of the water sources and the water purification facilities, as well as expansion of the distribution system.

However, following an analysis of the development and key problems in supplying the City with water the following observations can be made:

a) Capacities of water sources are inadequate.
b) No long term solution to supplying Belgrade with water exists.
c) There is a problem with sanitary protection of water sources.
d) The total capacities of the facilities for groundwater purification are adequate, but the technical conditions of the facilities are not satisfactory – both in terms of sanitary-technical criteria, as well as in terms of exploitation capacities.
e) Maintenance of the entire waterworks system is not adequate.
f) The distribution system (networks, pump stations and reservoirs) is outdated which results in high water losses.
g) For a certain number of suburban settlements which already have numerous urban characteristics, no water supply solution has been established.

The objectives of the economic, social and land development of the city for the next ten years is established by the document on the City's development. On the level of the City, such a planning act is the General Urban Plan.

Assumptions for long term development are based on previous research and were made by specialized institutions.

The key problems of the existing system for supplying the City with water, as well as planning assumptions, permit us to propose the basic objectives for the development of the Belgrade Waterworks System:

1. The basic objective which should be realized is the fulfillment of all needs on the entire territory of the city with quality, hygienically safe water.

2. It is necessary to conclude basic testing as soon as possible in order to establish ways for long term supplying of Belgrade with water, and at the same time to establish the degree to which groundwater sources are threatened.

3. New capacities need to be built to meet growing water consumption, and to create necessary reserves. The problem of overexploitation of water sources should be resolved in parallel.

4. Water losses in the system must be reduced through the reconstruction of the old network in certain parts of the City and through regulation of maximum pressures and flows in particular sections of the water supply network.

5. The existing groundwater purification facilities need to be reconstructed with a view to improving the sanitary-technical conditions of water treatment.

6. The distribution network should be reconstructed to the necessary degree and its expansion should be carried out in accordance with the planned development of the City, with modern maintenance.

7. The issue of financing should be resolved in order that the previous objectives can be met.

To conclude, the fundamental strategic decision of the City must be the creation of a waterworks system which will supply all consumers with healthy, hygienically safe water in adequate amounts, accompanied by necessary reserves.

This development program is founded on objective decisions which are based on previously unrealized plans and realistic assumptions for the future period under consideration.

The previous planning period of 1990-1995 is characterized by very limited investment activities in the construction of key waterworks facilities in the City.

This slowdown in the development of the waterworks represents a limiting factor for the City's development which prevents the normal functioning of the city – given that the waterworks system represents a basic requirement for the life of people in the City.

2.2. SECURING REQUIRED WATER QUANTITIES – REQUIRED BALANCE

According to the 1991 census, 96.11% of the population of central City's municipalities were connected to the BWS (Stari grad, Vracar, Savski venac, Palilula, Zvezdara, Vozdovac, Cukarica, Rakovica, Novi Beograd and Zemun), while in the suburban municipalities of Barajevo, Grocka, Mladenovac and Sopot only 22.49% were connected. On the average 73.90% of the residents on the entire territory of the city are connected to the water supply system. In assessing water requirements, the assumption was made that the entire population is connected to the BWS.

The projection of the required quantities of water as a basis for the development of the City and territorial reorganization of the population and industry represents fundamental information for the design of the future waterworks system.

With this in mind numerous studies and projects were considered, and Table 21 presents comparative data on required water quantities.

Table 21. Required Water Quantities

Study, Project Title	Year of Publication	Populat. Numbers	Water Requirements m³/sec.		Daily Median	Annual Media
		$x10^3$	Q cp	Q dail.max.	m^3/day	x 10^6 m^3
General Solution to the Belgrade Waterworks, Energoprojekt (1978)	1976. 1985. 2000.	1.572	8,08 10,51	7,06 9,42 12,30	908.000	
The Basis of Water Resource Mngmt. II-Long Term Project., "Jaroslav Cerni" Instit. (1987)	1985. 2000. 2050.	1.470 1.966 2.900			748.000 2.508.000 3.835.000	273,28 915,50 1.400,00
Prel.Design of Second Tunnel, J. Cerni and Hidrop. (1989)	2000. 2020.	1.740 2.126	12,0 17,1		1.036.800 1.477.440	378,43 539,26
Future Suppl. of Bgd. With Water, Cuzovic (1990)	2000. 2020.			10,0 13,0		
Preliminary Design of the Second Tunnel, Develop. of BWS (1992)	1991. 2000. 2010. 2020.	1.427 1.505 1.749 1.911	6,47 8,55 9,72 11,15	7,39 10,11 11,50 13,20	638.496 873.504 993.600 1.140.480	233,05 318,82 362,66 416,28

The required quantity of water for successful supplying of the City with water is the direct function of the amount of water produced, decreased by the losses in the system. Without elaborating on the necessary elements for establishing the required water quantities, for this was already done in the cited studies and projects, their values in the indicated periods are presented in Table 22. The term "required water quantity" here means maximum daily consumption with secured reserves of 10-20%. The complexity of Belgrade's water supply system and the need for a reliable water supply justify this degree of safety.

Table 22. Overview of Requirements and Capacities

Phase	Year, period	Required Quantity m^3/sec.	Existing Capacities m^3/sec.	New Capacities m^3/sec.
0.	1995.	8,5	7,5	1,0
1.	1995-2000.	10,0	7,0	3,0
2.	2000-2005.	11,0	6,5	4,5
3.	2005-2010.	12,0	6,0	6,0
4.	2010-2020.	14,0	5,5	8,5
5.	until 2050.	17,0	5,0	12,0

The reasonableness of the assessment of required water quantities for the prospective period can be argued in two ways (as presented in Tables 23 and 24):

- Comparative overview of specific water consumption of Belgrade and large cities in Europe,
- Comparative overview of annual increase in production for the period under consideration (for the realized and planned period).

Table 23. Specific Water Consumption

CITIES	Specific Consumption l/resid./day
Belgrade (1994)	443
Budapest (1990)	416
Zurich (1990)	429
Paris	350
Vienna	270
Hamburg	230
Moscow (1980)	550
Rome	651

Analysis of the waterworks of 33 large cities in the world, of which eight are similar in size to Belgrade (number of residents 1000-1,500,000 res.), yields specific water consumption of 200-500 l/res./day

Table 24. Annual Increase in Production

Realized		Planned	
Period	production increase in %	Period	production increased in %
1960 - 1970.	109,8	2000 - 2005.	13,6
1970 - 1980.	71,5	2005 - 2010.	12,5
1980 - 1990.	14,1	2010 - 2020.	11,8
1990 - 2000.	19,3		

Estimates which are used in defining the development of the most important infrastructure in Belgrade, the waterworks, need to be reliable. Based on the presented comparison with large European cities it can be concluded that they are reliable.

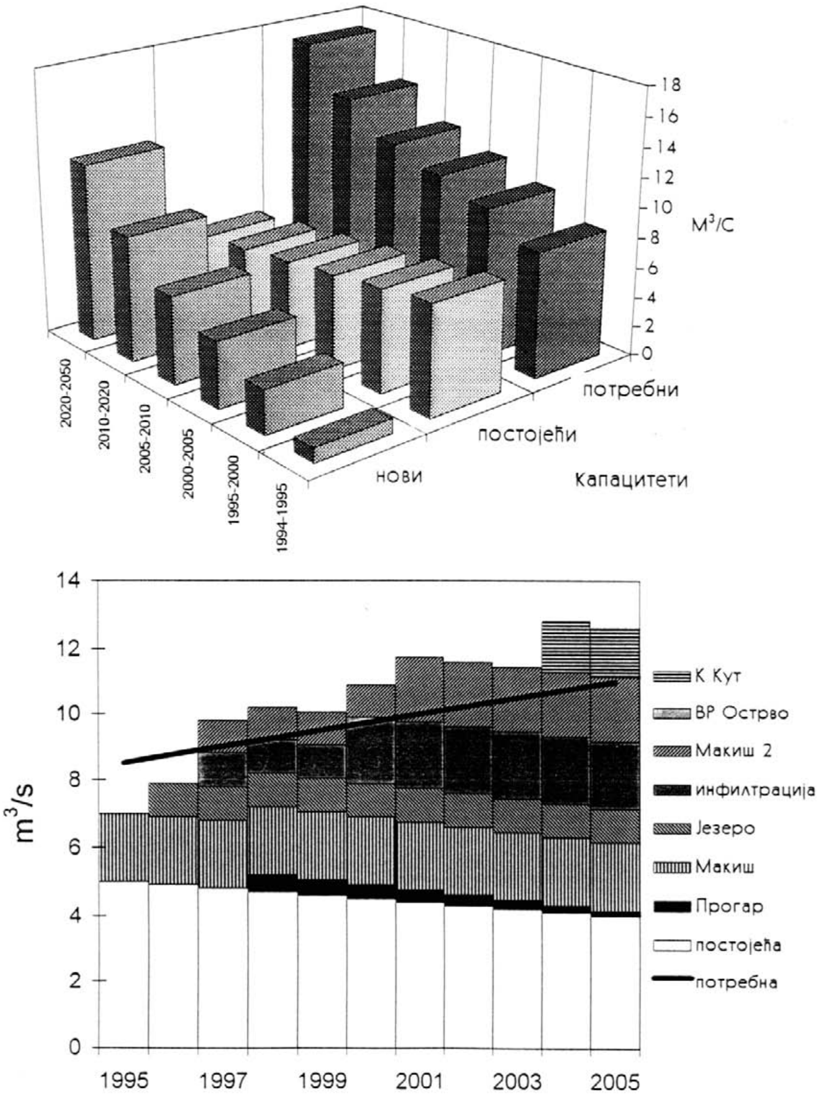


Image 9. Plan for Activating Water Sources

2.3. GENERAL CONCEPT OF SUPPLYING THE CITY WITH WATER

Today's water supply system of the City is a technically complex system which consists of 99 Reni wells, three groundwater purification facilities with a capacity of 8.0 m^3/sec., three river water treatment facilities with a capacity of 3.5 m^3/sec., a distribution system with around 2,500 km of a water supply network of different profile, with 28 pump stations that have installed capacities of 17.6 m^3/sec. and 18 reservoirs with a total volume of 247.679 м^3.

The general concept of supplying the City with water was planned as part of the General Urban Plan of Belgrade (prepared in 1950 and 1972). The General Solution for the Waterworks System of Belgrade from 1977 (project prepared by "Energoprojekt"), as well as changes and additions to the General Urban Plan of Belgrade (1987) defined the basic concept of supplying Belgrade with water. The solution for the future water supply of six suburban municipalities (Obrenovac, Barajevo, Sopot, Lazarevac, Mladenovac and Grocka) was designed in a separate project prepared by "Energoprojekt" – Belgrade. Planned measures were not fully realized – the land development concept of the City was not realized, nor the concept of supplying the City with water (planned consumption, groundwater source capacities, etc. were not realized).

2.3.1. General Presentation of the Existing System

The tapping, raw water transportation and purification facilities are water production facilities that include five separate plants:

a) "Bele Vode" facility taps and purifies river water from the Sava, and partially groundwater sources,
b) "Banovo Brdo" facility is located on the right bank of the Sava, groundwater purification facility,
c) "Bezanija" facility is located on the left bank of the Sava, groundwater purification facility,
d) "Makis" facility (on the right bank of the Sava) only purifies river water from the Sava,
e) "Vinca" facility taps water from the Danube.

The capacities of these facilities (plants) are provided in section 1.1.1.

The distribution water supply system in terms of area covers the water supply of the urban territory of the City on the right and left banks of the Sava and left bank of the Danube, as well as a certain number of suburban settlements.

The concept of supplying Belgrade with water is based on five production plants but, although it is unified, the functioning of this system is directed toward three areas of the City:

A) AREA OF THE CITY ON THE RIGHT BANK OF THE SAVA – the central part of the system is a complex system because it is supplied from three production plants:

   a) Water from pipe wells and some Reni wells (from the "Middle Makis" water source), as well as river water from "Sabacka" is purified at the "Bele Vode" facility. The purified water is pumped through two pump stations ("Bele Vode" 1a and 16) for supplying the southeastern area of the city (along the Ibar Highway and settlements along the right bank of the Sava) – settlements along the Sava valley, as well as settlements in the second elevation zone.
   This subsystem can supply nearly all parts of the City (zone I – to the Krajinski reservoir, Zeleznik and Umka and zone II – Dedinje), which indicates its enormous significance for the BWS system.

   b) Captured water from the Reni wells on the location of the "Makis" and "Bezanija" water sources is purified at the "Banovo Brdo" facility. The treated water is transported via tunnel T1 using gravitation to pump stations (Topcider 1 and 2, Vracar 1 and 2 and Tasmajdan), from where it is directed to the distribution systems of zone I (to reservoirs – Principal, Krajinski, Pionir) and zone II (into reservoirs – Dedinje, Zvezdara, Mokri lug). From the reservoirs of zone II pump stations pump the water to the third and fourth zones. The tunnel system is today the fundamentally facility of the City's distribution system on the right bank of the Sava.

   c) Water tapped from the Sava river is purified at the "Makis" facility. Given that the tunnel system T2 has not been constructed, today the purified water is brought to consumers through pump stations in the T1 tunnel to the center of the City, while the rest of the water is directed through a special pipeline to the "Zarkovo" reservoir from where, in the future, it will be brought to the settlement of Mladenovac through a future regional

system. Water from the "Bele vode" facility is brought to the Zeleznik reservoir which enables the water supply of settlements in the Sava valley.
The "Vinca" facility supplies the settlements at the foot of Avala mountain as a temporary solution. In the future these settlements will be connected to the Makis-Mladenovac system.

B) AREA OF THE CITY ON THE LEFT BANK OF THE DANUBE – this area is supplied with water from the central system (PS "Tasmajdan" and the "Pionir" reservoir) through an intake over the Pancevo bridge.
In the General Solution for the Waterworks of Belgrade the construction of a new system is planned on the left bank of the Danube which would consists of:
- groundwater tapping
- the "Danube" water purification facility
- a pump station with a reservoir (5000 m^3) and
- intake from PS "Rit" to the Pancevo bridge (joint 2 ∅800 mm toward Belgrade) and a second short one toward Zemun (underneath the Danube) to the Sava Kovacevic settlement.

C) AREA OF THE CITY ON THE LEFT BANK OF THE SAVA (New Belgrade and Zemun). The "Bezanija" production plant which supplies this area taps groundwater from Reni wells on the left bank of the Sava (from the Mouth of the Sava at the Danube to Progar), purifies it and delivers it gravitationally to the Bezanija tunnel in Studentski grad. The water supply of the settlements in this area from the production plant is carried out through the pump stations "Bezanija" and "Studentski grad", where the former is located on the plant grounds, and the latter at the end of the first section of the tunnel intake.
The Bezanija plant is used is assisting the water supply of the right bank of the Sava of zone one (pipelines across the bridge) which is why the New Belgrade network is under high pressure.

Because of ground configurations, the territory of the city is divided into four elevation zones, from 70 to 300 m above sea level. The whole of zone one is connected in a ring network into a single system; it extends from Batajnica to Kaludjerica; from Umka to Ovca; from Surcin to Visnjica, connecting all three City areas into a single whole in the range of 75 to 125 m.a.s.l. Zone two is for the biggest part connected into a single whole, except for parts of the Barajevo system and upper parts of Umka, elevation 125-175 m.a.s.l. Zone three consists of three subsystems, Sremcica, Rusanj, Dedinje-Torlak and Mirjevo (the last two are connected today through the PS Mokri lug brdo), elevation 175-225 m.a.s.l. Zone four developed in two directions – Barajevo and Kumodraz. These subsystems are located between elevation points 225 and 310 m.a.s.l.

2.3.2. Disposition of New Systems Facilities and Existing Dilemmas

Development of the City of Belgrade will include reconstruction of the City's water supply system, with the realization of planned fundamental facilities.

1. The General Solution of the Waterworks System of Belgrade (from 1977) includes the construction of a second tunnel intake (ring) with a capacity of 12 m^3/sec. In the period 1984-1987 a series of studies and preliminary designs were prepared which considered directions, elevation locations of the tunnel and capacities, and changes to the Long Term Urban Plan of Belgrade (1987) defined precise basic characteristics of the T2 tunnel, with the note that the first section (Banovo Brdo-Topcider) needs to be realized immediately.

2. The settlement on the left bank of the Sava (New Belgrade) is located in the first elevation zone, however pressures are higher and, as is planned in the General Solution, it is necessary to construct two water towers (bottom 135, overflow 139) with existing pump stations (Bezanija and Studentski grad).

3. New tapping facilities are planned on the left bank of the Danube, with transport of raw water to the Bezanija facility and the tunnel ring T1-T2. It is noted here that the General Solution suggests the formation of a new production plant in this area which would have significant advantages (directly in the area of consumption, and would assist both areas in its system extremities, which is a great exploitation advantage).

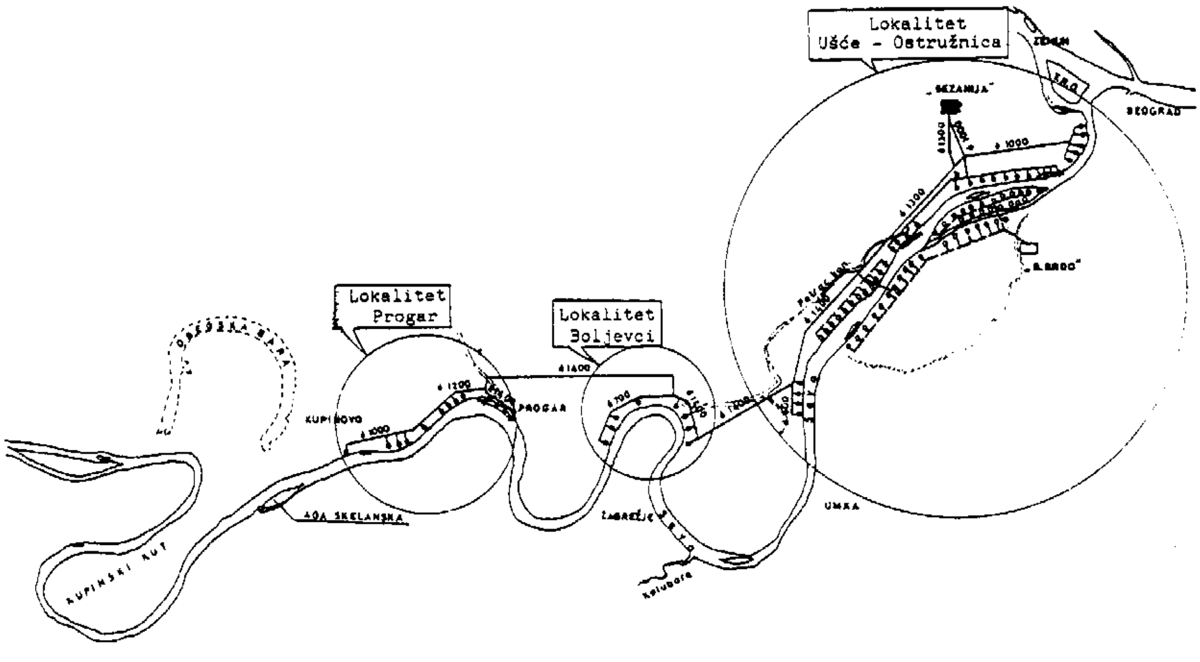
4. The construction of the regional system Makis-Mladenovac will form a new water supply system which will provide the water supply for five municipalities with around 500,000 residents. Around 20% of this system has been constructed.

