社会開発調査部報告書

JAPAN INTERNATIONAL COOPERATION AGENCY

No. 2

MINISTRY OF AGRICULTURE, WATER MANAGEMENT AND FORESTRY
BOSNIA AND HERZEGOVINA

THE FEASIBILITY STUDY ON THE WASTEWATER TREATMENT PLANT OF SARAJEVO CITY IN BOSNIA AND HERZEGOVINA

FINAL REPORT

VOLUME Ⅳ : APPENDIX

NOVEMBER 1999

TOKYO ENGINEERING CONSULTANTS CO., LTD.
NIHON SUIDO CONSULTANTS CO., LTD.

JAPAN INTERNATIONAL COOPERATION AGENCY

MINISTRY OF AGRICULTURE, WATER MANAGEMENT AND FORESTRY
BOSNIA AND HERZEGOVINA

THE FEASIBILITY STUDY ON THE WASTEWATER TREATMENT PLANT OF SARAJEVO CITY IN BOSNIA AND HERZEGOVINA

FINAL REPORT

VOLUME Ⅳ : APPENDIX

NOVEMBER 1999

TOKYO ENGINEERING CONSULTANTS CO., LTD.
NIHON SUIDO CONSULTANTS CO., LTD.

THE FEASIBILITY STUDY
ON
THE WASTEWATER TREATMENT PLANT
OF
SARAJEVO CITY
IN
BOSNIA AND HERZEGOVINA

FINAL REPORT

CONSTITUENT VOLUMES

VOLUME Ⅰ	SUMMARY REPORT
VOLUME Ⅱ	MAIN REPORT
VOLUME Ⅲ	ASSESSMENT WORK REPORT
VOLUME Ⅳ	APPENDIX

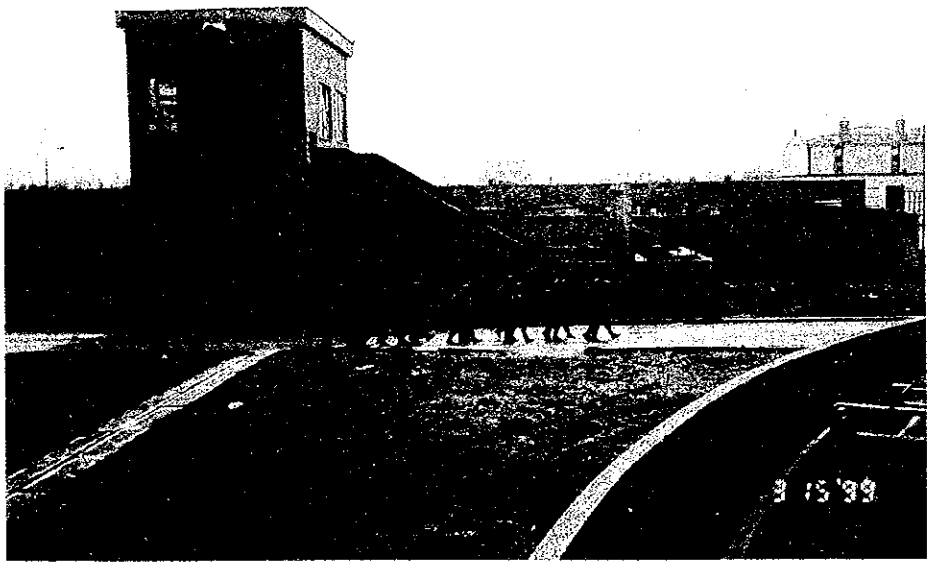
EXCHANGE RATE

KM 1.00 = DEM 1.00 = JPY 71.20

(Status as of 24 May 1999)