5. New groundwater sources have been located in Makis and Zidine (infiltration), on the left bank of the Danube, Jarak-Klenek and the Great War Island, while new surface water capacities are planned at the existing Sabacka-Makis location.

2.4. INCREASING CAPACITY OF KEY FACILITIES FOR WATER PRODUCTION AND DISTRIBUTION

A reliable water supply for the City with healthy drinking water can only be realized with large hydro technical systems which transport water from the zone of protected water sources to the areas of consumption. For this reason Belgrade opted for the general concept of water sources on the Sava. It must be observed that this water source is becoming risky for three reasons: first, the constant degradation of the Sava river water; second, because of the new geopolitical position of our country (more precisely the Sava is an international river today which flows through Slavonija, Croatia, Bosnia and Herzegovina, and has tributaries from a part of Montenegro); and third, the constant trend of reduction in the groundwater sources (overexploitation phenomenon).

The presented required quantities of water as a basis for understanding the direction of future development in the area of supplying Belgrade with water are a significant condition to planning land development needs and water sources, as well as the strategy for their exploitation in the future. The future perspective, that is to say the time line is the second decade of the next century, based on the available documents and experiences of other countries.



The consideration of the problem of supplying the City with water can be analyzed within the framework of two areas:

- Production capacities (waters sources – ensuring sufficient quantities of water and treatment of raw water in purification facilities) and
- Distribution system which makes up the water supply network, pump stations and reservoirs.

2.4.1. PRODUCTION CAPACITIES

Analysis of the current condition has led to the conclusion that the tapped water source capacities are inadequate even for today's requirements, while the capacities of purification facilities are adequate, but their functionality is not appropriate. In this sense an analysis will be provided which includes all significant groundwater and surface water sources with potential capacities (based on conducted tests), as well as the required capacities of the water purification facilities. Hence we will proceed to consider:

- Water sources
  - groundwater
  - surface water
- Purification facilities

2.4.1.1. Water Sources

Based on the studies and testing conducted during the past ten years, the systematization of the available water resources in the near and distant surrounding area of the City.

Water for long range requirements of Belgrade can only be provided by powerful waters sources in which it is possible to carry out efficient protection of water quality.

2.4.1.1.1. Groundwater

Extensive testing has been carried out over the past 25 years in the water source areas of Belgrade (from the Mouth of the Sava river to the Obetska bara), as well as on the War Island: around 6,000 analyses of granulometric makeup, several hundred analyses of the physical-chemical characteristics of groundwater. In 1991 (January-March) the measuring of groundwater levels was carried out on 300 typical measuring locations.

2.4.1.1.1.1. Increasing the Capacity of the Existing Source

The General Solution for the Waterworks of the City in 1977 foresaw addition 19.0 m^3/sec. from existing water sources (on the left and right banks of the Sava), upstream from active water sources.

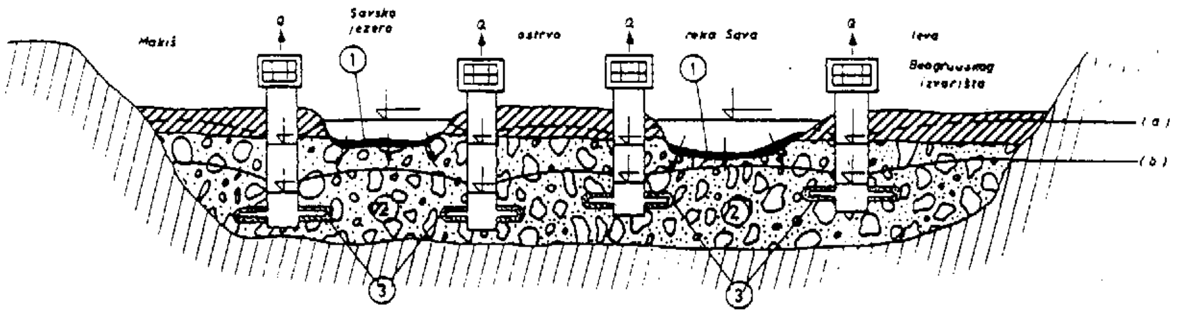
The planned assumptions were not realized, with the reasons for this being manifold:

- overly optimistic projections,
- the negative slowdown effect of the hydro-electric dam Djerdap on significant sedimentation in the area of our facilities (sedimentation of Sava's river bottom),
- sedimentation in the drain zones,
- loss of a portion of the water source (riverfront on the right bank of the Sava) because of the building of the Obrenovac industry.

The fundamental problem of the Belgrade water sources is the reduction in the capacities of the sources, and not the reduction in the capacity of capturing facilities, which has been verified by the latest tests. According to the conducted test, the assessment of potential quantities of groundwater at existing water sources is around 5.0 m/sec., while the average quantity of water from particular sources in 1991 and 1993 is presented in Table 25.

Table 25. Water Production at Wells

Reg. No.	Location of Water Sources	Production l/sec. 1991.	1994.
1.	Ada Ciganlija (19b)	700	807
2.	Makis (19b)	630	765
3.	New Belgrade (left bank of Sava 35b)	2.127	2.123
4.	Progar – Boljevac (21b)	1.369	1.164
	91-94 operating wells	4.853	4.856



ŠEMATSKI PRIKAZ, HIDRODINAMIČKE SLIKE STRUJANJA U ZONI REKE I JEZERA ZA USLOVE NEKOLMIRANOG DNA - POČETAK EKSPLOATACIJE (a) I KOLMIRANOG DNA - POSLE DUGOTRAJNE EKSPLOATACIJE (b) I ZONA PROMENA FILTRACIONIH SVOJSTAVA

① - Promena filtracionih svojstava u zoni reka - porozna sredina

② - Promena filtracionih svojstava u poroznoj sredini na putu kontakt reke - zona drenova

③ - Promena filtracionih svojstava u zoni drenova

Today's conditions of exploitation of groundwater sources are changed compared to conditions which existed during the initial years of exploitation. The constant trend in the reduction of groundwater sources points to the existence of overexploitation of Belgrade's water sources, as a consequence of the sedimentation of the Sava river bottom – that is to say a reduction in the infiltration from the Sava. This manifestation must be taken into account in the future.

The quantities of water required for setting the dimensions of the water sources are not the same as the required quantities for supplying the City (consumption). In establishing the appropriate quantities for setting the dimensions of water sources the risk of the system of exploiting water sources must be superimposed (reliability of operation, source characteristics, stoppage in electrical energy supply, etc.). Table 26 presents the required quantities of groundwater at water sources.

Table 26. Required Quantities of Groundwater at Water Sources

name of publication	Required Capacity m^3/sec.				
	1995	2000	2005	2020	2050
General Solution (Kordic 1978.)		17,0			
Future Supplying (Cuzovic 1990.)		10,0		13,0	15,0
Proposal for Groundwater Proportion *)	5,0	7,5	8,0	10,0	15,0

*) The required quantities of groundwater, based on current knowledge and conducted testing, can be secured in the following ways:

Artificial infiltration and from groundwater sources	1500 l/s
Great War Island	800 l/s
Left bank of the Danube	3000 l/s
Kupinski kut	5000 l/s
Macva	3500 l/s
Godomin	1500 l/s
Total	*15.300 l/s*

In order for the listed quantities of groundwater to be engaged in the Belgrade Waterworks System it is necessary to resolve many problems (urban conditions, projects, land ownership property rights, etc.).

Under the operating conditions of the intake system, where exploitation of groundwater sources exceeds infiltration, the result is overexploitation of water sources and a decrease in the level of groundwater sources in the wider area of the source, which is practically the case in the larger part of Belgrade's water source area. The technical intervention measures undertaken with a view to increasing the capacities of existing water sources in this sense are presented in Table 27 (May 1994).

Table 27. Technical Intervention Measures for Increasing the Capacities of Existing Water Sources

Reg. No.	Activities	Increasing Capacities l/s
1.	Engaging three wells according to the “Proisag” system	200
2.	Construction of connecting wells (estimate 7 wells = 4 progar +3)	550
3.	Replenishing a water source through an existing well	200
4.	Regeneration of the river bed and existing wells	150
5.	Technical measures on existing wells with replacement of pump aggreg.	100
	Estimate Total	1.200

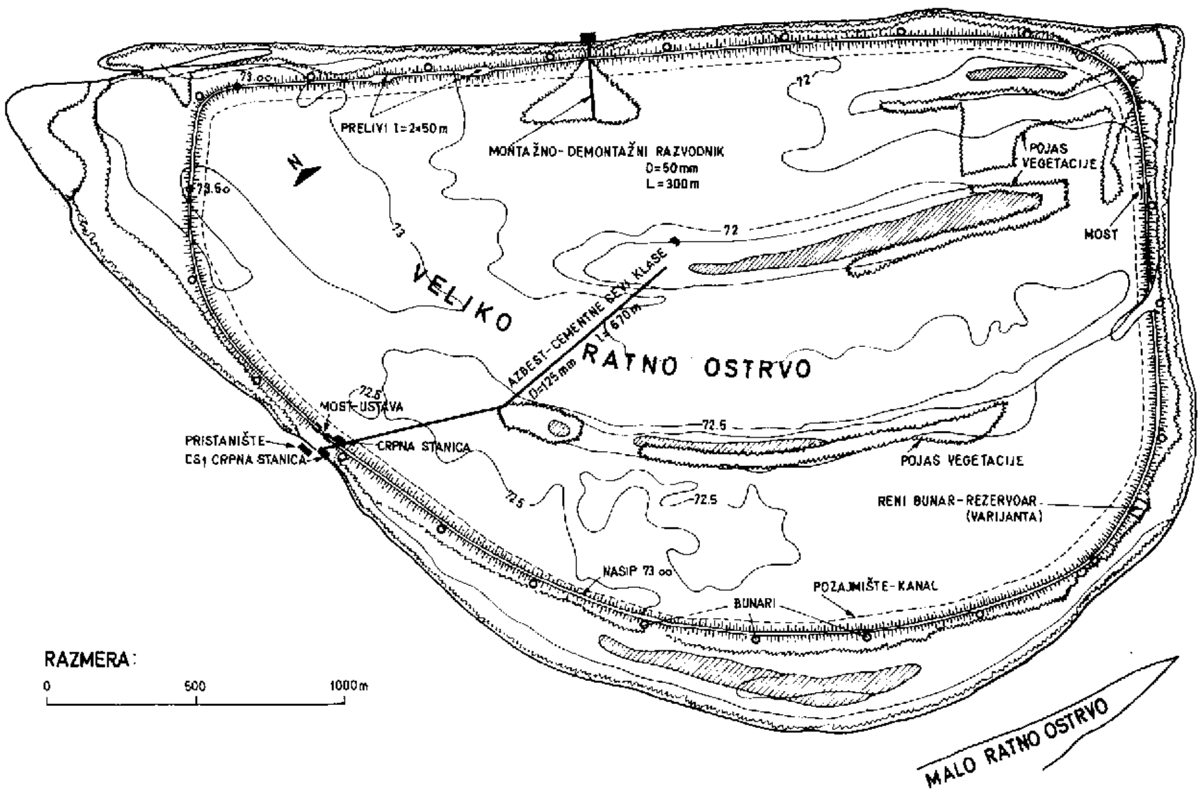
It is clear that the conducted studies on the existing water sources indicate that it is rational to invest effort urgently, in an organized way and energetically into increasing the capacities of existing water sources.

2.4.1.1.1.2. Great War Island

According to hydrologic testing and estimates that were made it can be expected that a groundwater source over an area of 175 ha will yield around 800 l/s (estimates 7 wells), for which reason the Enterprise is planning to build wells in this location. However, municipal authorities are not willing to issue permits. In order to resolve the conflict of interest between municipal authorities and the Waterworks, at the beginning of 1989 the Serbian Academy of Sciences organized a Consultation at which the proposal for constructing a water source on the War Island was supported, along with the concept of protecting the environment and the possibility of urbanization of the area.

In 1990 the Municipal Parliament of Belgrade organized a meeting of experts which was attended by foreign experts also. At this meeting the idea of using the island as a water source was not questioned.

To this day the City has not adopted the decision on creating a water source, even though this location has a pipeline (with required capacities), as well as the possibility of conducting water treatment at the Bezanija facility, which makes this location most rational.



2.4.1.1.1.3. Artificial Infiltration

Analyses of the decrease in the capacities of existing water sources point to the very low quality of replenishment of water sources. The application of artificial infiltration can be a solution for the very poor condition of existing water sources. The advantages of using the artificial infiltration method are the following:

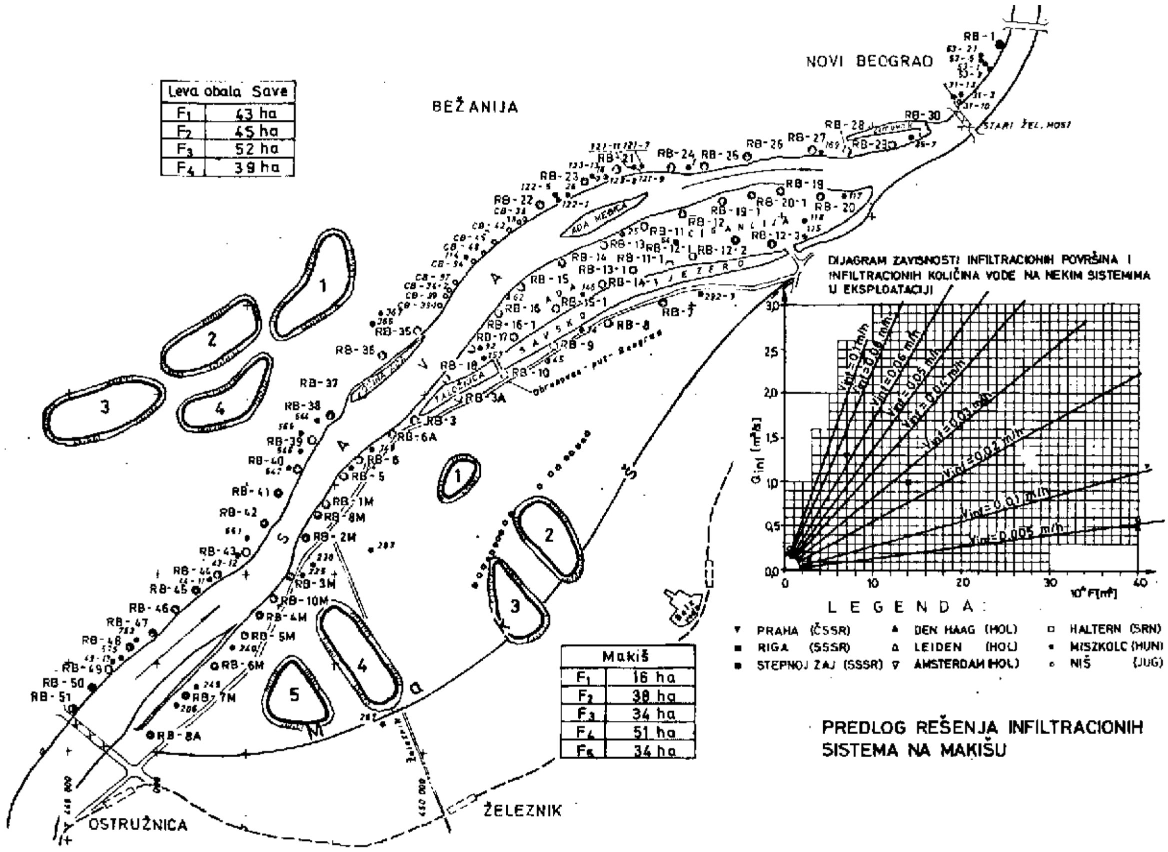
- more stable water quality;
- increase in the specific capacity of sources and
- strategic importance – as a reserve quantity of water.

The preliminary design project is scheduled for construction of test infiltration pools at Makis. Previous testing indicates that this method alone can yield from 1000 – 1500 l/s in the Makis water source area.

Artificial infiltration could be activated relatively quickly according to the following phases:

- Construction of new test pools and conducting of new testing, around 1 year
- Construction of capacities for tapping water, 3 years

Testing has begun at the water source "Zidine".



2.4.1.1.1.4. Kupinski Put

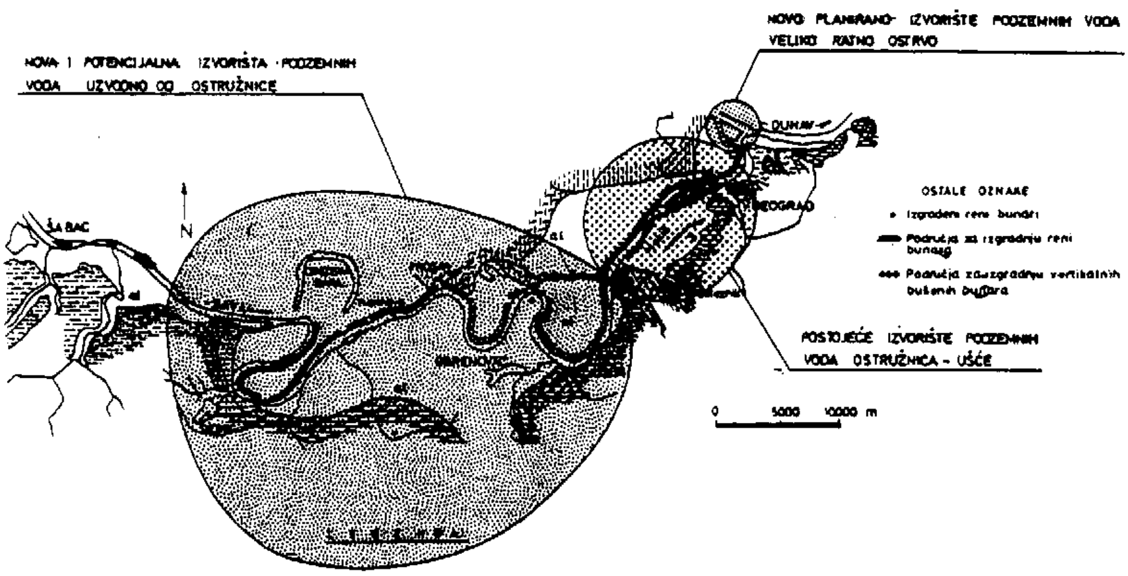
The results of extensive hydrologic testing carried out on a part of the Sava riverfront water sources (upstream from Progar), albeit it only basic testing, indicate that rough estimates of its capacities can be made. Certain problems are associated with this water source, together with Obetska bara (a significant environmental location in Vojvodina), but this will be solved through numerous phases of the project (only preliminary design complete).

Estimates for this water source range between 4,500 to 6,500 l/sec.

The closing and transport of these quantities to Belgrade precludes the following facilities:

- construction of 80 wells with horizontal drains,
- pipeline 2 × ∅1300 mm, length 40 km,

– pipe stations, reservoir space, electrical utility and electrical equipment.



2.4.1.1.1.5. Left Bank of the Danube

Based on the testing of the existing hydro geological work on the wider territory of the Pancevo rit (tr. Marsh) with an area of around 300 km^2 (fenced off by the waterways Danube and Tamis to the border of Stari Banovci – Glogonj), groundwater sources ranging from 2.5-3.5 l/s are expected to supply Belgrade. 20-30 wells can be built in this are with horizontal drains.

Detailed hydro geological testing on the "Crvenka" location have been completed. Tapping of groundwater can be realized through the construction of a "Proisag" type well, because of the fine grained environment of the Danube riverfront.

Testing was also conducted on the "Jabucki rit" location.

Planned studies and testing work has been delayed, but are necessary, given the fine grained materials and the fact that the water source zone subject to many years of slowdown of the Danube (hydro electrical dam Djerdap).

An artificial infiltration facility is planned with the objective of increasing the efficiency of this water source, which would make it possible for the negative effects of well capacity reduction to be decreased.

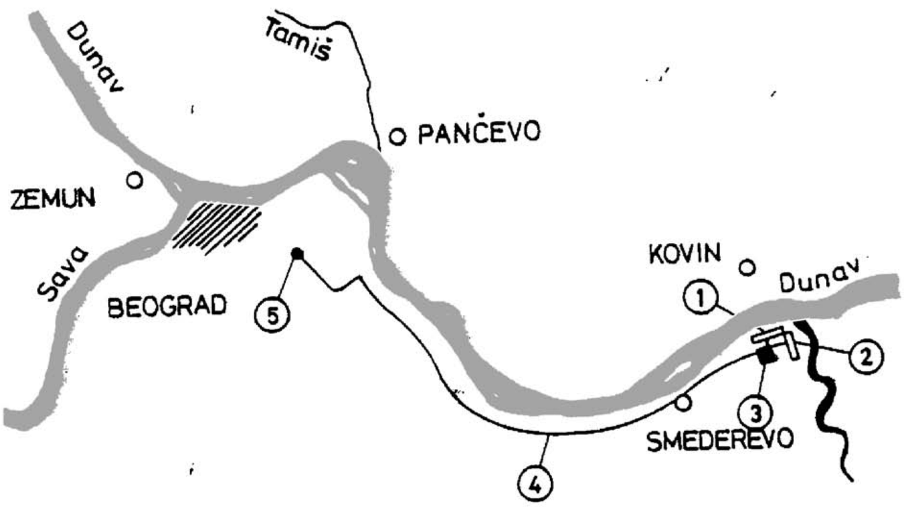
At this stage of the work other vital facilities must also be resolved (collecting pipelines, pipe stations, water treatment-purification and transport to area of consumption). In this sense the existing concept of realizing these capital facilities demands consideration because of the amount of required investments, exploitation reliability and other solutions – e.g. construction near capturing and production facilities in this area.

2.4.1.1.1.6. Godomin Source

The location of the Godomin fields between Smederevo and Dubravica has an area of around 5,000 ha. Based on the results of hydrodynamic testing and the possibilities of tapping groundwater for consumption in Belgrade, estimated capacities are 1,500-2,000 l/s. Tapping and transportation of water to Belgrade, including systems facilities for artificial replenishment of sources, requires the construction of the following:

- 30 wells with horizontal drains
- pipeline ∅1400mm, length 65 km
- infiltration facilities
- pipe station with water treatment.

However, this water sources has the following disadvantages: first, the water source is not protected and second, it is located in the area of the Djerdap accumulation and is under threat from sedimentation of the Danube river bed.

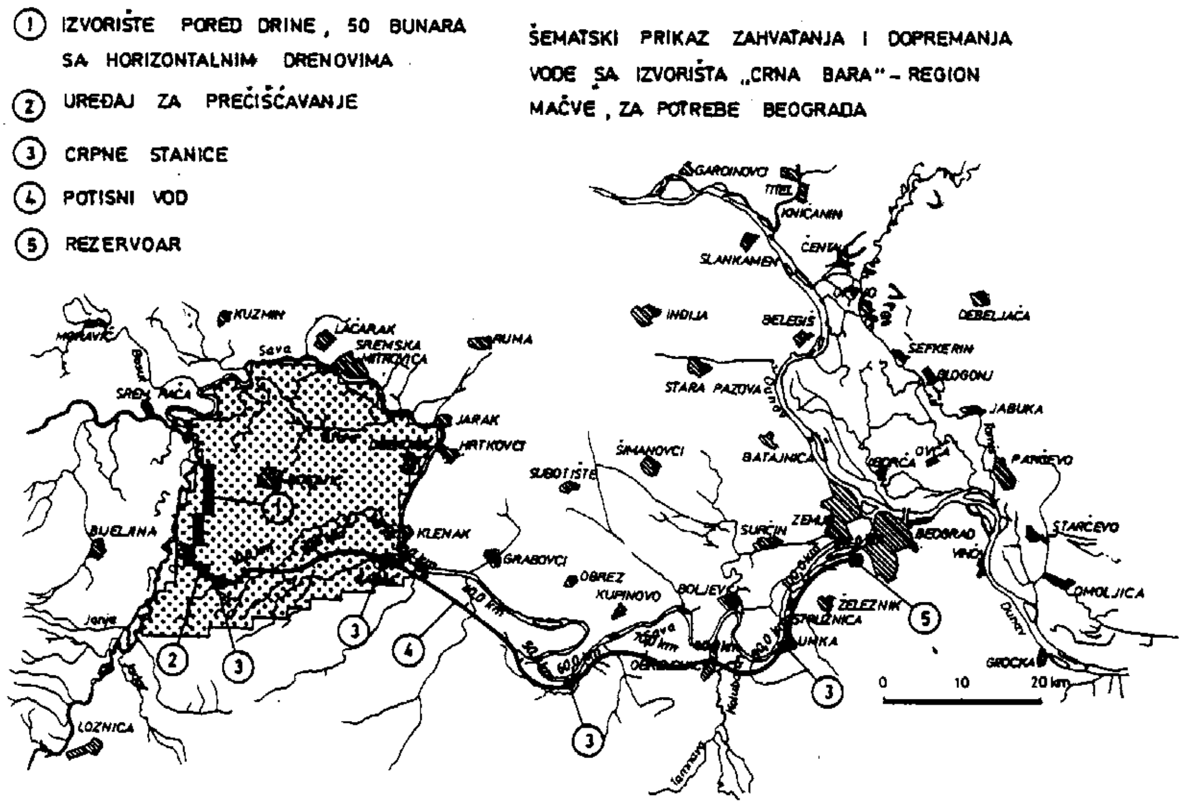


2.4.1.1.1.7. Macva Region

The region of the Drina and Sava riverfront, part of the so-called "Jarak", the Macva region was considered in previous studies as a potential water source for supplying Belgrade. The location is called "Crne Bare" with an area of around 100 ha in the direction Crne Bare – Bodovinci, along the Drina, at 1 km distance from the river. The capacities of this water source are estimated at 3-5 m^3/sec. An alternative source is Jarak.

Tapping and transportation to Belgrade would require the following components for this newly designed system:

- construction of 50 wells with horizontal drains (or pipe wells)
- pipeline 2 × ∅1400mm, length 110 km
- construction of infiltration pools
- plant, reservoirs and pump stations



2.4.1.1.2. Surface Water

The nature of the water supply for the population and the industry in Belgrade, as well as its necessity for life, indicates that today and in the future only large capacity sources can be used. Given that the City of Belgrade is located on the two largest waterways, the Sava and the Danube, it is only natural that the city resolved its water supply problems through these waterways. Hence, the Bele vode surface water purification facility was built already in the period 1926-27. The proportion of surface water in the total amount of water production (and consumption) varies, as presented in Table 28.

Table 28. Source of Raw Water

Source of Water	Year				
	1930.	1970.	1985.	1991.	1994.
Groundwater (in %)	50,0	96,2	92,1	75,24	68,91
Surface water (in %)	50,0	3,8	7,9	24,76	31,09

Potential sources of surface water are:

a) use of the Sava and Danube rivers
b) accumulations in Starovlaske mountains and
c) sources on the Drina and Mlava rivers.

The sources under b) and c) are developed at the level of preliminary designs, with the essentially characteristics of these water sources being presented below.

2.4.1.1.2.1. Surface Water Source on the Territory of Belgrade

The Sava and Danube rivers are “transport waterways” of our Republic, but also endless sources of water for supplying Belgrade with water. However, the quality of these waters is uncertain, given the geopolitical situation and the international character of these waters. Slowdown and accumulation from the hydro-electrical system “Djerdap”, during low water, extends all the way to Sabac and Novi Sad. In this way the “transport waterways” Sava and Danube in their Belgrade sections have been changed from waterways with typically flowing waters into waterways with still waters. The direct consequences of the change in water regimen of these two largest rivers are the sedimentation of undesirable materials and the acceleration of all negative processes occurring under accumulation. Scientific research projects conducted by the “Jaroslav Cerni” institute have verified this (especially for the water quality of the Danube).

2.4.1.1.2.2. Source in the Starovlaski Mountains

The study carried out by the “Jaroslav Cerni” Institute on the long term water requirements of Belgrade takes into account the use of the river basin of the Starovlaski Mountains, and in a series of analyzed variants this one got top priority for realization. The region of the Starovlaski Mountains has a very high specific outflow value – one of the highest in Serbia: 10-15 l/s/m^2. Around 300 million m^2/year could be secured for Belgrade (i.e. around 9.5 m^2/sec.). The water potentials of the waterways which drain the region of the Starovlaske Mountains are presented in Table 29.

Table 29. Potential of Waterways on the Territory of the Starovlaske Mountains

Waterway	Separation point	Area of River Basin F (км^2)	Median Flow Q_{cp} (м^3/с)	Low Water $Q_{95\%}$ (м^3/с)	Available Quantities Q (м^3/с)
Rzav	Arilje	564	7,97	1,06	4,00
Uvac	Kokin Brod	1.057	14,30	1,54	7,00
Lim	Prijepolje	3.160	81,90	9,80	
Kamenica	Rozci	200	1,60	0,10	0,75
Cemernica	G. Gornjevica	139	1,08	0,07	0,50
Dicina	Semedraz	204	1,50	0,10	0,75

The quality of these waters is among the best in Serbia. With planned technical solutions the waters of Uvac river, after the Kokin Brod system, would be directed toward the river basin of Veliki Rzav or Arilje, and would further continue toward Belgrade. The considered technical solution also estimates tapping of 11 m^3/sec. of which the "Rzava" water supply system would engage 2 m^3/sec., while the rest would be conducted for use in Belgrade. The transport of water to Belgrade is gravitational (from elevation point 375 m.a.s.l. to elevation point 104 m.a.s.l. at Banovo Brdo). Several paths for the intake have been considered: the length would be around 170 km (with 25% tunnel lengths – tunnel sections).

2.4.1.1.2.3. Drina River Source

The basic hydrologic characteristics of the Drina indicate that required quantities of water could be tapped (quantities being practically unlimited). We note that the geopolitical situation today is far less favorable than at the time when studies were conducted for a long range water supply for Belgrade.

2.4.1.1.3. Proposal for Activating Potential Water Sources

The previous sections presented an overview of potential water sources for the Belgrade Waterworks. A summary overview of potential water sources with potential capacities and required construction schedule follows:

Table 30. Overview of Potential Water Sources

	Groundwater	l/s		Surface Water	l/s
1.1.	Existing sources		2.1.	Existing Facilities on the Sava	2.500
	a) capacity circa	5.300	2.1. a	New Jezero Facility	1.000
	b) new capacities	1.200	2.1. б	Makis 2 Facility	2.000
1.2.	Great War Island	800	2.1. ц	Makis 3 Facility	2.000
1.3.	Artificial Infiltration	1.500	2.2.	Starovlaske Mountains	9.500
1.4.	Kupinski kut	3.500	2.3.	Drina	10.000
1.5.	Left Bank of Danube	3.000	2.3. a	Mlava	3.000
1.6.	Godomin	1.500			
1.7.	Macva	5.000			
	TOTAL:	21.800		TOTAL:	30.000

Based on the previous overview of potential water sources, Table 31 presents the proposed schedule for planned connection of water sources according to previously established phases.

Table 31. Schedule for Connecting Water Sources

Period	Capacities m^3/sec.			Proposal for Activating Water Source
	Required	Existing	New	
I 1995-2000.	8,5	7,5	1,0	"Jezero" Facility (1 m^3/sec.)
II 2000-2005.	10,0	8,0	2,0	"Makis 2" Facility (2 m^3/sec.)
III 2005-2010.	12,0	9,5	2,5	"Zidine" Infiltration (1,5 m^3/sec.) Great War Island (1,0 m^3/sec.)
IV 2010-2020.	14,0	11,5	3,5	Left Bank of Danube (1,5 m^3/sec.) Macva – Jarak (2 m^3/sec.)
V 2020-2050.	17,0	13,5	3,5	Kupinski kut (3,5 m^3/sec.)

After year 2050 activation of the waters sources of Godomin, Starovlaske mountains and Drina riverfront.

Table 32 presents the proposed schedule of planned construction and connection of water purification facilities which corresponds to the schedule of connecting water sources.

Table 32. Schedule for Connecting Facilities

Period	Capacity m³/sec.	Activation of Facility
I 1995-2000.	8,5	"Jezero" 1 m³/sec. (surface water)
II 2000-2005.	10,0	"Makis 2" 2 m³/sec. (surface water)
III 2005-2010.	12,0	"Bezanija 3" 2 m³/sec. + (groundwater)
IV 2010-2020.	14,0	"Danube-City I" 2 m³/sec. (gourndwtr.); +"Jarak" 1,7 m³/sec. (groundwtr.)
V 2020-2050.	17,0	"Makis III" 2 m³/sec. (surface water)
After 2050.		"Danube-City II" 2 m³/sec. (groundwtr.); + "Drina"- 4 m³/sec. (surface water)

2.4.1.2. Water Purification Facilities

The current capacities of the water purification facilities in Belgrade are:

a) Groundwater:		
- Bele vode	600 l/s	43.200 m³/day
- Banovo Brdo	4200 l/s	362.800 m³/day
- Bezanija	3200 l/s	276.480 m³/day
Total (a):	*8000 l/s*	*682.560 m³/day*
b) River water:		
- Bele vode	500 l/s	43.200 m³/day
- Makis	2.000 l/s	172.800 m³/day
- Jezero	1.000 l/s	86.400 m³/day
- Vinca	80 l/s	6.912 m³/day
Total (б):	*3.580 l/s*	*309.312 m³/day*
Sum Total (a + b):	*11.580 l/s*	*988.872 m³/day*

The applied technology of water purification facilities differs depending on the source of water being purified: groundwater or surface water. The capacities of the groundwater facilities are adequate for current requirements. However, the facilities are outdated and must be modernized.

The facilities for purification of river water are outdated (old fashioned – Bele Vode), but also include facilities of the highest technical level – Makis. Increase in the capacity of water purification facilities, as well as bringing existing facilities up to functional operational levels is planned according to the following program:

- Establishing the role of the "Bele vode" facility in the BWS system
- "Banovo brdo" and "Bezanija" groundwater facilities
- Surface water treatment facility at the "Makis" location.

2.4.1.2.1. Establishing the Role of the "Bele vode" Facility in the BWS System

The Development Department prepared a proposal with several variants for resolving this problem.

The existing distribution system of the Belgrade Waterworks is developed in such a way that the role of the "Bele Vode" facility, especially the pump stations, is very significant – especially during moments of disruption, when it is possible to direct appropriate quantities of water fairly quickly both to the first and second elevation zones.

For this reason the reconstruction and rebuilding of this Plant is necessary – for one of the roles which are specified in the project.

2.4.1.2.2. "Banovo brdo" and "Bezanija" Groundwater Facilities

The existing facilities must be urgently reconstructed and modernized, bringing their capacities up to levels specified in the project (7.9 m³/sec.).

It is estimated that the capacity of existing purification facilities is adequate for existing and some new water sources (War Island and Kupinski kut).

There is a dilemma about a water source on the left bank of the Danube – whether to build an expensive intake system of raw water under the Danube to “Bezanija” or whether it is more rational to build a facility together with the water source on the left bank, with an appropriate pump station which would direct water to the area of consumption (settlements on the left and right sides of the Danube).

The General Solution for the Waterworks of Belgrade (Energoprojekt, 1977) specifies the construction of the “Rit” purification facility, and the “Jaroslav Cerni” Institute also in the hydro technical project “Danube City” specifies the construction of a water purification facility on the left bank of the Danube – with significant advantages over the variant in which groundwater would be transported from this location to the facility in Bezanija.

2.4.1.2.3. Surface Water Treatment Facility at the “Makis” Location

The General Solution for the Waterworks of Belgrade (Energoprojekt, 1978) specifies an installation for purifying river water with a capacity of 6 m^3/sec. at the Makis location. In adopting the decision on building the purification plant “Makis 1” (1983) and because of public resistance, the position was taken that the quantity of river water must be limited, that is to say that the proportion of purified river water in the total water production should be kept at 30%. This criterion was also established in the Study on Ensuring Water for the Requirements of Belgrade (The Basis of Water Resource Management of Serbia).

Today’s “Makis” and “Bele Vode” river water treatment facilities produce between 3.0-3.5 m^3/sec. Water deficits can be eliminated through construction of the “Jezero” facility with a capacity of 1 m^3/sec.

2.4.2. DISTRIBUTION SYSTEM

The distribution system represents a part of the water supply system whose task is to transport, accumulate and distribute water to users (consumers), that is to say that the distribution system consists of: water supply network, “clean water” pump stations and reservoirs.

Because of its size and functioning the distribution system, in terms of structure of costs represents the biggest investment and exploitation cost, which is evident from the overview provided in Table 33 (1988, Public Enterprise “BWS”).

Table 33. Participation of Capital in Operating Assets

No.	Waterworks Facilities	% of capital in operating assets
1.	Capturing Facilities	29,94
2.	Purification Facilities	9,34
3.	Pump Stations	6,26
4.	Reservoirs	5,74
5.	Water Supply Network	48,72

From this Table it can easily be concluded that of the total value of all Belgrade Waterworks facilities (in 1988), 61% goes to the distribution system. This gives even greater importance to the problem of the distribution system.

The main tunnel intake (tunnel system T1) with pump stations is becoming a limiting factor in recent years for carrying water to the area of consumption. The capacity of existing pump stations in the tunnel is around 4,000 l/s, with the maximum capacity of the tunnel being only slightly higher. On days of maximum consumption this system becomes a bottleneck in the successfully supplying of the City with water.

The capacity of the system of facilities and pump stations on the left bank – “Bezanija” purification facility, “Bezanija” and “Studentski Grad” pump stations – amounts to 2,500 l/s.

The universal "Bele Vode" plant with pump stations (1a and 16) can direct 900-1000 l/s into the system.

The new facility, pump station "Zarkovo" (together with the reservoir) makes it possible to pump 500 l/s into the second and third zones. This suggests the conclusion that radical reconstruction of the distribution system is necessary in order for water distribution to be at the level of 12 – 17 m^3/sec.

2.4.2.1. Water Supply Network

Keeping in mind the hundred years of tradition it is necessary to use materials for the pipelines whose use will ensure longevity and functionality. The experience of foreign cities in the use of ductile pipes is stressed here, but not metal pipes (in zones of aggressive soil). It is assessed that the revitalization of old pipelines must begin immediately in order to secure the conducting power of "metal pipes". The same holds true where improvement of sanitary conditions is concerned. Revitalization of the pipeline today is carried out with exterior cement lining or plastic lining inside a pipe.

Pipelines are grouped according to function into:

- main intakes
- main pipelines and
- secondary networks.