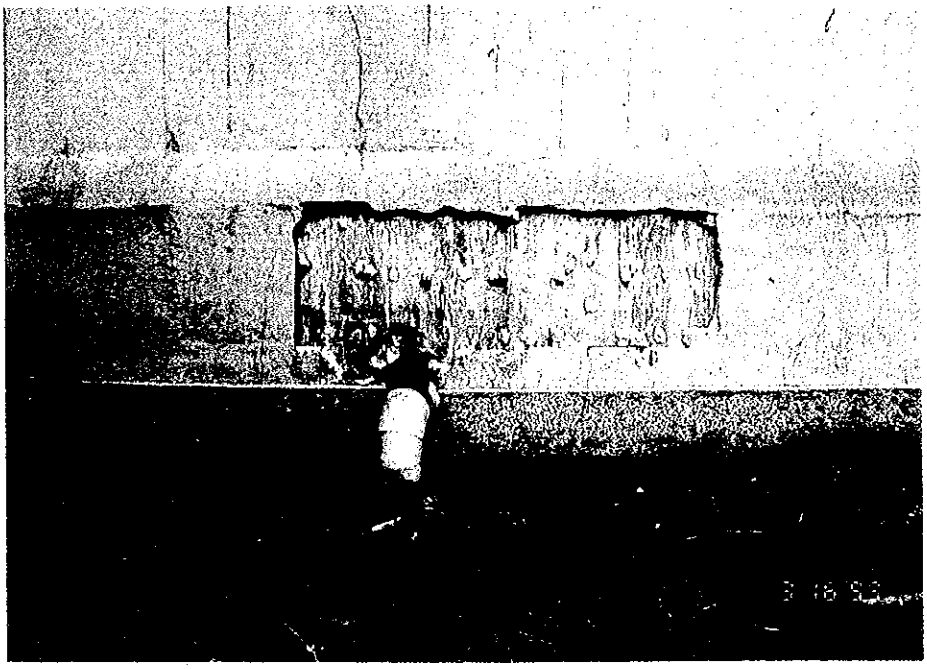
LIST OF APPENDIX

A. PHOTOGRAPHS OF ASSESSMENT OF THE SITE

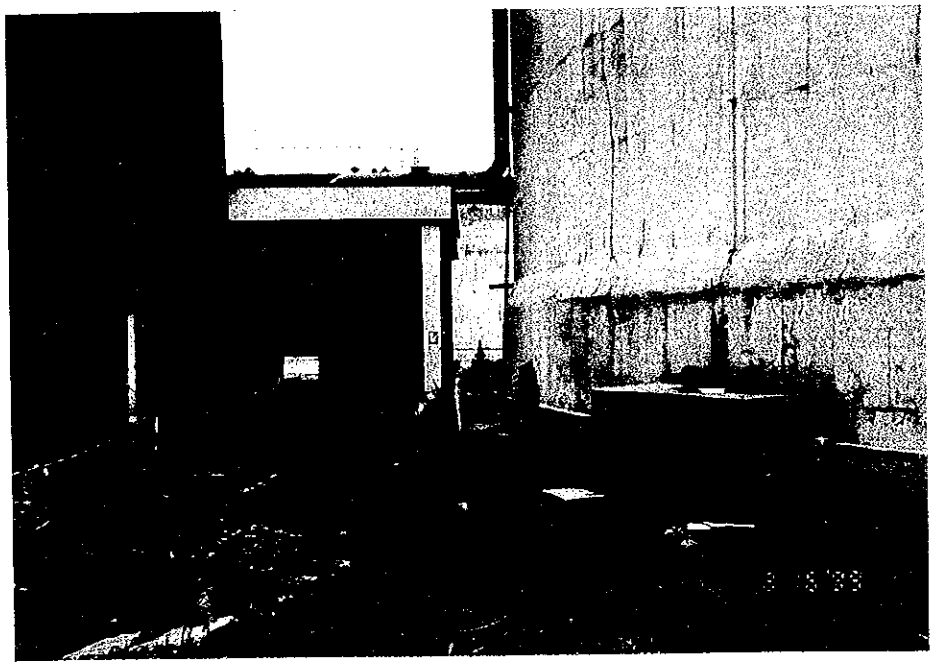


APPENDIX A. PHOTOGRAPHS OF ASSESSMENT OF THE SITE