2.4.2.1.1. Main Intakes

a) Connecting tunnel T1-T2 with connecting facilities on Banovo brdo and a chamber and reservoir on Julino brdo
b) Reconstruction of tunnel T1, construction of a facility for protection against hydraulic shocks – reservoir "Topcider" (which permits pump stations to work at higher capacities at times of maximum consumption)
c) Regional system "Makis-Mladenovac"
d) Main tunnel outtake: analysis indicates that it is not necessary in the coming future period to build the entire T2 tunnel system. However, in order to satisfy the requirements of the area of consumption for tunnel T1 it is necessary to build a new section of the tunnel Banovo brdo – Topcider Valley with a length of 2000 m (phase one of the T2 system) with a diameter of 2.5 m; pipeline ∅1500 mm from the exit of the tunnel to the PS "Topcider", around 1500 m; as well as a pipeline from PS "Topcider new" – "Dedinje" around 3 km, ∅1000 mm.
e) Rebuilding of phase two of the tunnel in New Belgrade from PS "Studentski grad" to PS "Zemun", ∅2000 mm, length 1100 m.

2.4.2.1.2. Main Pipelines

a) Pipeline "Makis" purification plant: ∅1200mm, 5,2 km
b) Pipeline PS "Topcider – new" – Dedinje: 3 km. ∅1000 mm,
c) Intake for zone I from reservoir "Pionir" to reservoir "Visnjica 1": ∅500 mm, 5,5 km,
d) Intake for zone I from reservoir "Zeleznik" to Umka: ∅500 mm, 11,5 km,
e) Connecting intake (left and right banks of Sava) Topcider – Ada Ciganlija – Tosin bunar: ∅800 mm, 4 km,
f) Connecting intake (left and right banks of Sava) Bele vode – Ada Ciganlija – Upper Zemun: ∅700 mm, 13 km,
g) Connecting intake (left and right bank) Zarkovo – Ostruznica – Surcin – Bezanija: ∅700mm, 20 km,
h) Intake for zone II Mirjevo to Gradac reservoir: 2 ∅500 mm, 5,4 km, construction to begin in 2006,
i) Pipeline PS "Vracar" – Slavija: ∅500 mm, 1,4 km, construction to begin in 2003,
j) Pipeline for zone II through Mokri lug Valley: ∅900/800 mm, 2.4 + 1.4 km, completed,
k) Pipeline PS "Bezanija" – area of consumption: ∅1200/1000 mm, 4.0 km, construction began in 2003,
l) Pipeline for zone III PS "Dedinje" – "Torlak" reservoir: ∅800mm, 4.6 km, nearing completion,
m) Pipeline New Belgrade – "Zvezda" reservoir: ∅800 mm, 1.5 km, planned for 2003-2005,
n) Pipeline PS "Vracar – Main": ∅500mm, 2.5 km, beginning of construction 2003,
o) Pipeline PS "Zeleznik" – reservoir "Lipovica", zone III, built in 2002,
p) Pipeline PS "Lipovica" – "Guncati" reservoir, zone IV, completed,

q) Pipeline Vinca-Zuce-Suplja stena, completed, party operating.
r) Pipeline over the old Sava bridge, ∅ 700 mm, planned for reconstruction in 2003-2004,
s) Pipeline "Stojcino brdo" reservoir – Mirjevo, zone III, beginning of construction in 2006,
t) Pipeline "Petlovo brdo" reservoir – Rusanj, beginning of construction in 2006.

2.4.2.1.3. Reconstruction of Network

Table 34 presents available data on frequency of cracked pipes in the cities of London, Vienna and Belgrade (excluding interventions on house installations). It provides a basis for assessing the non-functionality of the pipelines which are operating – and which need to be replaced.

Table 34. Network Disruptions

City	Year Lngth. of network (km)	Number of Disruption in an Average Year month. max.	 month. min.	 per year	No. of Disrupt. by km of ntwrk.
London	1978 16.000	January 600	April 100	2860	0,179
Vienna	1987 3.000	September 70	April 35	656	0,219
Belgrade	1987 1.827	January 225	July 195	2640	1,346

In Belgrade there are 615% more defects per kilometer of network than in Vienna, and as much as 753% more than in London.

Analysis of losses in the water supply system also indicate that the Belgrade Waterworks suffers from significant losses and that reconstruction of the network could significantly reduce losses (cases of Paris and Vienna).

A study of defects as a function of the materials used in the pipeline was conducted in Denmark and interesting information was arrived at: gray mould – 0.19 defects/km, modular mould – 0.04 defects/km, steel – 0.46 defects/km. The only drawback of this analysis is that the influence of the age of a pipeline was not taken into consideration.

Using the experiences outlined in the Distribution Committee (AQWA 1977) announcement presented in Table 35, the criteria for replacing – reconstructing existing pipelines can also be applied to the Belgrade Waterworks.

Table 35. Criteria for Replacing a Pipeline

Criteria	No.	%
Frequency of breakage	33	58
Condition of pipes	22	39
Age of pipes	20	35
Pipe diameter (increasing capacity)	16	28
Economic considerations	12	21
Position of pipe	11	19
Problem of water quality	6	11
Pipe materials	5	5

That is why established statistics which are collected for some time now and which are presented in Table 36 could present a basis for a water supply network for assessing conditions for reconstructing old outdated networks.

Table 36. Causes of Interventions on Pipeline

Description of intervention	*Meas. Unit*	*Years* ***1983.***	***1984.***	***1985.***	***1986.***	***1987.***	***1988.***	***1989.***	***1990.***
fixing pipeline	unit	1041	1104	425	1343	2083	2093	1431	1806
fixing joints	unit	1091	933	270	695	688	822	693	1183
fixing gate valves	unit	834	352	713	877	1066	732	722	1408
fixing hydrants	unit	759	787	531	494	654	441	587	954
fixing pipe joints	unit	899	1205	690	660	1132	584	630	1060
fixing valves	unit	6780	7523	390	362	649	936	1031	989

closing joints	unit	490	371	333	229	349	240	263	393
chng. butterfly on valve	unit	534	767	557	301	605	398	476	585
chng. gasket on joint	unit	738	1058	587	948	960	506	472	733
change of valve	unit	5543	4201	3920	3093	3500	2602	2300	3128
lifting cap on valve	unit	946	1535	817	726	963	1172	322	605
lifting cap on joint	unit	2006	2786	1421	806	896	992	553	804
cap on hydrant	unit	734	1189	575	484	676	717	204	713
road excavation	m3	4181	3738	3238	2201	4897	7241	5811	4489
soil excavation	m3	5894	1059	7642	12741	15325	14658	14115	18488
filling trench with gravel	m3	-	3634	3971	5114	7292	8345	6328	4569
filling soil from trench	m3	-	-	-	-	8913	7412	8175	7140
draining network	km	725	1059	1186	858	455	2299	3071	2172
replacement of meter	unit	21759	16277	12719	10620	17649	18326	13015	12371
fixing of meter	unit	18696	15806	15977	11767	16783	16823	16001	12954
Total interventions:	*unit*	*40355*	*32033*	*28696*	*22387*	*34432*	*35185*	*29016*	*25325*

According to rule, distribution systems are designed to last 30 to 50 years, with the note that in terms of investment costs a distribution systems amounts to at least 50-70% of total investments. However, where settlements grow at a rapid pace, a distribution system can become inadequate. As it is not economical to replace an existing distribution system with a new one, analyses are conducted for expanding or modifying the existing system. This is achieved in the following way:

a) by securing new “joints” in the system with reconstruction of pump stations,
b) by building new distribution pipelines or replacing existing ones (e.g. tunnel system of London and Belgrade, also).

In this sense data obtained from the city of Geneva is interesting where in the 60’s the effect of demographic explosion was met with the construction of new pipelines (2/3 new, 1/3 replaced), where since the 70’s the new network occupies only 1/3, while replacements represent 2/3 of the total of the newly constructed network.

Based on this it can be concluded that in the reconstruction of a facility in the distribution system of a waterworks (mainly network) the following parameters are of key importance:

- required quantities of water and
- construction costs.

In this sense, it is economically justified to replace a pipeline (if there are problems with it) when reconstructing a street, because 50% of the costs go on reconstructing the street.

In the distribution system of the Belgrade Waterworks the following should be reconstructed:

a) Raw water pipelines:
   - Right bank of Sava 2.0 km/year
   - left bank of Sava 2.5 km/year.

б) Water supply network
   - Based on specification and technical criteria with the objective of reducing water losses in the system. The Belgrade Waterworks has around 300 km of network which need to be replaced (“white pipes”), which amounts to 35 km per year, various diameters.

Table 37 presents technical information about waterworks systems of some European cities – compared with Belgrade.

Table 37. Technical Parameters of Distribution Systems

	Belgrade	Vienna	Budapest	Hamburg	Zurich	Paris	Sofia
No. of residents/km	671.5	505.8	515.2	360.9	340	681.9	375.0
Capacity m^3/km	288.8	184.5	293.5	78.4	75.5	246.9	181.9
No. of valves/km	5.62	31.90	5.83	9.80	37.80		
No. of connect./km	43.7	31.46	40.32	38.34	23.94	28.90	

The majority of IWSA member countries adopted their own standards for distribution systems, as well as technical rulebooks for drafting, construction and exploitation of the system. The Belgrade Waterworks, as the largest one in the country, should represent the base where such standards and rule books will be developed in our country, given its tradition and accumulated experience and potential.

The successful operation of a distribution system requires:

- automatic control of flow and pressure at various points in system,
- constant measuring of consumption,
- constant control of water levels in reservoirs.

2.4.2.2. Reservoirs

Reservoirs are hydro technical facilities which are used in a water supply system of a city as the basic elements of economic and exploitation rationalization and reliability. Today reservoir space in the Belgrade Waterworks System only covers 30% of daily consumption. Such a situation is unsatisfactory from all aspects.

Data from large European cities indicates the following:

- the degree of securing the reliability of the system through reservoir space differs (from 322% in Vienna to 32% in Belgrade),
- the average value of the volume of reservoir space in technically good systems, expressed in terms of maximum daily consumption, should amount to 77.3%, or 346 liters per resident.

Table 38. Volume of Reservoir Space

	Belgrade	Vienna	Budapest	Hamburg	Zurich	Paris	Sofia
Volume (l/res.)	148,4	939,5	132,7	176,4	389,1	521,7	275,0
% of max.daily consum.	32	322	24	65	34	120	45

The degree of security is defined as the proportion of "coverage" by the volume of a reservoir in a given zone (expressed in %) of maximum daily consumption in a year (e.g. in 1996 on October 12 maximum daily production was 683,728 m^3/day). Table 39 presents the degree of security according to elevation zones for that characteristic day.

Table 39. Degree of Security According to Zones

	Zone I	Zone II	Zone III	Zone IV
Volume of reservoirs in m^3	95.131	79.908	25.881	5.758
Consumption in zone in %	59	21	17	3
Consum. in zone on day of max. consum. m^3	403.852	145.409	120.069	14.398
Degree of system security by zones in %	23	55	21	40

The previous table indicates that zones I and II have the "calculated" smallest degree of system security and that is why all volumes need to be increased as a function of consumption.

That is why volume increase of 128,000 m^3 is planned, and around 60,000 m^3 in the tunnel.

a) "Rakovica" reservoir (in tunnel T2) 20,000 m^3
b) "Topcider" reservoir (in tunnel T1) 20,000 m^3
c) "Studentski grad" reservoir (in Bezanija tunnel) 20,000 m^3
d) "Topciderska zvezda" (I) 20,000 m^3 phase one 8,000 m^3
e) "Principal" reservoir (I) 20,000 m^3 phase one 10,000 m^3
f) "Studentski grad" water tower (I) 8,000 m^3
g) "Visnjisca" reservoir (I) 10,000 m^3 phase one 5,000 m^3
h) "Mokri lug hill" (II) 10,000 m^3

i) “Gradac” reservoir (II) 10,000 m^3
j) “Torlak” reservoir (III) 20,000 m^3

The functioning conditions of the existing reservoirs need to be improved (reconstruction of intakes and outtakes for improvement of hydraulic flow of water).

2.4.2.3. Pump Stations

2.4.2.3.1. A special program of reconstruction of existing pump stations is planned:

a) PS “Dedinje”, reconstruction planned until 2006.
b) PS “Topcider”, reconstruction planned until 2006.
c) PS “Bele Vode”, reconstruction planned until 2006.
d) PS “Pionir”, reconstruction partially complete, rest until 2006.
e) PS “Ripanj”, reconstruction completed 2000-2001.
f) PS “Surcin” raw, reconstruction planned until 2006.
g) PS “Principal” reconstruction completed 2000-2001.
h) PS “Vracar” reconstruction partially complete 2001.
i) PS “Studentski trg” reconstruction planned until 2006.
j) PS “Sabacka” reconstruction partially complete 2001.
k) PS “Bezanija A” (reconstruction under way)

2.4.2.3.2. Program of Construction of New Pump Stations

a) PS "Bezanija B " reconstruction under way,
b) PS "Zemun" (in "Bezanija" tunnel, completion after construction of tunnel)
c) PS "Topcider valley" (new in tunnel T2, after construction of tunnel T2)
d) "Staro Sajmiste" buster
e) "Vracar" – new until 2006.

2.5. WATER LOSSES AND THEIR REDUCTION IN THE BWS

One of the significant problems in the development of the distribution system in recent years is the reduction of water losses in the system.

The problem of every waterworks system is the loss of water in the system, for this is a regular occurrence in every waterworks system. This is also the case with Belgrade's system.

Analysis of the extent of water loss in waterworks systems indicates that it is possible to establish criteria for assessing operational rationality of a system as a function of the extent of losses.

Modern world practice indicates that the extent of losses can be reduced to 5% from a technical perspective, while economically there is no justification for losses greater than 15%.

Table 40 presents an overview of losses over time, based on the statistical-technical information from the Belgrade Waterworks.

Table 40. Water Losses in the BWS

Water Quantity Parameters	Year					
	1960.	1970.	1980.	1990.	1994.	2001.
Production in millions m^3/year	49.57	104.03	178.40	203.8	222.40	242.8
Consumption in millions m^3/year	37.94	79.80	141.15	161.78	164.05	233.0
Loss in system %	23.47	23.29	20.87	20.62	26.22	
System consumption %		4.06	4.41	3.51	2.83	4.03

The previous data indicates that there is considerable "room for improvement" in this area.

Drafting of a proper Program for Reducing Losses could postpone investments in construction of new capacities for water production (example of the city of Vienna – total production is constantly dropping since 1978 because of reduction in losses).

There are three aspects to water losses in waterworks systems:

- technical - sanitary
- economic and
- social – political.

Water losses represent a significant technical problem. It is assessed that the technical limit of magnitude of losses is 3-5%, while from a sanitary perspective it would be best to reduce losses to 0%.

The loss of water fundamentally represents an economic factor (the greater the loss, the less economical the system). Some studies (Petersin) indicate that investment in new capacities of 1 l/s are 10-40 times greater than investment necessary for reducing losses for the same quantity of water.

Water losses in waterworks systems in terms of cause and category are divided into:

- technical and
- administrative.

Only technical losses will be considered here.

Table 41 presents comparative data on water losses in waterworks systems of some characteristic cities.

Table 41. Water Losses in Certain Cities

City	Number of residents	Water Consum. m^3/day	Length of Netw. km	Losses (%) 1985.	Losses (%) 1990.	Special Loss m^3/hr km
Amsterdam	1,100,000	230,000	1,480	22	22	1.4
Vienna	1,500,000	441,000	3,072	12	9	0.6
Budapest	2,300,000	875,000	4,464	12	11	0.9
Belgrade	1,350,000	559,000	2,128	24	20	2.3
Brazilia	900,000	328,000	3,000	40	40	4.6
Zurich	400,000	202,000	1,085	10	3	0.6
Denver	1,005,000	712,000	3,200	15	15	1.4
Hamburg	1,950,000	430,000	5,402	4	3	0.1
London	6,000,000	2,020,000	16,000	19	19	1.0
Paris	2,100,000	800,000	3,373	20	12	1.2
Rio de Janeiro	4,200,000	2,365,000	6,400	30	30	4.6
Rome	3,000,000	1,534,000	3,700	25	25	4.3
Stockholm	1,930,000	385,000	1,710	21	21	2.0
Sao Paulo	9,000,000	1,975,000	2,300	30	30	10.7
Sofia	1,200,000	582,000	3,200	27	30	2.3
Tokyo	10,500,000	4,943,000	17,600	21	21	2.5

It is a foregone conclusion that if losses in the system are higher, the requirements of water treatment plants, pump stations and all other hydro technical facilities are higher. Hence the need for expanding the network appears earlier, which leads to greater costs of water production from an economic perspective, and hence to an increase in the price of water.

Furthermore, by reducing water losses, the necessity for new investments is also reduced, depreciation costs are reduced, as well as the costs of water production and distribution. In short, the selling price is lower.

Table 42 presents basic parameters of production and losses for seven waterworks systems on the territory of the former Yugoslavia, with the effects of a reduction in the dissipation of water of only 1% annually (for 1987).

Table 42. Effects of Reduction in Water Losses

Cities	Production m^3/day	Loss %	Prod.-Sales m^3/year	Price of Water din./м³	Value in din. for 1% loss
Belgrade	540.841	20,07	54.644.000	134,6	73.577.744
Zagreb	329.904	23,19	26.902.000	161,5	43.446.730
Ljubljana	132.757	30,90	15.009.000	328,5	49.304.560
Sarajevo	199.831	31,60	33.501.000	216,7	72.613.417
Skolje	220.852	20,57	38.451.000	202,5	77.863.275
Podgorica	56.690	51,00	3.919.000	120,0	4.702.800
Novi Sad	30.462	36,30	6.931.000	160,0	11.089.600

The investment costs for the production and delivery of 1 l/s of water (which is sufficient for supplying 200-250 residents) amount to around 20,000-25,000 US$.

Thorough analysis of investment programs and practical measures for reducing losses can lead to significant savings in business operations. The example of Belgrade indicates that it is more rational to reconstruct the water supply network than to invest in the construction of new facilities.

The saving of 100 l/s represents a reduction in investments of 2,000,000 – 2,500,000 US$, which permits the investment of funds into reconstruction of the water supply network, and that can certainly guarantee a reduction in losses of more than 2%.

Based on comparative indicators of water losses in the country and the world it is clear that the differences do not speak in favor of waterworks systems in the country. Losses are especially significant in large cities which points to the need (both economic and technical) for initiating extensive work on their reduction. Admittedly, these types of activities are already unfolding in many cities, which could be observed at many conferences and in publications, but they need to have the character of wider and more continuous action – in keeping with the significance of effects achieved in this way.

On the basis of data gathered in a survey of 81 cities in 15 countries, members of IWSA (International Waterworks Systems Association), Table 43 presents factors which influence the extent of losses.

43. Causes of Losses

Factor	No.	%
Ground mov't – settling	34	61
Pipe corrosion	25	45
Overload due to traffic	14	25
High pressure	12	21
Road construct., digging for other infrastructure	9	16
Age of pipes	9	16
Low temperatures	9	16
Pipe defects	6	11
Pipe joint damage	5	9
Ground conditions	4	7
Technical installation (incorrect)	2	4

Each of the listed factors can influence total technical loss of water in a waterworks system. For each of the factors modern science established certain technical measures for reducing this influence to a minimum.

Methods for reducing water losses in waterworks systems can be technical, financial, legislative and disciplinary. They are mutually connected.