1. BUTILA WASTEWATER TREATMENT PLANT



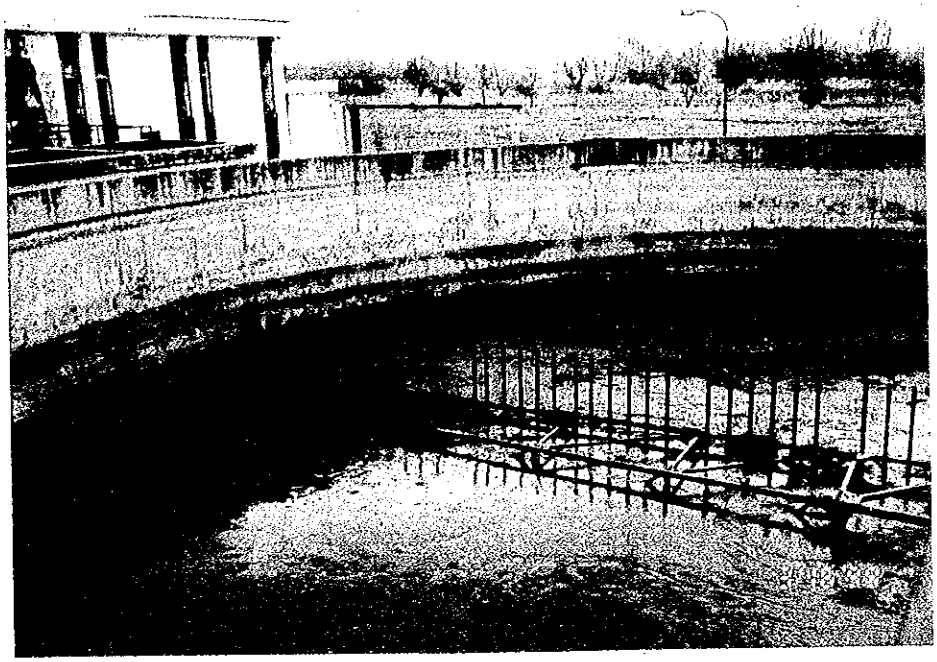
Deteriorated Insulation Wall at Digestion Tank



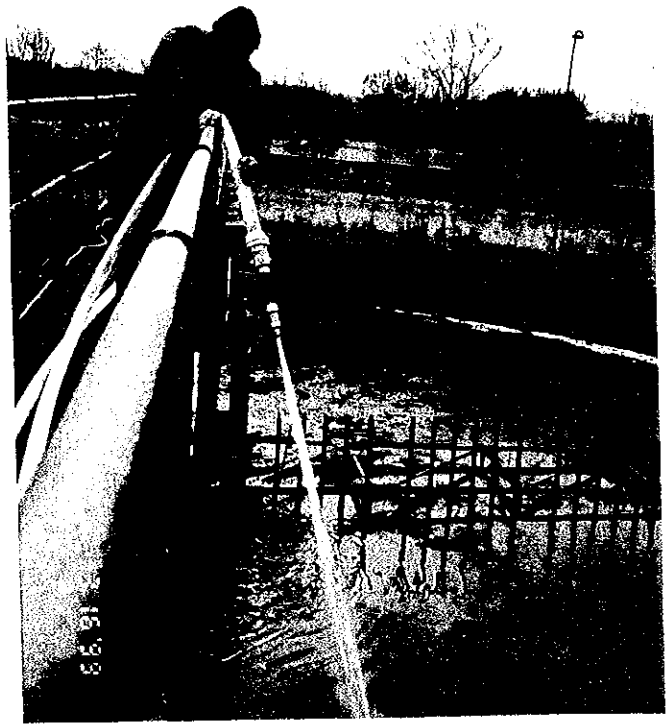
Current Situation of Mechanical Piping at Digestion Tank

Inlet Chamber of Butila WWTP

Deteriorated Slab at Aeration Tank



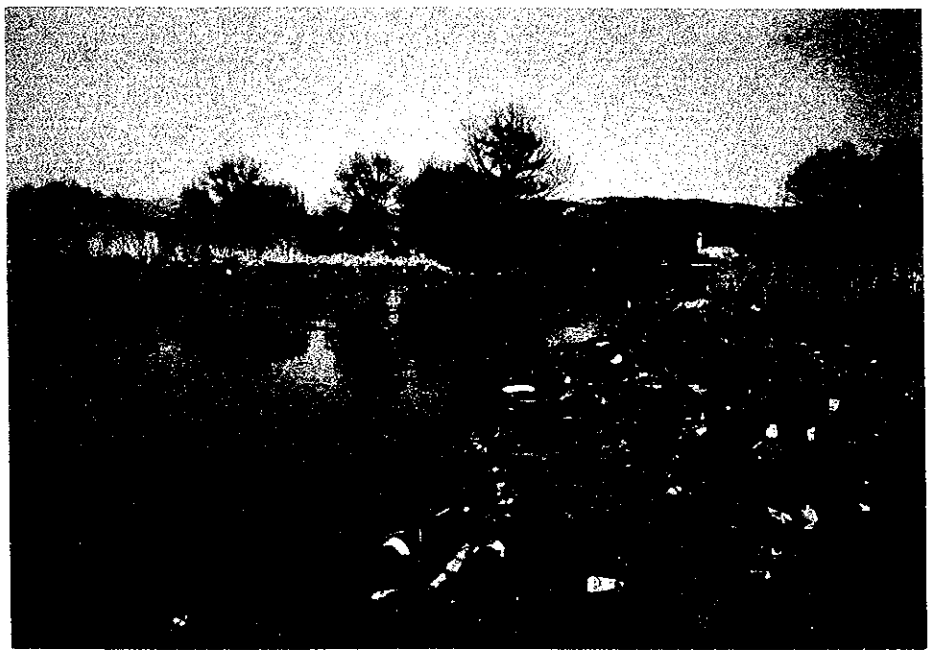
Accumulation of Digested Sludge in Sludge Holding Tank



Cleaning of Sludge Holding Tank

2. WATER QUALITY TESTING

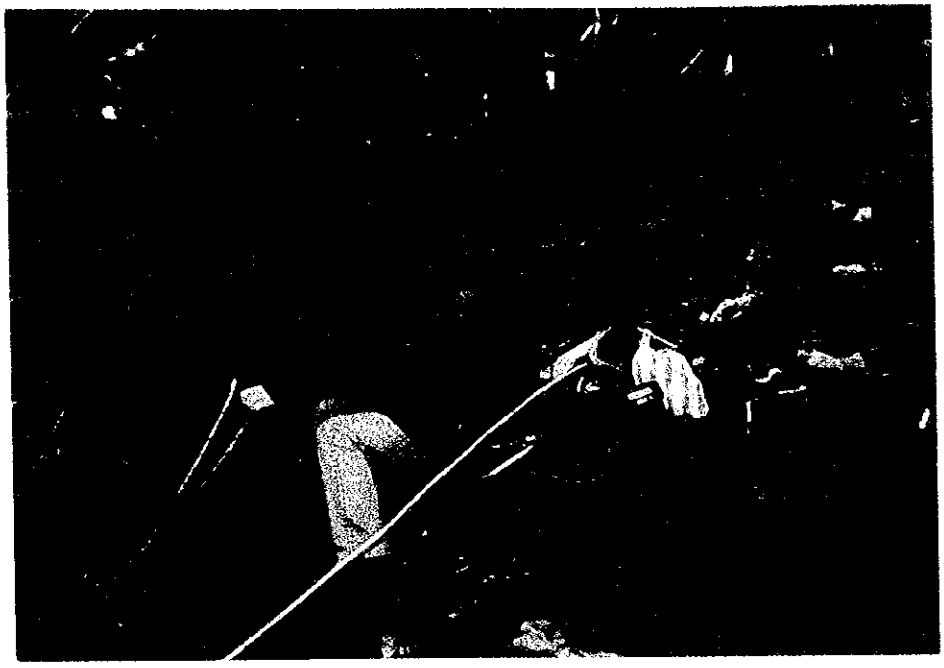
Bosna Springs – Beginning of Beautiful Bosna River