In terms of locating and reducing losses there are two groups of methods for approaching this problem:

- Passive methods which include the reduction of losses, without control and
- Active methods such as
  - acoustic measurements
  - measurements of losses
  - water supply network analysis (hydraulic calculations)

In terms of measures taken in locating and reducing losses methods can be divided into direct and indirect methods:

- Direct
  - survey of water supply network
  - measuring of minimal consumption
  - lowering pressure in network
  - network reconstruction
- Indirect
  - water supply network analysis (hydraulic calculations)

In recent years domestic companies have appeared which manufacture equipment for regulating pressure. Pressure regulators operate on the principle of exploiting the potential energy of the water itself.

Given that losses are approximately proportional to the amount of pressure, there is a tendency for resolving the problem of water losses by maintaining minimal acceptable pressures. Of course, this is possible, but is not correct. It is more rational to invest the money which would be used for the purchase and subsequent, very expensive maintenance of this equipment, to invest it in fixing defects and network reconstruction. This is a permanent and certain way for reducing losses.

Experiences in Belgrade indicate that the previous criteria are correct. Concretely speaking, if the cost of pipeline maintenance per 1 km exceeds 7-10% of the value of the pipeline, with losses exceeding 0.8-1.0 m^3/hr., analysis of the technical-economic aspects of such reconstruction needs to be conducted.

While acknowledging all the criteria of rationalization, economic and technological-sanitary development, all modern methods for reducing technical water losses must be applied in the Belgrade Waterworks.

2.6. SYSTEM MODERNIZATION AND AUTOMATIZATION

The Belgrade water supply is very complex. This complexity consists of the following:

- facilities are removed from one another and spread out, but act as independent units,
- for optimum operation of the system it is necessary to have insight into the operation of all facilities.

The City's water supply system consists of the following facilities:

a) Capturing facilities – wells with raw water pipelines
b) Purification facilities
c) Pump stations
d) Water supply network
e) Reservoirs

In order to ensure a regular water supply for the City it is necessary to control the operation of these facilities, through remote control with optimizing of the operation of the entire system. The Belgrade Waterworks created the conception for its system control in the 60's, which means that more than 30 years have passed since "modernization and automatization".

The condition of the equipment for system control, signalization and automatic operation requires analysis of causes which have led to the current bad state:

- overly ambitious project, burdened with unnecessary protection and equipment which is "created for institutes" (sensitive but not sufficiently robust for operational use),
- complicated automatization process,
- poor equipment maintenance.

In the past 30 years of "BWS automatization" it has been established that the project needs to be modernized, but the concept should be retained.

Besides the use of modern technologies, modernization and automatization of the system should also strive for standardization of facilities in this technical area, with the objective of improving exploitation and maintenance of the system. Uniform automatization equipment for BWS facilities (wells, pump stations, reservoirs) should be as simple as possible, while being functional, reliable, easy to use and maintain.

Communications equipment evidently should be retained: telephone cables and UHF radio connections.

System modernization requires the drafting of projects which will solve the following problems:

a) Command-control center with local automatization equipment in facilities
b) Radio connections for verbal communication
c) Distributional regulation of equipment for closing and opening of valves from command center
d) Measuring technology intended for controlling the system
e) Providing facilities and services with modern equipment

3. PLAN OF PROJECTED COSTS OF WATERWORKS FACILITIES UP TO 2005

3.1. Introductory Explanation

Section 1.1.3 presented an overview of investments in waterworks facilities with a view to understanding investment activities in the previous period (1971-1995).

Since this is an initial version of the prospective program, the economic part does not include costs and the production price of water. After the list of necessary facilities is established, it is necessary to prepare an economic costs section with appropriate elements (operating power, production plan, energy, cost plan and price of water).

Here we present a summary of the economic analysis of variants prepared by the “Jaroslav Cerni” Waterworks Institute (with prices at the end of 1986).

1. Surface water - Makis
   - capacity 160×10^6 m^3/year
   - price 1.17 €/m^3
   - 1 m^3 installed capacity 0.17×10^9 €

2. Surface water - Arilje - 160 km.
   - capacity 150×10^6 m^3/year
   - price 1.35 €/m^3
   - 1 m^3 installed capacity 0.35×10^9 €

3. Groundwater – riverfront of Drina - Macva - 110 km
   - capacity 100×10^6 m^3/year
   - price 1.35 €/m^3
   - 1 m^3 installed capacity 0.35×10^9 €.

4. Groundwater – Godomin (Smederevo) - 60 km
   - capacity 65×10^6 m^3/year
   - 1 m^3 installed capacity 0.25×10^9 €.

The 1963 Decree on the Municipal Waterworks (Waterworks Monograph 1892-1975, p.76) for the first time defined the price of water according to the m^3 of consumed water. Together with the contribution for water meter maintenance it amounts to:

up to 50 m^3	2.0 din/m^3
50 - 100 m^3	2.5 din/m^3
over 100 m^3	3.5 din/m^3
river water	2.5 din/m^3

The following is an overview of prices according to type of work carried out on waterworks facilities and is used for approximate cost estimates (which will be carried out here).

3.1.1. WELL WITH HORIZONTAL DRAINS (PROISAG)

3.1.1.1 Well opening R = 2.5 m; H = 25 m

a)	Preparation	32,500 €
b)	Excavation of opening	2350 x 25 = 58,750 €
	Concrete	143,750 €
c)	Steel Cutter	31,000 €

3.1.1.2. Drains ∅ 500 - 3 x 50 m — 150 x 5,700 = 855,000 €

Total for well with horizontal drains — *1.088,500 €*

3.1.2. WATER PURIFICATION - FACILITIES

3.1.2.1. Construction part — 225 €/м^3

3.1.2.2. Equipment

Capacity l/s	100	500
Aeration, €	15,000	60,000
Fast filter, €	150,000	500,000
Ozonation, €	100,000	450,000
Chlorination, €	10,000	15,000
Mud treatment, €	25,000	125,000

3.1.2.3. Filter materials:

-quartz sand	120 €/м^3
-anthracite	210 €/м^3
-active carbon	600 €/м^3
-slag	130 €/м^3
-dolomite	225 €/м^3

3.1.3. RE-PUMPING OF WATER – PUMP STATIONS

3.1.3.1. Construction Part of Work

Capacity l/s	50	100	500
Constructed area €/m^3	750	1000	3750
Area costs €/m^3	250	225	200

3.1.3.2. Machine Technical Equipment

Capacity l/s	50	100	500
Aggregate, H = 50 m, €	5,500	10,500	16,500
Aggregate, H = 100 m, €	10,000	20,000	30,000
Installation, €	2,500	5,000	10,000

3.1.3.3. Hydraulic Equipment

Capacity l/s	50	100	500
Per aggregate, €/aggr.	5,000	25,000	100,000

3.1.3.4. Electrical Equipment

Capacity l/s	50	100	500
High, low voltage power substation €/unit	5.000	25.000	50.000
Command center, meter, regulator, €/unit	30.000	50.000	100.000
Diesel fuel aggregate, €/unit	40.000	60.000	120.000
Low voltage intake, €/m	28	47.5	750
High voltage intake (2000 V), €/m	30	30	30

3.1.4. WATER SUPPLY NETWORK

3.1.4.1. Excavation (15-20%) of the Price of Pipeline

Type of ground	topsoil I k	light II k	soft rock III k	heavy rock IV k
a) with machinery €/m^3	25	15	25	40
b) hand finishing €/m^3	25	35	35	70

3.1.4.2. Road braking 15 €/m^2

3.1.4.3. Road fixing

- asphalt surface		15 €/m^2
- cobble stones:	purchasing	25 €/m^2
	installation	15 €/m^2

3.1.4.4. Purchase, Transport, Laying of Pipes (€/m)

Type of ∅	80	100	200	300	400	500	600	700	800	900	1000	1200
Duct	24	27.5	53	79	117.5	165	200					
Steel, imported		28	40	48	62	75	87.5					
Steel, domestic						158	237.5	305.5	381.5	414	465	514
Asbest. cement		11.5	29	50	62.5	71						
PVC	8.5	10.5	28.5	46.5								

3.1.4.5. Accessories and fittings for main pipelines
upper price per meter increased by 5 - 10%

3.1.4.6. Tunnel with diameter 2.5 m with concrete covering 2,750 €/m

3.1.5. RESERVOIR (DUG IN)

3.1.5.1. Reservoir up to 5000 m^3 175 €/m^3

a) Valve chamber 200 €/ м^3

b) Hydro-machine equipment 100,000 €

3.1.5.2. Reservoir up to 10,000 m^3 150 €/m^3

a) Valve chamber 200 €/m^3

b) Hydro-machine equipment 200,000 €

APPROXIMATE COST ESTIMATE

3.2. SOURCE AND PRODUCTION FACILITIES

Name of Facility		***Value in € x 10^3***
3.2.1. Increasing the capacities of existing water sources		
3.2.1.1. Construction of 7 wells on the "Progar" location, 7 pcs. x 1,100,000 €/unit		7,700.-
3.2.1.2. Replenishing the waters sources with construction of pipeline 5 pcs. x 55 €/m x 1 km		275.-
Total		*79,750.-*
3.2.2. Construction of well on the Great War Island		
3.2.2.1. Construction of 7 wells on location "Progar" 7 pcs. x 1,100,000 €/unit		7,700.-
3.2.2.2. Construction of raw water pipeline (10km) which passes beneath the Danube 10 km x 600 €/m		6,000.-
3.2.2.3. Equipment at wells with energy installations		
- purchase of 7 aggregates	350,000 €	
- installation	35,000 €	
- machine equipment	175,000 €	
- electrical equipment	175,000 €	
- cables	750,000 €	1,500.-
Total		*15,200.-*
3.2.3. Artificial infiltration		
3.2.3.1. Construction of an infiltration test pool		
3.2.3.2. Construction of system for getting water		
- tapping facility 2.5 m^3/sec. from river with pipeline		5,000.-
- pretreatment facility with 2.5 m^3/sec.		6,000.-
- infiltration pool with land expropriation		25,000.-
- construction of well 12 × 1.25 10^6 €		15,000.-
Total		*51,000.-*
3.2.4. Kupinski kut water source		
3.2.4.1. Construction of raw water pipeline, phase one, 5 km x 0.6 10^6 €		3.000.-
3.2.4.2. Energy installations		****
3.2.4.3. Construction of well, 40 pcs. x 1.25 10^6 €		50.000.-
3.2.4.4. Expropriation, forest protection and access roads		****
3.2.5. Source on the left bank of the Danube		
3.2.5.1. Construction of raw water pipeline, 15 km x 0.6 10^6 €		9,000.-
3.2.5.2. Energy installations		10,000.-
3.2.5.3. Construction of well, 25 pcs. x 1.25 10^6 €		31,250.-
3.2.5.4. Pure water pipeline, expropriation, road with land development…		5,000.-
Total		*74,500.-*

Name of Facility	*Value in € x 10^3*
3.2.6. Godomin water source	
3.2.6.1. Construction of well with expropriation, 30 pcs. x 1.0 10^6 €	30,000.-
3.2.6.2. Construction of raw water pipeline, 15 pcs. x 0.6 10^6 €/km	9,000.-
3.2.6.3. Construction of Godomin-Belgrade pipeline, 65 km x 0.6 10^6 €/km	39,000.-
3.2.6.4. Purification station, pump station, reservoir,...	21,000.-
Total	*99,000.-*
3.2.7. Macva water source	
3.2.7.1. Construction of well with expropriation with raw water pipeline, 50 pcs. x 1.0 10^6 €	50,000.-
3.2.7.2. Purification station, pump station, energy installations, expropriation,....	32,500.-
3.2.7.3. Construction of intake pipeline, 110 km x 0.6 10^6 €/km	66,000.-
Total	*148,500.-*
3.2.8. Surface water sources on the territory of Belgrade	
3.2.8.1. Tapping facility	2,500.-
3.2.7.2. Purification facility, capacity 2 m^3/sec.	37,500.-
3.2.7.3. Construction of pipeline for delivering water	1,500.-
Total	*41,500.-*
3.2.9. Sumadija water source	
3.2.9.1. Construction of accumulation with expropriation	35,000.-
3.2.9.2. Purification facility, capacity 4-5 m^3/sec.	35,000.-
3.2.9.3. Construction of pipeline to Belgrade, 160 km x 0.75 10^6 €/km	120,000.-
Total	*190,000.-*
3.2.10. Reconstruction of existing water purification facilities	
3.2.10.1. Makis (ozonation, clearing, sedimentation)	5,500.-
3.2.10.2. Bele vode	5,000.-
3.2.10.3. Banovo brdo	10,000.-
3.2.10.4. Bezanija	5,000.-
3.2.10.5. Central - chlorification	3,250.-
Total	*28,500.-*

3.3. DISTRIBUTION SYSTEM

Name of Facility		***Value in € x 10³***
3.3.1.	**Principal intakes**	
3.3.1.1.	Connecting tunnel T1 - T2 with facilities	10,000.-
3.3.1.2.	Reconstruction of T1 tunnel	3,750.-
3.3.1.3.	Regional system Makis-Mladenovac	60,000.-
3.3.1.4.	Main tunnel T2 with pipeline	10,000.-
3.3.1.5.	Bezanija tunnel, phase two	5,000.-
	Total	*88,750.-*
3.3.2.	**Main intakes**	
3.3.2.1.	Pipeline PS Topcider (new) – Dedinje reservoir	750.-
3.3.2.2.	Zone one intake Pionir - Visnjica	800.-
3.3.2.3.	Intake Zeleznik - Umka	2,250.-
3.3.2.4.	Connecting intake for left and right banks of the Sava	1,600.-
3.3.2.5.	Connecting intake for Upper Zemun	5,500.-
3.3.2.6.	Connecting intake Zarkovo - Bezanija	8,500.-
3.3.2.7.	Zone two intake for Mirjevo	2,250.-
3.3.2.8.	Pipeline Vracar-Slavija	350.-
3.3.2.9.	Zone two pipeline Vracar – Makis	1,900.-
3.3.2.10.	Pipeline Bezanija to area of consumption	2,400.-
3.3.2.11.	Zone tree pipeline Dedinje-Torlak	1,850.-
3.3.2.12.	Pipeline New Belgrade - Zvezdara	550.-
3.3.2.13.	Pipeline Vracar - Principal	750.-
	Total	*29,450.-*
3.3.3.	**Network reconstruction**	
3.3.3.1.	Chlorination station (10 pcs.)	2,500.-
3.3.3.2.	Reconstruction of rundown water supply network, 30 km/year	5,000.-/year
3.3.3.3.	Reconstruction of raw water pipeline, 5 km/year	2,000.-/year
3.3.3.4.	Installation of new valves with rubber stoppers	2,500.-/year
3.3.4.	**Reservoirs**	
3.3.4.1.	Rakovica (on T2)	3,500.-
3.3.4.2.	Topcider (on T1)	4,000.-
3.3.4.3.	Studentski grad (Bezanija tunnel)	3,500.-
3.3.4.4.	Zvezdara	3,500.-
3.3.4.5.	Principal	5,000.-
3.3.4.6.	Studentski grad water tower	10,000.-
3.3.4.7.	Visnjica	1,750.-
3.3.4.8.	Mokri lug hill (II)	3,500.-
3.3.4.9.	Gradac (II)	1,750.-
3.3.4.10.	Torlak (III)	3,500.-
	Total	*43,500.-*

Name of Facility		***Value in € x 10^3***
3.3.5.	Pump stations	
3.3.5.1.	Reconstruction of existing PS	1,000.-
3.3.5.2.	Bezanija	2,500.-
3.3.5.3.	Zemun (on the Bezanija tunnel)	5,000.-
3.3.5.4.	Topcider A (new T2)	7,500.-
3.3.5.5.	Vracar – new	7,500.-
3.3.5.6.	“Staro sajmiste” buster	500.-
Total		*23,750.-*

3.4. MODERNIZATION AND AUTOMATIZATION OF THE BWS

Name of Facility	***Value in € x 10^3***
3.4.1. Modernization and automatization	
3.4.1.1. Command-control center with KKM	100.-
3.4.1.2. Software support with network	100.-
3.4.1.3. Distribution regulation equipment with commands in center (network fittings) (15 pcs./year=150 pcs., price 7,500 €/pc.	1,125.-
3.4.1.4. Local automatization equipment for facilities, (PS: 5,000 €/pc.; RB: 2,500 €/pc.) (20x5,000=100,000)+(100x2,500=250,000)	350.-
3.4.1.5. Radio equipment for verbal communication	
- 370 pcs. x 1,250 €/pc. 462,500	
- infrastructure 250,000	
- data transfer 180,000	
	892.5-
Total	*767.5-*
3.4.2. Modernization of water supply network plants	
3.4.2.1. Regulation valves, 250 pcs/year 250 x 2,500	625-
3.4.2.2. Air valves, 300 x 500	150.-
3.4.2.3. Valves (various), 600 x 500	300.-
3.4.2.4. Measuring equipment	
- 2 electromagnets	50.-
- 20 portable measuring units on wheels 20x5,000	100.-
- Mechanization (10 new machines)	500.-
Total	*1,750.-*
3.4.3. Production	
Total	*1,750.-*
3.4.4. Maintenance	
Total	*1,250.-*

4. SCHEDULE OF REALIZATION OF PLANNED ACTIVITIES

The plan of construction of facilities in the prospective period until 2005 is conceived as more ambitious for two basic reasons:

a) investments for fulfilling current requirements, with minimal reserves, that is to say resolution of “currently inadequate capacities” and
b) investments into new capacities with the objective of fulfilling the development of the city for the period in question.

The construction of all basic facilities of the waterworks system, from the water sources to the distribution system, is within the plan.

The interpretation of the schedule of investments presented in the tables takes into consideration the requirements and technical possibilities for construction.

Financial sources are a necessity for a successful water supply in the city, but there is no space for considering their availability.

4.1. SOURCE AND PRODUCTION CAPACITIES

An assessment of the required water quantities – source balance of requirements for water production for the period until 2050 was made on the basis of available technical documentation presented in section 2.2

However, the subject of this report is the prospective plan until 2005, so that offered estimates are in the service of meeting current requirements (covering “inadequate capacities”) and fulfilling the development plan for the City.

Today Belgrade is supplied 70% from groundwater sources along the riverfront area of the Sava river. In the past there was a constant battle to build the necessary number of wells, but no reserves have been secured in the water source capacities because of the drop in the source capacities of these capturing facilities. This quantity is limited to 30% of total water production in the Belgrade Waterworks System. Because of the untimely realization of groundwater sources in the period before 2000, surface water capacities will have to be increased.

Table 44 presents the balancing of required quantities with potential water sources.

Table 44. Balancing of Required Quantities of Water

Period	Type of well (l/sec)				Total
	groundwater		surface water		
1995 (I-VI)	4,958 l/s (70 %)		2,137 l/s (30 %)		7,096
1996-2000	Existing sources	1,000	Jezero Purif.Plant	1,000	
	Infiltration	500	Makis II Purif.Plant	1,000	
	Progar 7 well	4,500			
	Total:	*6,000*	*Total:*	*4,000*	*10,000*
2001-2005	Existing sources	800	Makis II Purif.Plant	1,000	
	Great War Island	1,500	Existing sources	4,000	
	Left bank of Danube	1,500			
	Kupinski kut	5,000			
	Total:	*8,800*	*Total:*	*5,000*	*13,800*

The previous table presents potential groundwater sources, even though technological-economic analysis has not provided unequivocal answers as to whether the offered solutions are optimal. However, the potential exists and is presented in section 2.4. Groundwater capacities range start with 15.3 m^3/sec.

4.2. DISTRIBUTION SYSTEM

It is necessary to construct a system of transport and distribution to users in order for the water supply of the City to be successful. The schedule of realization of facilities is in the service of delivering specific quantities of water.

Construction and rebuilding is also planned: main intakes, main pipelines, distribution network, reservoir space and pump stations in the distribution system.

4.3. MODERNIZATION AND AUTOMATIZATION OF THE BWS

A modern waterworks system of Belgrade must be modernized according to the following programming requirements:

- automatization of facilities with possibility of control from center
- development of radio system for the purpose of verbal communication
- enable control over the basic waterworks network system through distributional regulatory equipment.

Table 45. Investments for the Prospective Plan Until Year 2005 (in million €)

Pos.	Name of facility and capacity	Total	Schedule	
			1995-2000	2000-2005
1	**WATER SOURCE AND PRODUCTION CAPACITIES**	**520.4**	**395.0**	**125.0**
1.1.	Maintenance of existing capacities (regeneration and reconstruction)	90.0	80	10
1.2.	Construction of 7 wells (Progar)	20.0	20	-
1.3.	Artificial infiltration at Makis (2.4 m^3/sec.)	120.0	60	60
1.4.	Artificial infiltration of existing sources (1.0-1.5 m^3/sec.)	10.0	10	-
1.5.	Great War Island (800 l/s)	30.4	-	30.4
1.6.	Left bank of Danube, phase 1 (1.5 m^3/sec.)	80.0	80	-
1.7.	Kupinski kut, phase 1 (1.5 m^3/sec.)	100.0	100	-
1.8.	Jezero purification facility (1 m^3/sec.)	20.0	20	-
1.9.	Makis II purification facility (2 m^3/sec.)	50.0	25.0	25.0
2	**DISTRIBUTION SYSTEM**			
2.A.	*PRINCIPAL INTAKES*	*177.5*	*147.5*	*30*
2.1.	Connecting tunnel T1 - T2 with facilities	20.0	20	-
2.2.	Reconstruction of T1	7.5	7.500	-
2.3.	Regional system Makis-Mladenovac	120.0	120	-
2.4.	Main tunnel T2 (phase 1) with pipelines	20.0	-	20
2.5.	Bezanija tunnel phase 2	10.0	-	10
2.B.	*MAIN INTAKES*	*62.4*	*27.4*	*35.0*
2.6.	Pipeline PS Topcider - Dedinje	1.5	-	1.5
2.7.	Zone 1 intake Pionir-Visnjica	1.6	-	1.6
2.8.	Intake Zeleznik-Umka	4.5	4.500	-
2.9.	Connecting intake left-right bank of the Sava	3.2	-	3.2
2.10.	Connecting intake for Upper Zemun-Zarkovo	11.0	5.0	6.0
2.11.	Connecting intake Bezanija	17.0	3.0	14.0
2.12.	Zone 2 intake for Mirjevo	4.5	4.500	-
2.13.	Pipeline Vracar-Slavija	0.7	0.7	-
2.14.	Zone 2 pipeline Mokri lug valley	3.8	3.8	-
2.15.	Pipeline Bezanija to area of consumption	4.8	4.8	-
2.16.	Zone 3 pipeline Dedinje-Torlak	3.7	-	3.7
2.17.	Pipeline New Belgrade – Topciderska zvezda reservoir	1.1	1.1	-
2.18.	Pipeline Vracar – Brace Jerkovica reservoir	3.5	-	3.5
2.19	Pipeline Vracar - Principal	1.5	-	1.5
2.C.	*NETWORK RECONSTRUCTION*	*130*	*67.5*	*62.5*
2.20.	Chlorination station 15 km	5.0	5.0	-
2.21.	Reconstruction of water supply network 30 km/year	0.1	0.05	0.05
2.22.	Installation of fittings	25.0	12.5	12.5
2.D.	*RESERVOIRS*	*87.0*	*39.0*	*48.0*
2.23.	Rakovica (on T2)	7.0	-	7.0
2.24.	Topcider (on T1)	8.0	8.0	-
2.25.	Studentski grad (New Belgrade tunnel)	7.0	-	7.0
2.26.	Zvezdara	7.0	7.0	-
2.27.	Mokri lug 1.	7.0	-	7.0
2.28.	Principal – new	10	10	-
2.29.	Studentski grad water tower	20	-	20
2.30.	Visnjica	3.5	-	3.5
2.31.	Mokri lug hill 2	7.0	7.0	-
2.32.	Gradac 2	3.5	-	3.5
2.33.	Torlak 3	7.0	7.0	-
2.E.	*PUMP STATIONS*	*49.5*	*23.5*	*26.0*
2.34.	Reconstruction of existing PS	2.0	2.0	-
2.35.	Tasmajdan	1.500	1.5	-
2.36.	Bezanija	5.0	5.0	-
2.37.	Zemun (at the Bezanijska kosa tunnel)	10	-	10
2.38.	Topcider A (new on T2)	15.0	-	15.0
2.39.	Vracar – new	15.0	15.0	-
2.40.	"Staro Sajmiste" buster	1.0	-	1.0
3	**MODERNIZATION**	**13.7**	**6.8**	**6.8**

Table 46. Recapitulation of Investments in Waterworks Facilities Until 2005

Pos.	Name of facility	Total € X10^6	1995-2000 € X10^6	2000-2005 € X10^6
1	*Source and production capacities*	*260.2*	*197.5*	*62.7*
2	*Distribution system*	*253.2*	*152.5*	*100.8*
2.A.	Principal intakes	88.8	73.8	15.0
2.B.	Main intakes	31.2	13.7	17.5
2.C.	Network reconstruction	65.0	33.8	31.3
2.D.	Reservoirs	43.5	19.5	24.0
2.E.	Pump stations	24.8	11.8	13.0
3	*Modernization of facilities*	*6.9*	*3.4*	*3.4*
	TOTAL :	***520.3***	***353.4***	***166.9***

添付資料-3

ベオグラード市都市整備計画・上下水道管理計画

（Integrated Water Management）

6.2 Integrated Water Management

The notion of *integrated water management* is used in establishing the basic strategy of water use, water protection and protection from water, with its fundamental document being The Basis of Water Resource Management in the Republic of Serbia (Official Gazette of the Republic of Serbia, no. 11/2002).

The fundamental strategic goal of the basis of water resource management is defined in the Law on Waters (Official Gazette of the Republic of Serbia, no. 46/91, 53/93, 67/93, 48/94 and 54/96) as: "Maintenance and development of the water supply which insures the most effective and efficient technical, economic and environmental solutions for unified water management, protection from detrimental effects of water, water protection and water use."

Water management must be integrated, unified, complex and rational as part of integrated management, use and protection of all resources and potentials. To begin with it is necessary to recognize the existence of connections between various types of waters in cities and to accept the term urban waters from European practice as the basis for further work.

Urban waters consist of: drinking water (surface or groundwater sources, manufactured water, spent water); industrial-technical water (process water, cooling water, service water); used water (sanitary, industrial or agricultural origin); atmospheric water (channeled or freely moving on ground surface); waste water (used water mixed with atmospheric water); surface water in waterways (floods, water collectors); groundwater (seepage waters from water supply and sewage networks, alluvial, arterial waters from deep and deeper sources); water which is an element of the city environment or is used for recreation and sports.

Integrated management of urban waters in a city implies temporal and spatial management of elements of the water balance at the level of the corresponding sources, taking into account the interaction which exists between them. In the most general sense this represents water management in interaction with other elements of the living environment, where the living environment includes, besides the infrastructure of the city and the natural environment, also the entire social, economic and institutional environment.

Four groups of activities – legislative, institutional, economic and technical – are planned as part of the introduction of the concept of integrated water management in the City of Belgrade.

Legislative activities imply the gradual adjustment of our laws, regulations and procedures to the single package of European Union legal documents known under the name Acquis Communautaire. In Europe the issue of water falls under the domain of protection of the environment, where the Acquis include all directives, provisions and decisions adopted by the EU in the area of protection of the environment based on various agreements, laws, legal principles, legal interpretations and international agreements signed by the European Commission.

Institutional activities include preparations for transforming community enterprises in the city, as well as continued support for the development of an already established municipal institution with the objective of granting it a new mandate for urban water management. This change of mandate will permit the activation of certain, already existing but unused mechanisms for charging these new services.

Economic activities include the development and presence of economically sustainable mechanisms for financing services related to urban waters. Urban water management is not a social activity, but a service which costs.

Technical activities in the coming period include four basic types of actions: rebuilding of existing infrastructure, conclusion of initiated capital investments from the previous period, preparation of planning documentation for all areas of municipal waters in accordance with the integrated management concept, realization of plans within the realistic possibilities of the city.

6.2.1 Supplying the City With Drinking Water

It is estimated that today the Belgrade municipal water supply system supplies around 1,350,000 citizens, the majority of industrial companies and all municipal institutions. Total annual water production is approaching 250 million m^3. The Belgrade Water System (BWS) extends over an area of around 21,000 hectares, including, besides the central city zone, peripheral sections of suburban municipalities and is divided geographically into six subsystems: Srem, Zarkovo, Mladenovac, Central, Bolec and Banat Subsystems. Organizationally the municipal water supply system consists of five water production plants where water is purified – "Makis", "Bele vode", "Banovo brdo", "Bezanija" and "Vinca – prior to entering the distribution system.

The source of the Belgrade water system extends along the river bank of the Sava River, on the right bank from its mouth to Ostruznica (Ada Ciganlija and Makis, and to Kupinovo on the left bank of the Sava River). Today the water balance of the BWS draws on 60% groundwater from 47 pipe and 99 well sources with horizontal draining and 40% on the Sava and Danube Rivers. The water supply for the city is mainly based on one waterway – the Sava River. The source for the city of Pancevo is located on the territory of the Municipality of Palilula within city limits at the following locations: "Sibnica" source with capacity of around 70 l/s, "Filter" source with capacity of around 100 l/s, "Gradska Suma" source with capacity of around 200 l/s, "OB" wells with capacity of around 70 l/s, whose current condition and expansions are respected.

The available capacities of sources of the Belgrade water system are: around 5,000 l/s groundwater and 3,500 l/s river water, yielding a total of 8,500 l/s.

The total capacities of the water purifying plants for groundwater (Bele vode, Banovo brdo and Bezanija) are adequate, which cannot be said for their technical conditions, nor for their level of applied technologies. The total projected capacity for these three plants is 8,000 l/s, working capacity 6,800 l/s, with real capacities being only 5,300 l/s. The total capacities of the water purifying plants for river water (Bele vode, Makis, Jezero and Vinca) amount to 3,580 l/s, which is equal to their total working capacities.

Because of ground configurations the distribution system of the Belgrade water system is divided into five elevation zones which are distributed between elevation levels 70.00 and 325.00 m above sea level. The whole of zone one is a unified ring network extending from Batajnica to Kaludjerica, from Umka to Ovca and from Surcin to Visnjica. Zone two is for the biggest part connected into a single whole, excluding parts of the Barajevo system and upper parts of Umka. The third, fourth and fifth zones together make up around 15% of the total system and serve to supply the highest points in the city. Zone three consists of three subsystems: Kosutnjak subsystem (Kanarevo brdo, Petlovo brdo and Kosutnjak); Dedinje (Dedinje, Topcider); Zvezdara subsystem (Zvezdara, Kaludjerica, Mirjevo), while zone four developed in two directions: part of the southern Kumodraz system and zone five of Kumodraz. The Belgrade water systems has at its disposal 20 pump stations, another 99 pump stations for the Reni Well, 7 pump station facilities and 20 reservoirs of pure water. A list of basic

indicators for the Belgrade water system for year 2000 are presented in the following table.

Table 76: Basic Indicators for the Belgrade Water System for Year 2000

Average charged daily consumption per consumer	(l/s/day)	233
Average charged monthly consumption per household	(m^3/hse./mnth.)	22.8
Length of network per consumer	(m/consumer)	1.7
Length of network per connection	(m/connection)	20
Volume of reservoir space per consumer	(m^3/consumer)	0.17

The Belgrade water system (BWS) can be characterized as a system that up to now reliably supplied up to 95% of its users with drinking water. The following problems are currently recognized in planning the further development of the BWS:

- in recent years 5% of BWS consumers located in the highest and in suburban areas of the city regularly experience water supply problems in the summer months;
- the reliability of the water supply of the greater majority of consumers is steadily decreasing because of overexploitation of groundwater sources, loss of water in old pipes, inadequate capacities of main distribution directions, pump stations lack reserve aggregates during regular operation, the delay in expanding the volume of reservoirs, problems associated with the existence of illegal connections and improper use of water, as well as problems associated with disrespect for sanitary protection of sources;
- the equipment in the water purifying plants "Banovo brdo", "Bele vode" and "Vinca" is outdated and inadequate. It is necessary to reconstruct and modernize the water purifying plant "Banovo brdo" as soon as possible through installation of modern equipment. By building the new plant "Makis 2" conditions will be met for closing down the "Bele vode" and "Vinca" plants;
- the list is long of planned, but unrealized capital facilities of the BWS whose role and size is significant in the coming period.

6.2.1.1 Objectives

It is necessary in one sweeping move to bring the Belgrade water system up to the level of the actual demands of managing the basic production process, as well as to take account of the entire water supply system in terms of management. The intention is to establish the system in such a way that it can accommodate changes imposed by the development of the water system, as well as development of management technologies and techniques based on research, measurement and exchange of information within the BWS itself. The maximum exploitation of groundwater and surface water sources from the alluviums of the Sava and Danube rivers is a priority in supplying the city with water, with a dependence on sources that are protected by law from pollution through legal, urban and water supply system regulations. Additional required quantities will be supplied from large environmentally protected sources, as well as by using methods of artificial tapping.

Future water consumption will be established by measuring and balancing real consumption, especially industrial consumption. Water for technological requirements in the industry will be tapped from waterways and wells and will be regulated for repeated use with multiple use in technological processes.

6.2.1.2 Conception of Development

The solution to supplying the city with water is based on the construction of capital facilities for water supply, with securing of technological reserves of 10-20%, which will ensure a high degree of reliability in supplying the city with water in the long range. These facilities are above all else source facilities, revitalized facilities for groundwater purification, a second tunnel duct with accompanying facilities, as well as rebuilding and reconstruction of the distribution system.

Optimum solutions for the development of the water supply system must have a high degree of operational reliability and the option of connecting suburban municipalities to the central city system with the construction of a regional system. The program for revitalizing and modernizing existing sources and purification plants, constructing a new network and revitalizing and rebuilding the existing network, facilities and equipment of the distribution system, rebuilding to correct water loss, rationalization of water spending and construction of unrealized capital facilities of the BWS will be realized. The ratio of groundwater and river water sourcing will depend on future water consumption and technological-economic criteria in decision making.

6.2.1.3 Sources

The required quantities of water necessary for keeping up with the development of the city up to year 2006 will be secured through the use of the following sources:

a) Groundwater sources

Table 77: Groundwater Sources

Revitalization of existing sources at Makis, Ada Ciganlija and the riverbank area of the Sava River (water sourcing facilities, basin and riverbank);	200 l/s
Revitalization of the Sava Bay as an infiltration bay;	
Building of the "Usce" well along the right bank of the Danube and the left bank of the Sava rivers, if it is established that the supply of water and the quality of the tapped water are satisfactory;	100-150 l/s
Testing work on a source at the Jarak-Klenek location on the left bank of the Sava River (realization dependant on the quality of the tapped water and the source volume)	500-1500 l/s

The source potentials on the left bank of the Danube, the right bank of the Sava, the alluvium of Drina and systems listed in The Basis of Water Resource Management in the Republic of Serbia will be reserved and environmentally protected.

The areas of the Great War Island, Ada Ciganlija and the region of Makis are areas with current use and future potential for water resource management. The areas currently used by the Belgrade water system are the left and right banks of the Sava River, Ada Ciganlija and Makis, while the area of the Great War Island is yet to be activated.

b) Surface Waters
Building of the second phase of the "Makis" plant 2000 l/s

c) Environmental protection and construction of an infiltration system at the location "Zidine" on the left bank of the Danube with facilities and pipelines 500 l/s

The listed sources will be developed not only on the basis of their supply capacities, but also on the basis of technological-economic criteria which presume comparison with alternative solutions. The city will resolve its water requirements in its immediate surroundings. Prognostication of required water quantities for the entire BWS (which extends beyond the city limits) indicates that the median annual requirement will be around 8.2 m^3/s in 2006 and 9.0 m^3/s in 2021.

6.2.1.4 Water Purification Plants

The surface waters of the Sava and Danube rivers are purified at four locations whose production capacity has reached the volume of 3.5 m^3/s. The location of Makis will have its purification capacities secured for 5 m^3/s of surface water from the Sava River ("Makis I": 2 m^3/s, "Bay": 1 m^3/s and "Makis II": 2 m^3/s). Besides the construction of the second phase of "Makis", other plants will also be rebuilt and reconstructed using modern technologies.

6.2.1.5 Distribution System

In the previous twenty year period important hydrotechnical facilities have been built or their construction has begun. They are taken into account in the definition of the future concept of development. The backbone of the municipal distribution system will be constituted by the second tunnel duct. According to this development concept water will depart from the "Makis" complex in two direction. Part of the water will be channeled toward areas in the southern part of the city, toward the "Zarkovo" reservoir and beyond, toward the regional system Petlovo brdo-Mladenovac. The second, larger volume of water will be channeled for supplying the central part of the city, directed toward the second tunnel duct. The "Makis" and "Banovo brdo" plants will be brought up to the same hydraulic regimen which will create conditions for connecting the "Bezanija" plant into that system.

The reservoir capacities of the Belgrade water system today represent only 30% of maximum daily consumption. Building of additional reservoir space is necessary, so that the BWS should increase its reservoir space by 50% of maximum daily consumption. For this reason urgent rebuilding of existing and construction of new reservoirs is planned, along with reconstruction and building of pump stations.

Besides the development of the distribution system in the central city zone, the supply of water for suburban municipalities is also planned through the construction of parts of the distribution system toward the suburbs. The construction of a regional pipeline in the direction of Mladenovac which will supply 23 settlements has begun, with a length of 52 km and diameters

ranging from 1.200 mm to 800 mm. The beginning of this pipeline is in the "Petolovo brdo" reservoir, while its end is in the reservoir in Mladenovac. On the other side, the system on the left bank of the Sava River, in the western area beyond the limits of the City Plan, has been expanded to the settlements of Progar and Petrovcic.

The water supply system of the southern suburban direction which today supplies the municipalities of Cukarica and the entire municipalities of Barajevo is scheduled for major reconstruction with connection of the remaining settlements in the municipality of Barajevo and expansion of the pipeline further to the south, with connection of the system of peripheral villages in the municipalities of Obrenovac and Lazarevac. Also planned is connection with the water supply system of Pancevo and connection and expansion toward the region of "Eastern Srem". The municipal water system is getting a regional character which is the development strategy of the water supply according to The Basis of Water Resource Management in the Republic of Serbia.

The development of the Belgrade water system in the period up to 2021 includes: the opening of new sources (at the "Zidine" location on the left bank of the Danube, establishment of the new source Jarak-Klenak and testing of potentials for a source on the Great War Island which will not disturb the scenic environment), construction of new water purification facilities for drinking water (phase three of "Makis", Jarak-Klenak purification plant) and development of the distribution network (second tunnel duct, pipelines, pump stations and reservoirs).