Bosna River near Treated Water Discharge Point of Wastewater Treatment Plant

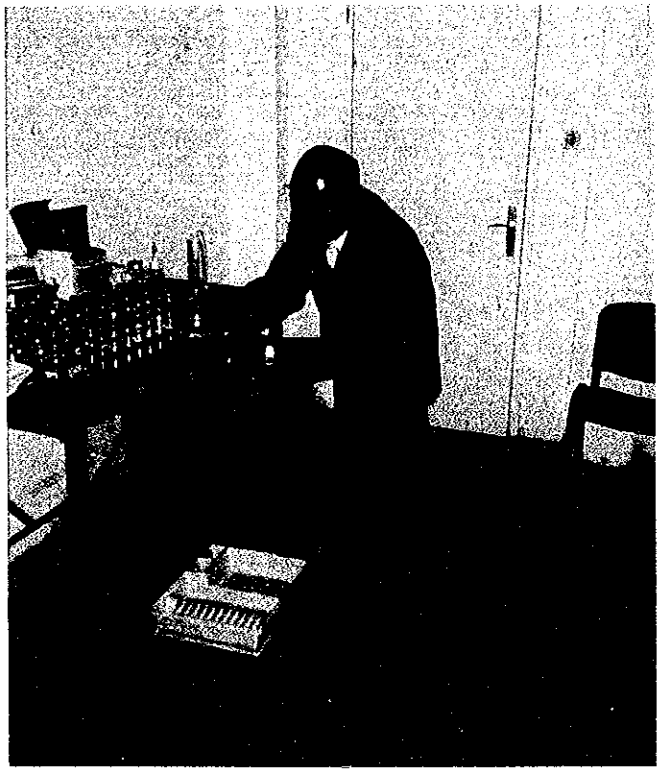
Confluence of Miljacka River and Bosna River – Dry Weather

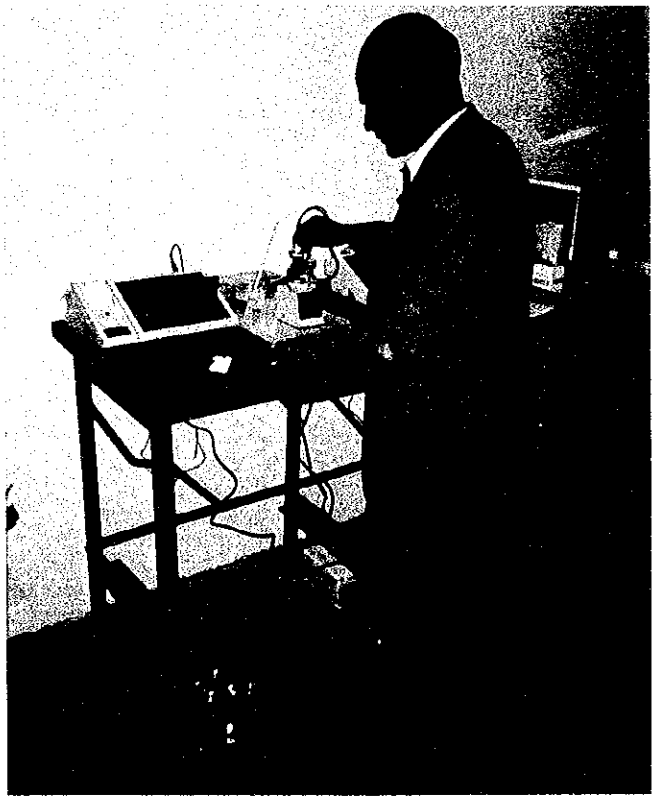
Confluence of Miljacka River and Bosna River – Wet Weather