6.2.2 Channeling of Atmospheric and Waste Waters

Today the Belgrade sewage system is developed over an area of more than 11,500 hectares and covers the area of old Belgrade, New Belgrade, Zemun and some settlements on the left bank of the Danube River. The sewage system is used for evacuating atmospheric and waste sanitary water, waste industrial water, as well as drainage water and waterway water. The sewage system empties into municipal waterways – the Sava and Danube rivers and other waterways – without any purification. The sewage system is of the mixed type – 40% is of the general type, while the newer portions of the city are channeled according to a separation system. The length of the network today amounts to over 1,500 km. Around 30% of the users of the municipal water supply do not have access to the sewage system. The degree of canalization of the connected territory of Belgrade in the inner city limits does not exceed 80% for used water and 65% for atmospheric water. The sewage system is developed according to five independent systems of which the "central" system is most developed.

A special problem are many unplanned urban settlements where there is no general solution for channeling waste water. The new General Project will provide solutions for these settlements, while settlements where the system is already implemented require modification.

Channeling of Waste Water

The most significant characteristic of the sewage system is that 25% of the population of Belgrade is still not connected to it. A certain number of streets in the very fabric of the city (municipalities of Vracar, Savski venac, Palilula, Vozdovac, Zvezdara, Cukarica, Zemun) are not connected to the sewage system. Suburban settlements such as Mali mokri lug, Kaludjerica, the majority of Kumodraz, Jajinci, the majority of Batajnica, Krnjaca, Ovca, Vinca, Lestane and the better part of settlements which were built according to no particular plan present a particular problem.

The situation in the sewage system is exceptionally difficult and can be described in the following way:

- the Belgrade sewage system has 24 outlets into municipal waterways, the Sava and Danube rivers, without any prior purification;
- the majority of the total of 37 pump stations of the sewage system are dilapidated, while some of them operate according to the status "provisional";
- in the Sava river there are 116 and in the Danube there are 136 direct outlets of waste water, along with a series of individual and grouped sewage systems emptying into small waterways and melioration channels;
- because the building of initiated capital sewage system facilities has not been completed, the water source zone of "Makis" is not protected from atmospheric waters;
- no environmentally protected solution has been reached for a dumping point for sewage cistern trucks carrying sewage;
- none of the five planned sewage treatment plants have been built;
- the maintenance of drainage shafts in city streets is inadequate because it is complicated by pronounced soil erosion and the way in which streets are cleaned;
- there are no large collectors, tunnels and pump stations;
- there are no facilities for transferring waste water from the Sava river into the Danube river, nor are there collectors-interceptors for channeling all municipal water for treatment.

Channeling of Atmospheric Water

Former brooks such as, for example, Mokri lug, Kumodraz, Banjica, Bulbuder and Cubura brooks are covered by wide roadways such as the Belgrade-Nis Highway, Bulevar JA, Cvijiceva Street and Juzni Bulevar, which has changed the natural course of atmospheric water outflows. The channeling of atmospheric water is not fully realized because roadway construction was not accompanied by the realization of appropriate rainwater facilities.

Atmospheric surface waters which are not planned for evacuation through the underground sewage system (known as internal waters) move through streets in an uncontrolled manner and create flood zones at the lowest points in the city.

6.2.2.1 Objectives

The fundamental strategic objective is to create a sewage system which will ensure long-range continuity in the operation of the system. Future development of the Belgrade sewage system needs to follow the direction of adapting existing concepts of development to the realistic financial possibilities of the city and, in accordance with this, toward the finishing of initiated but not completed facilities.

With the objective of applying modern sewage system solutions it is necessary to plan solutions for outflow surfaces, and hence treatment of water prior to its release into receptors. Planned development of the sewage system must continue within the framework of autonomous systems which should constitute a technical whole, concluding in a sewage treatment facility. This is why it is necessary to relocate the principal sewage outflows outside the city and to relocate sewage outflows in the Sava river to the Danube. Environmental protection of the "Makis" source zone must be carried out against atmospheric and surface waters, along with the development of the network and facilities for the Ostruznica sewage system.

In terms of establishing the volume of waste water it is necessary to establish continual measurement of the hydrologic and hydraulic characteristics of the sewage system, along with the measurement of the water quality at pump stations and at ejection points, balancing of volumes and of pollution, as well as mathematical modeling of the sewage system.

6.2.2.2 Conception of Development

It is planned that the city sewage system will develop within five large systems each of which will have one mechanical, biological and tertiary purifications treatment plants for sewage, as prescribed by the directive principles of the European Union in the area of water policy, which also covers the unloading of sewage cistern trucks. The following sewage systems are planned:

Central Sewage System

The central sewage system covers a significant territory of old Belgrade between the Denube and Sava rivers, to the water division in Kumodraz, Mali mokri lug and the left bank of the Sava river, New Belgrade and Zemun, all the way to the industrial zone. A key facility is an interceptor-collector which takes in water from the left and right banks of the Sava river and the right bank of the Danube and channels it to a water purification facility. Rainwater is released into the Sava and Danube rivers, that is to say into city waterways of the corresponding rivers. This system covers over 31,000 hectares of city territory. The central sewage system is a mixed channeling system, partly a general system (old city core) and partly a separation system (New Belgrade, Zemun and all newer settlements in the Sumadia parts of Belgrade).

In the portions where the channeling system is based on general principles of channeling it is planned to continue separating rainwater from wastewater using a system of overflowing facilities. In some parts of the city such as Dorcol and the old core of Zemun it is planned for the existing network of channels to be used for rainwater, while a new network will be built for wastewater. In some of the waterways planned retention facilities are planned after regulation in the upstream portions of waterways for the purpose of holding back a flood wave (Mirijevo, Mokri lug, Jelzovac, Zarkovo brooks, Kumodraz brook, as well as the Zeleznik river).

The protection of the “Makis” complex is planned through the construction of the rain collector “Padinski Channel”, the “Zeleznik-Sava” collector and the “Peripheral Channel” along the new Belgrade-Obrenovac highway.

Reducing the pressure on the Sava river from waste waters from the city sewage system from the territory of the Mokri lug brook, the Topcider river and the territory of Sremcica-Zeleznik-Zarkovo-Senjak is planned with the construction of the sewage facility or tunnels “Emergency Aid – Djure Djakovica”, as one possible option. The territory of the lower Sava river

zone is transferred into the Danube river through the already built pump station “Zeleznik” through the “Balkanska-Djure Djakovica” tunnel. The waste waters of the Zemun-New Belgrade part of the central system are brought to the pump station “Usce” which needs to be rebuilt and expanded. The collected water would be transferred to the right bank of the Sava river and further on to the future interceptor, from where waste water would be channeled to a sewage treatment facility.

Bolec Subsystem

This system covers over 10,000 hectares of city territory. It covers the area of the settlement of Kaludjerica, Vinca, Lestane and the Bolec Valley, as well as Beli potok, Zuce and Vinca. In phase one it would be a separate sewage system with a sewage treatment facility “Vinca” which would be built on the bank of the Bolecica river. In the final phase the possibility will be reviewed of conducting the more complex sewage treatment and sludge treatment in another facility. The sewage system would follow a separation system. Rainwater will be channeled to the Danube and waterways. Wastewater will be channeled to a collector which is planned in the valley of the Zavojnicka and Bolecica rivers, to the pump station “Vinca” and on to the sewage treatment facility.

Batajnica System

This system covers around 12,000 hectares of city territory. It covers the territory northwest of the settlement of “Galenika” with the settlements of Dobanovci, Ugrinovci, Batajnica, Zemun polje, the working zone of Surcin-Dobanovci, and the industrial zones of Upper Zemun and Surcin. The wastewaters of these settlements are brought to the collector pump stations “Batajnica” and “Zemun polje II” by a system of collectors and pump stations, from where they are channeled to the common sewage treatment facility “Batajnica” on the right bank of the Danube. The sewage system follows the separation system. Rainwater is channeled to the Danube and melioration channels. The release of rainwater which gravitates toward the source location on the left bank of the Sava river must be planned for purification in order to protect the source location and the Galovica Channel. It is necessary to provide environmental protection for the Galovica Channel which today represents a collector of the worst sewage from the territory of Surcin, the airport, etc.

Ostruznica System

This system covers around 6,500 hectares of city territory. It includes the territory south of Zeleznik with the settlements of Ostruznica, part of Sremcica, Mostanica, Umka, with the sewage treatment facility "Ostruznica". This location is upstream from the water source at Makis making sewage treatment and purification necessary. The sewage system follows the separation system. Rainwater is released into the Sava river and other waterways.

Banat System

This system covers around 12,000 hectares of city territory. It covers the territory with settlements on the left bank of the Danube river in the area of Banat, with Padinska Skela, Borca, Ovca, the industrial zone "Pancevacki rit", Krnjaca and Kotez. The sewage system is a separation system. Rainwater is drained in two ways: with a system of channels in local melioration channels and rainwater drains to the pump station "Reva", from where the water is emptied into the Danube. Sewage is brought to the sewage treatment facility "Krnjaca" using a system of channels-collectors and pump stations, and from there it is released into the Danube. This system is partly realized.

Because of the low elevation in the area of the left bank of the Danube which is subject to high groundwater levels it is necessary to undertake hydro-technical measures of uneven ground buttressing (minimal elevation 72.5-76 m above sea level), construction of hydro-technical drainage curtains, development of the "Reva" pond and reconstruction of the melioration system for accepting atmospheric water. Regular maintenance of operational functionality of the channel network is necessary, together with contact with the water carrying layer of ground until the final solution of buttressing is realized.

6.2.3 Development of Waterways

The territory covered by the General Plan includes the river waterways of Sava and the Danube with the river banks with a total area of around 10,000 ha, of which 6,800 ha are river banks and around 3,200 ha are water. The Sava river flows around 24 km and on city territory accepts water from 8 tributaries with very complex hydrographic networks, with a total length of around 160 km. The Danube river flows around 50 km and in this area of its flow accepts water from 8 tributaries, with a total hydrographic network

of around 115 km. The Tamis river is a bordering waterway with a length of 2.5 km.

The left banks of the Save and the Danube rivers (Sumadija section) are particularly characteristic with elevations that range from 69 to 300 m above sea level, for this part of the territory contains numerous flood flows of varying size and significance. They represent natural recipients of the surface waters of Belgrade: the Zeleznik river, the Topcider river, the Mirijevo brook, the Manastirski brook, the Kumodraz brook, the Bolecica river, etc. In the central area of the city rainwater is drained through a system of collectors whose principal directions nearly completely correspond to the topographic waterways of former brooks. Hence the collectors also carry the names of these brooks: Mokri lug collector, Kumodraz collector, Duboki potok collector, Cubura collector and Bulbuder collector.

On the territory covered by the General Plan, of the 115 km of riverbanks around 29 km include fortified riverbanks and quays, with primary emphasis on the central city area. On the left banks of the Sava, Danube and Tamis rivers the recipients are a network of melioration channels whose waters are pumped to the Sava and the Danube via pump stations. The main waterways are: Galovica, Petrac, Vizelj, Kalovit and Sibnica.

In terms of regulative construction on small waterways the work done includes modification of the riverbed of the Topcider river and its tributaries (Kaljevo, Rakovica, Kijev, Pariguz, Bel reka and Banjica brooks), the Bolec, Ostruznica and Zeleznica rivers with tributaries (Krusik and Manastirine) and the Mirijevo brook, with a length of around 55 km, with small accumulations in the Pariguz and Bela reka brooks.

Over 40% of the territory of Belgrade (the New Belgrade-Zemun and old Belgrade locker) is located in the lower riverbank areas of the Sava and Danube rivers, up to the elevation point of 77 m above sea level and are potentially exposed to the danger of flooding from catastrophically high flood flow levels of the Sava and the Danube. The City of Belgrade is not entirely protected against flooding. The old embankments which have not been reconstructed to meet planned protection levels could give way to flood flows or could be overflowed and lead to catastrophic consequences for the city. The lower parts of Zemun, New Belgrade, Stari grad and Makis would end up under several meters of water, including the entire Pancevo Marsh. There is still no comprehensive solution for eliminating the negative effects of flood flow levels on the riverbank areas (the lower plateaus of the riverbank along the Zemun quay are flooded and cannot be used, as well as parts of the right bank of the Sava river, nor are there systems in place for protection against groundwater, etc.).

6.2.3.1 Objectives

In the area of development of river basins, regulation of waterways and melioration channels top priority will go to reconstruction and expansion of existing systems, adaptation for use and construction of the most rational types of systems.

Defense against flooding in small waterways will be realizable within integrated systems of active protection through retentions and accumulations, reducing flood flow waves and through passive protection in building linear systems of protection. On the large waterways of the Sava, Danube and Tisa rivers flood protection will take place through the reconstruction and building of linear systems of protection. Protection measures will be carried out and water quality levels will be improved up to prescribed levels (II A and II B), with quality of surface waters and protection of groundwater quality. The priority in water management is rationalization of water consumption and multiple use of water in technological processes. Anti-erosion construction will be undertaken in river basins prone to erosion with the objective of protecting soil and water management facilities, with reconstruction and operational level rebuilding and revitalizing of facilities which are used for protection against erosion and flooding.

6.2.3.2 Conception of Development

The development and building of a system of protection is carried out with the objective of reconstructing and rebuilding facilities for protection against floods in the riverbank areas of the Sava, Danube and Tamis rivers from the influences of the thermoelectrical dam "Djerdap" under operating conditions of elevations above 69.6 m above sea level in sections of the riverbank area where the appropriate level of protection has not been achieved. The established criteria for setting the dimensions of the defensive facilities on the territory of Belgrade are functional for flood flows whose probability of occurrence is once in a hundred years (1%), while additional elevations would secure protection for a period of 500 to 1000 years (0.2-0.1%). The indicative calculated level at the mouth is an elevation of 76 m above sea level. Exceeding of the indicative levels for flood flows in protective embankments on the Danube amounts to 1.5-1.7 m, and for embankments along the Sava and Tamis rivers, 1.2-1.5 m. For quay walls the protective elevation ranges between 0.5 and 1.2 m.

In the next planning period the existing criteria for protection facilities against floods on the Sava, Danube and Tamis rivers will be retained. The regulation lines defined for low water will be retained (with eventual minimal corrections), keeping in mind that accompanying natural embankments have been formed, facilities have been built, as well as waterways, which does not exclude different urban solutions along riverbank areas.

The first regulation line for small waters which is appropriate for 290 days per year in terms of time is determined by the level of the outer edge of the footing of embankments at the elevation level of 70.5 m above sea level. The second regulation line has been adopted as a level which is appropriate for water levels that lasts for 20 days and prescribes the level of the first embankment of riverbank protection at the elevation of 73.5 m above sea level. The third regulation line, the line for flood flows and protection against floods, is adapted to conditions in certain riverbank areas, with the establishment of continuity and functionality during protection against floods. In terms of elevation levels it ranges between 76.5 and 77.5 m above sea level.

In the development of small waterways it is proposed that existing criteria be retained for profiling dimensions for handling flood flows, depending on the riverbank areas which are being protected. The incidence period is most frequently one hundred years for urban and industrial areas or smaller (probability 2% or 5%) for other areas.

The protection, maintenance and development of the use of waters will exclusively be planned according to natural wholes, i.e. according to river basin areas or portions of waterways, keeping in mind nature and its tendencies. One of the priorities of urban policy is the maintenance of the natural valleys of small waterways, that is to say their revitalization. In this sense natural development of the river basins of waterways is an objective, with the use of appropriate biological-technical measures in river basin areas and the formation of retention facilities and multi-purpose accumulation areas.

6.2.4 Maintenance and Development of Water Use

The waters of the Sava and the Danube bring pollution to Belgrade from settlements and industries located upstream, with the territory of the city being an additional burden on them with technological, sanitary and waste waters, as well as atmospheric waters. The city waste water flows into natural recipients, most frequently without prior treatment. In the waters of the Sava and the Danube the most frequent difference in quality with respect to prescribed values relates to suspended matter and organic pollution, as well as consequences of intensive erosion processes in river banks and large quantities of waste waters rich with organic materials. The water quality in the Topcider, Zelesnik and Bolec rivers is very poor because of the waste waters which are ejected into them. The Galovica channel in southeastern Srem which passes through Belgrade's environmentally protected water sources is burdened by high levels of organic and microbiological pollution for some time now. The channels in the Pancevo Swamp (Kalovita, Sibnica and Vizelj channels) are under the direct influence of the waste waters of the BWS, with the ejection of sanitary used waters being on the rise also.

The waters of the recreational and sourcing complex of Ada Ciganlija are not exceeding accepted values for chemical and microbiological pollution. The characteristics of the groundwater in the alluvial sediments of the Sava river are conditioned by the quality of surface water, given that there is direct hydraulic connection between the river basin and the riverbank area. Because of the overlap between the protection zone of wells in the riverbank area and previously built roadways, very jagged condition of the sources and collision with the fabric of the city, there is increased risk of pollution of groundwater, accompanied by the fact that required environmental protection measures for this type of terrain are not being respected. The available measures for management of the quantity and quality of the urban waters balance with a view to protecting and developing water use on the territory of Belgrade in the future are both structural (reconstruction and development) and organizational.

The planned solutions of the principal strategy of maintenance and development of water use are:

- Protection against pollution is implemented as a concept which equally respects and demands maintenance of recipients, surface and all groundwater and requires control of effluents. The *first measure* would be the cleaning and protection of the area from illegal dumping, cleaning and development of natural waterways and open channel networks, construction of the sewage system network, primarily in areas where high groundwater levels result in the mixing of septic tank contents with groundwater, and building of the rest of the sewage system network with sewage treatment and purification facilities and equipment for local treatment of sewage.
- Water management should be conducted according to natural river basin territorial wholes – water territories.

- Control should be established over balanced water stocks within which integrated consumption management would be exercised with protection of water resources, based on the concept of sustainable development.
- Rational use of water should be defined as the fulfilling of minimally regulated hygienic-sanitary requirements of consumers in terms of quantity and quality, with reduction of losses.
- Public participation through raising of public awareness about the need for rational water use and protection of water from pollution.
- Protection from water, both surface and groundwater, should be developed through the establishment of protection criteria by zoning potentially threatened areas and regulation of the conditions and manner of their use.

6.2.5 Additional Water Supplies

The area west of the Sava and the Danube is characterized by a sandy plateau, as well as an alluvial construction which is dominated by the settlements of New Belgrade, Zemun, Bezanij, Surcin and Batajnica. From the perspective of groundwater presence this area is characterized by the first source level formed in alluvial sediments along the Sava and Danube riverbanks at the depths of 30-40 m, and less often even deeper. Exploitation facilities which draw water from these source levels represent the backbone of the water supply of Belgrade.

As part of the deeper water carrying strata which have also been observed in this area, with numerous water supplying facilities captured at depths over 150 m, significant quantities of quality water can be secured. Depending on location, the number and depth of water carrying strata which can be captured, as well as the technical characteristics of the water supplying facilities, it is possible to draw between 6-12 l/sec. The quality of drawn waters in this area is relatively good, while in the areas of alluvial sediments, especially in the areas of deep well complexes in New Belgrade and Zemu, decrease in water quality has been observed.

The terrain on the left bank of the Danube and the territory north from it, up to the city limits, represents the alluvial plateau of the Danube and Tamis rivers. It is dominated by the settlements of Ovca, Borca and Krnjaca, as well as by numerous agricultural and industrial centers. This terrain is characterized by "initial" source levels formed within gravelly-sandy sediments at depths between 25-45 m. These sources are rich with water and the facilities which tap them on the average, depending on location and type of well, yield 8-12 l/sec per facility.