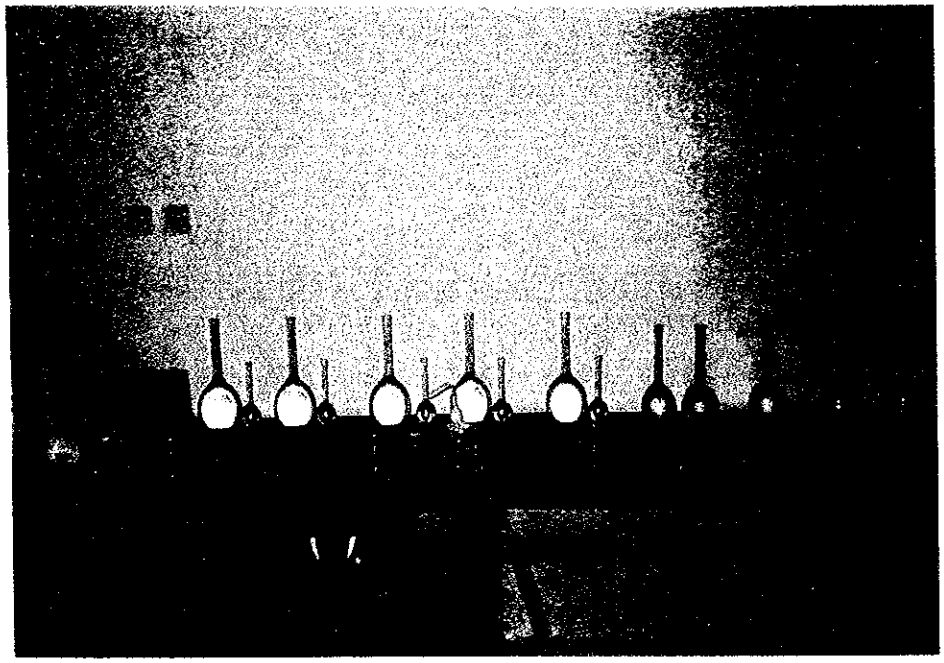
Collecting Sample of Miljacka River Upstream of Main Collector By-pass