Between 40 and 120 meters there are several water containing strata of different thickness which can yield, depending on location and the number of captured strata and type of well, water quantities between 5 to 8 l/sec. per facility.

Within the “initial source levels” tapped in this area the water quality is, as a rule, poor which is conditioned by the presence of numerous polluters in this area. With treatment these waters can be brought to a level of quality which would permit them to be used for water supplying, and also, with minimal treatment or even without it, they can be used as technological water for industry or for irrigating large agricultural surfaces.

By contrast with the waters from this source level, the waters drawn from deeper water carrying strata are of a good quality and because of geological conditions are practically not in danger of being polluted, which means that with appropriate standard treatment they can be used for water supplying.

The area south of the Danube and the Sava is fairly complex from a hydrologic perspective and has not been sufficiently tested.

The city core is mostly densely developed and populated, which represents the principal limiting factor which in this area practically makes it impossible to draw water for different uses. The hydrogeological characteristics of this terrain permit the tapping of significant quantities of water, which has been practically achieved with several wells which draw water from water sources formed within lime sediments for use by the BIP breweries “Mostar” and Skadarlija, where the tapped water is bottled, which is a sufficient indicator of its quality. The capacities of these wells range between 2 to more than 10 l/sec. of drinking water.

South of the Danube and the Sava, in the area dominated by the settlements of Vinca, Kaludjerica, the settlements at the foot of the Avala Mountain, Cremcica, Umka, etc., in certain areas significant quantities of water can be drawn from deep sources which could be used for supplying this area with water, as well as for technological purposes, for irrigating agricultural areas.

The presence of lime has been established on the territory of Zeleznik with the territory of Cukarica and Kijev, the Kumodraz brook, and the zones of Visnjica and Lestani. In these locations these sediments have been drilled to

depths of 100 m, while construction of wells would permit drawing of water from 3 to 10 l/sec.

Along the Belgrade-Nis highway, in the Zavojnica river valley, downstream from the toll booth, the presence of sandy sediments has been established. They are located at depths in excess of 100 m. For this source individual well facilities could be constructed with a capacity of 3-5 l/sec. The quality of this water makes it usable both in the water supply, as well as for technological purposes.

The area on the right bank of the Danube, from the mouth of the Sava to Ada Huja and the alluvial strata of the area of Veliko selo are specific not for their hydrologic conditions, but for the use of this area which constitutes the industrial city zone. In this area a water rich source was formed within alluvial sediments which is tapped for use by particular industrial facilities through exploitation facilities. These facilities yield between 5 to 10 l/sec., depending on location and technical characteristics. The alluvial sediments in the Veliko selo area are at a depth of 20 m and are fitted for drawing groundwater which can be used as technical water. The estimated water supply of these sources could yield 5-10 l/sed.

6.2.6 Presence of Mineral, Thermal and Thermomineral Waters

Besides water supplies special attention on the territory of Belgrade should be given to the results of many years of geothermal testing which point to the geothermal potentials of the central and wider territory of Belgrade. It should be pointed out that mineral and thermal waters in this area are still insufficiently tested. On the territory of the municipality of Zemun the presence of thermal waters has been established, while in the municipality of Stari Grad the presence of groundwater thermal waters has been established, while in the municipality of Palilula there is a mineral water source in Visnjicka Banja, in Ovca thermomineral waters flow freely with no organized use where only the local population exploit this, while in the municipality of Vozdovac the appearance of warm water was registered in the settlement of “Brace Jerkovic”, with the water freely flowing with no organized exploitation, while in the municipality of Grocka thermomineral water is present in Bolec, Ritopek, Lestani, Vinca, Vrcin, in the Zavojnicka river valley along the Belgrade-Nis highway, while in the eastern foothills of the Avala mountain the presence of thermal waters has been registered.

添付資料-4（1）

セルビア国飲料水水質基準

List I

MICROBIOLOGICAL PROPERTIES OF POTABLE WATER

ord. No.	Microorganism kind	purified and disinfected water and water bottled at the spring	natural water	
			closed sources	open sources
1.	Bacteria of the Salmonella specie, Shigella specie, Vibrio cholerae and other pathogenic microorganisms, coliform bacteria and streptococcus of fecal origin, proteus species, pseudomonas aeruginosa			
2.	intestine protozoa, intestine helminths and their developmental forms	must not contain		
3.	Vibriones			
4.	Bacteriophaga			
5.	Algae and other organisms which can change water looks, smell and taste			
6.	Aerobe mesophyle bacteria on agar after 48 hours incubation at 310.16°K (36°C) in 1 ml of water up to	10*	100	300
7.	Total coliform bacteria determined as the most probable number (MPN) in 100 ml of water up to	0	10	100
	Total coliform bacteria determined by the membrane-filter method in 100 ml of water up to	0	5	10
8.	Sulfite reducing clostridia in 100 ml of water up to	0	1	10
9.	Number of infectious units of enterovirus in 10 l of water	zero	one	one

List II

MICROBIOLOGICAL PROPERTIES OF POTABLE WATER UNDER EXTRAORDINARY CIRCUMSTANCE

	total number of aerobe mesophyle bacteria in 1 ml	total number of coliform bacteria determined as MPN in 100 ml
Purified and disinfected water and bottled water	up to 10	up to 10
Chlorinated water irrelevant of the origin	up to 100	up to 20
Natural water from closed sources	up to 100	up to 50
Natural water from open sources	up to 300	up to 100

List IIIa

MAXIMUM PERMISSIBLE CONCENTRATIONS OF INORGANIC SUBSTANCE IN POTABLE WATER (mg/l)

Description and designation of the chemical substance	Maximum permissible concentration under normal circumstance
Ammonium (NH3)	0.1*
Antimony (Sb)	0.003
Arsenic (As)	0.01
Copper (Cu)	2.0
Barium (Ba)	0.7
Borium (B)	0.3
Cyanides (CN)	0.05
Zinc (Zn)	3.0
Fluorides (F)	1.2
Chrome, total (Cr)	0.05
Chlorides (Cl)	200
Cadmium (Cd)	0.003
Calcium (Ca)	200.0
Potassium (K)	12.0
Magnesium (Mg)	50.0
Manganese (Mn)	0.05**
Molybdenum (Mo)	0.07
Sodium (Na)	150.0
Nickel (Ni)	0.02
Nitrates (NO3)	50.0
Nitrites (NO2)	0.03**
Lead (Pb)	0.01
Selenium (Se)	0.01
Mercury (Hg)	0.001

* for Waterworks to 5,000 ES up to 1 mg/l

** the water is considered satisfactory in case that in 20% of non-subsequent measurements in the course of the year the concentration level does not reach 0.1 mg/l. Measurement frequency according to the effective Regulation.

List IIIb

MAXIMUM PERMISSIBLE CONCENTRATIONS OF ORGANIC SUBSTANCE IN POTABLE WATER (mg/l)

Substance	Under normal circumstance
Aromatic carbohydrates	
Benzol	0.001
Ethyl-benzol	0.002
Xylol	0.05
Styrol	0.2
toluene	0.7
Polycyclic aromatic carbohydrates (RAN)	
Total 1	0.0002
Benzol(a)pyrene	0.00001
Chorinated alkanes	
1.1 - dichlorethane	-
1.2 - dichlorethane	0.003
dichlormethane	0.02
1.i.1 - trichlorethane	Note 2
Carbon-tetrachloride	0.005
Chlorinated benzols	
Monochlorbenzol	0.3
1.2 - dichlorbenzol	Note 1
1.4 - dichlorbenzol	-
1.4 - dichlorbenzol	0.3
Trichlorbenzol	0,02
Chlorinated ethenes	
1.1 - dichloretene	0.03
1.2 - dichloretene	0.05
Tetrachloretene	0.04
Trichloretene	0.07
Vinyl chloride	0.0005
Other	
Dialkyltines	-
Di-2-ethylhexil Adipinat	0.08
Di-2-ethyl phthalat	0.008
Epichlorhydrin	0.0004
Ethylene diamine tetraacetate acid EDTA	0.2
Hexachlorbutadien	0.0006
Nitrile triacetate acid	0.20.2
Tributoinoxin	0.002
Mineral oils 4	0.01
Oils and fats 4	0.1
PCB 2	0.0005
Phenols 3	0.001
Detergents (anions)	0.1
Orthophosphates	0.15

1) Polycyclic aromatic hydrocarbonates (PAH). referent substances :
- fluoroanthene
- benzo-3,4-fluoranthene
- benzo-11,12-fluoranthene
- benzo-1, 12-perylene
- indeno-(1,2,3-cd)-pyrene

2) Concerns the following: (2 chlorobophenyl 2,3-dichlorobiphenyl, 2,4,5-trichlorobiphenyl, 2,2,4,4-tetrachlorobiphenyl, 2,2,3,4,6-pentachlorobiphenyl, 2,2,4,4,5,6-hexachlorobiphenyl, 2,2,3,3,4,4,6-heptachlorobiphenyl, 2,2,3,3,5,5,6,6-anthochlorobiphenyl)

3) Phenolic matter reacting with 4-amino antipyrine

4) After extraction in carbon tetrachloride

List IIIa

MAXIMUM PERMISSIBLE CONCENTRATIONS OF PESTICIDES IN POTABLE WATER µg/l

Substance	Under normal circumstance
TOTAL	0.5
Alchlor	0.1
Aldrin	0.03
Dieldrin	0.1
Atrazine	0.1
Bentazone	0.1
DDT	0.1
2.4-D-hexachlorbenzol	0.01
heptachlor epoxy	0.03
chlortoluron	0.1
isoproturon	0.1
carbofuran	0.1
lindan	0.1
MCRA	0.1
methoalchlor	0.1
molinate	0.1
pendimetalin	0.1
pentachlorophenol	0.1
permetrine	0.1
piridit	0.1
simazin	0.1
trifluralin	0.1
chlorophenoxy herbicides different from 2.3-D and MCRA 2.D-dichlorprop	0.1

* It is required to determine only those pesticides which are in use and influence the source

List IV

PERMISSIBLE CONCENTRATION OF COAGULATION AND FLOCCULATION AGENTS IN POTABLE WATER mg/l

Substance	Under normal circumstance
Aluminum	0.2
Iron	0.3
Acrylamide	0.00025
Epichlorhydrin	0.0004

List V

PERMISSIBLE CONCENTRATION OF DISINFECTING AGENTS AND INCIDENTAL DISINFECTION PRODUCTS mg/l

Substance	Under normal circumstance
Disinfecting agents	
Chlorine	?
Chlorine dioxide	?
Residuals of disinfecting agents	
Residual chlorine, free	up to 0.5
Incidental disinfection products	
Bromate	0,01
Formaldechyde	0.9
Halogenated acetonitrile	
- Dibromacetonitrile	0.1
-Dichloracetonitrile	0.09
- Trichloracetonitrile	0.001
Chloralhydrate	0.01
Chlorine cyan (like CN)	0.05
2.4.6-trichlorophenol	0.02
Chlorite	0.2
Chlorinated acetate acids	
- Dichloroacetic acid	0.05
- Trichloroacetic acid	
Trichloromethanes	
- Dibromo-chloromethane	0.01
- Bromoform	0.015*
- Dibromo-chloromethane	
- Chloroform	0.04*

* The samples for these parameters are taken after any time of chlorine action and at the outlet from the water treatment plant. The values for the bromo-dichloromethane concentration may be increased to 0.025 mg/l is the chloroform concentration is reduced to 0.03 mg/l.

List VI

PHYSICAL, PHYSICO-CHEMICAL AND CHEMICAL PROPERTIES OF THE POTABLE WATER WHICH MAY CAUSE THE CONSUMER COMPLAINTS

ord. no.	Parameters	Maximum permissible value of concentration
		normal circumstances
		purified water
1.	Color	5 grades of cobalt platinum scale
2.	Smell and taste	none
3.	Turbidity	up to 1 NTU *
4.	Hydrogen ions concentration (pH)	6.8 - 8.5
5.	Oxidability (mg KMnO4/l)	up to 8 **
6.	Conductivity (µScm at 20°C)	up to 1000
7.	Temperature	source temperature or lower
8.	Dissolved oxygen (% saturation)	50 ***
9.	Sulfates	250 ****
10.	Hydrogen sulphide	without ****
11.	Total organic carbon	-

* For waterworks supplying population up to 5,000 the turbidity up to 5 NTU (mefelometric turbidity unit) is allowed

List VII

MAXIMUM PERMISSIBLE VALUES OF PHYSICAL, PHYSICO-CHEMICAL AND CHEMICAL PARAMETERS IN POTABLE WATER UNDER EXTRAORDINARY CIRCUMSTANCES

Parameter	Unit of measure	Value
Turbidity	NTU	6
Color	cobalt-platinum scale grade	50
KMnO4 consumption	mgKNO4/l	12
Electrical conductivity at 293.16 K (20°C)	µScm-1	2500
Oxygen saturation at 293.16 K (20°C)	%	50
Chlorine, residual free*	mg/l	1.0

* in waters disinfected with chlorine or chlorine compounds

List VIII

RADIOACTIVE PROPERTIES POTABLE WATER PERMISSIBLE LEVELS OF α-ACTIVITY AND TOTAL β-ACTIVITY

Type of radioactivity	Bq/l Notes a and b
Total α-Activity	0.1
Total β-Activity	1.0

a If the specific activity of α and/or β unstable radionuclides are higher from those listed a detailed analysis of the radionuclide content is required

b Higher values of specific activity of α and/or β unstable radionuclides does not mean automatically that the water is not for human use.

The parameters for basic and periodic analyses according to the Statute on teh Hygienic Safety of Drinking Water (The Official Gazette of the FRY 42/98)

PHYSICO-CHEMICAL PARAMETERS BASIC ANALYSES

- TEMPERATURE
- COLOUR
- SMELL
- TASTE
- TURBIDITY
- pH
- $KMnO_4$ CONSUMPTION
- FREE CHLORINE
- CHLORIDES
- AMMONIA
- NITRITE
- NITRATE
- RESIDUE FUMES
- ELECTRIC CONDUCTIVITY
- IRON
- MANGANESE
- SPECIFIC EXPECTED MATTERS

PHYSICO-CHEMICAL PARAMETERS PERIODIC ANALYSES

- TEMPERATURE
- COLOUR
- SMELL
- TASTE
- TURBIDITY
- pH
- $KMnO_4$ CONSUMPTION
- FREE CHLORINE
- CHLORIDES
- AMMONIA
- NITRITE
- NITRATE
- RESIDUE FUMES
- ELECTRIC CONDUCTIVITY
- IRON
- MANGANESE
- SPECIFIC EXPECTED MATTERS
- FLUORIDES
- DETERGENTS
- PHENOLS
- COAGULATING AGENTS (Al)
- MINERAL OILS
- DISINFECTION BY PRODUCTS (THM)
- %OXYGEN SATURATION

MICROBIOLOGICAL PARAMETERS

- TOTAL COLIFORM BACTERIA
- COLIFORM BACTERIA OF FAECAL ORIGIN
- TOTAL No. OF AEROBIC MESOPHYLIC BACTERIA
- STREPTOCOCCI OF FAECAL ORIGIN
- SULPHITOREDUCTIVE CLOSTRIDIA
- PROTEUS SPECIES
- PSEUDOMONAS AERUGINOSA
- BOWEL PROTOSOE AND HELMINTHS AND THEIR DEVELOPMENTAL FORMS

OFFICIAL GAZETTE
OF THE FEDERAL REPUBLIC OF YUGOSLAVIA *(No. 42/98)*

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EXCERPT FROM THE

REGULATION ON SANITARY REQUIREMENTS FOR POTABLE WATER

Article 1

By this Regulation the sanitary requirements for the potable water used for public supply or production of foods intended for the sale (hereinafter: the potable water) are prescribed.

... omitted as irrelevant ...

添付資料-4（2）

地下水及び表流水の水質試験結果

T9

WATER QUALITY

Water quality data of Sava river (WTP Makis inlet- raw water and after the treatment- potable water)
Samples were taken and analyzed on March, 12, 2001 by Sanitary Control of BVK.

Parameters	River water	Potable water
Date	3/12/2001	3/12/2001
Temperature C^0	10	10.5
Turbidity NTU	9.6	0.16
Colour (Pt-Co color units)	30	5
pH value	7.8	7.4
Conductivity μS/cm	320	320
Total Solids mg/l	230	214
Fixed Total Solids mg/l	-	-
Suspended Solids mg/l	20	-
Settleable Solids mg/l	-	-
KMn O_4 demand	8.2	3.2
Ammonia mg/l	<0.05	<0.05
Nitrite mg/l	0.02	<0.05
Nitrate as N mg/l	4.4	4.9
Free chlorine mg/l	-	0.45
Total chlorine mg/l	-	0.55
Chlorides mg/l	9	10
Fluorides mg/l	<0.06	0.17
Alkalinity mE/l	3.2	3
Total hardness ^{0}dH	10.64	10.19
Carbonate hardness ^{0}dH	8.96	8.4
Calcium mg/l	60	54.2
Magnesium mg/l	12.13	10.8
Bicarbonates mg/l	195.2	183
Sufates mg/l	17	24
Phosphorus P_2O_5 mg/l	0.037	<0.01
Silicates SiO_2	-	5
Oxygene mg/l	9.2	-
Total Iron mg/l	0.09	<0.05
Manganese mg/l	<0.05	<0.05
ABS mg/l	<0.01	-
Phenol mg/l	<0.001	<0.001
Chrome mg/l	<0.01	<0.01
UV extinction	0.069	0.012

Heterotrophic plate count in 1 ml	24000	∅
MPN of coliforms in 100 ml	96000	∅
Identified bacteria	E.coli, Cittrobacter, Strepto "0"	-
Sulfate- reducing Clostridia in 1l		∅

Water quality data of Makis groundwater from tube wells
Samples were taken and analyzed on March, 12, 2001 by Sanitary Control of BVK.

Parameters	Groundwater	Potable treated groundwater WTP Bele vode
Date	3/12/2001	3/12/2001
Temperature C^0	14.4	12.1
Turbidity NTU	8	0.51
Colour (Pt-Co color units)	30	5
pH value	7.2	7.7
Conductivity μS/cm	550	440
KMn O_4 demand	3.2	3.4
Ammonia mg/l	0.4	<0.05
Nitrite mg/l	0.007	<0.005
Nitrate as N mg/l	3.1	3.5
Free chlorine mg/l	-	0.45
Total chlorine mg/l	-	0.55
Chlorides mg/l	14	14
Fluorides mg/l	0.16	0.17
Alkalinity mE/l	5.4	4.2
Total hardness ^{0}dH	17.58	14
Carbonate hardness ^{0}dH	15.12	11.76
Calcium mg/l	80	72
Magnesium mg/l	23.6	7.6
Bicarbonates mg/l	329	256
Sufates mg/l	31.6	20
Phosphorus P_2O_5 mg/l	0.032	<0.01
Silicates SiO_2	10	7.5
Total Iron mg/l	2.6	<0.05
Manganese mg/l	0.25	<0.05
Phenol mg/l	<0.001	<0.001
Chrome mg/l	<0.01	<0.01
UV extinction	0.029	0.018
Heterotrophic plate count in 1 ml	∅	∅
MPN of coliforms in 100 ml	∅	∅
Identified bacteria	-	-
Sulfate- reducing Clostridia in 1l	∅	∅