Flow Measurement on the Main Collector By-Pass to Miljacka River

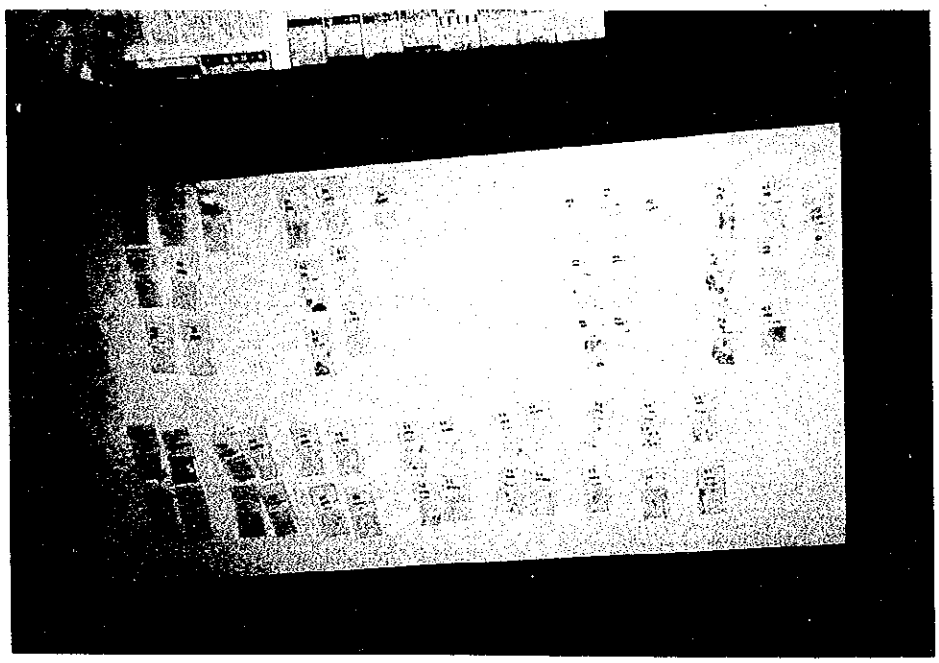




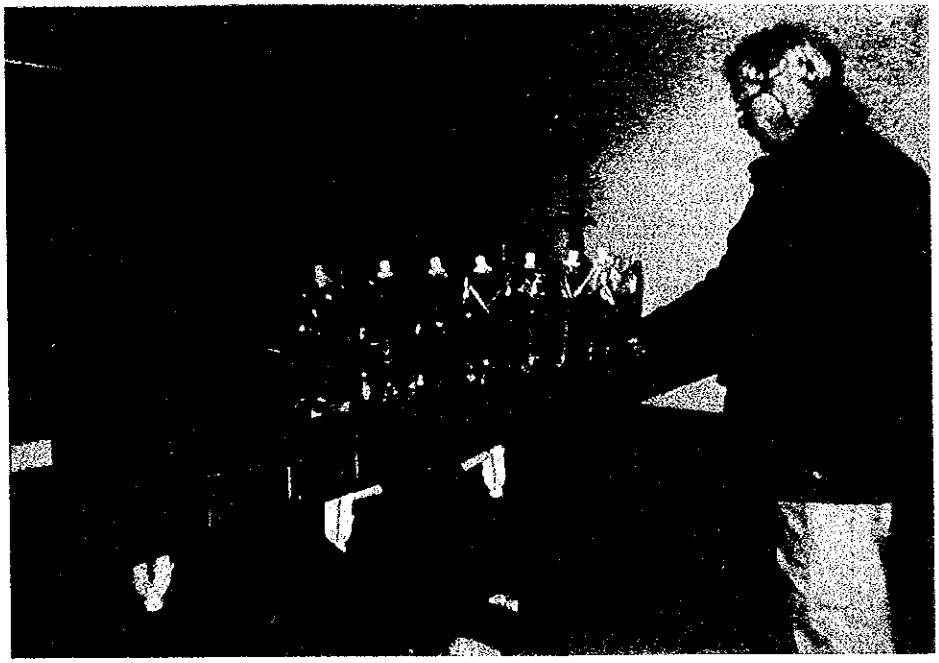
Water Quality Analysis – Biochemical Oxygen Demand (BOD_5)



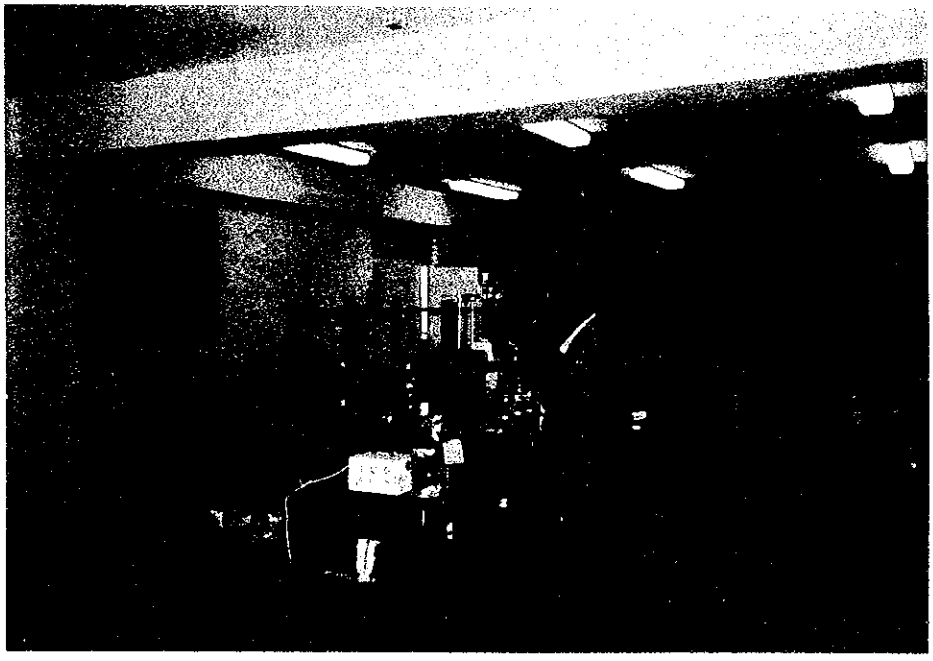
Water Quality Analysis – Dilution for Fecal Coliform



Evidence of Fecal Coliform in Rivers and in Collector

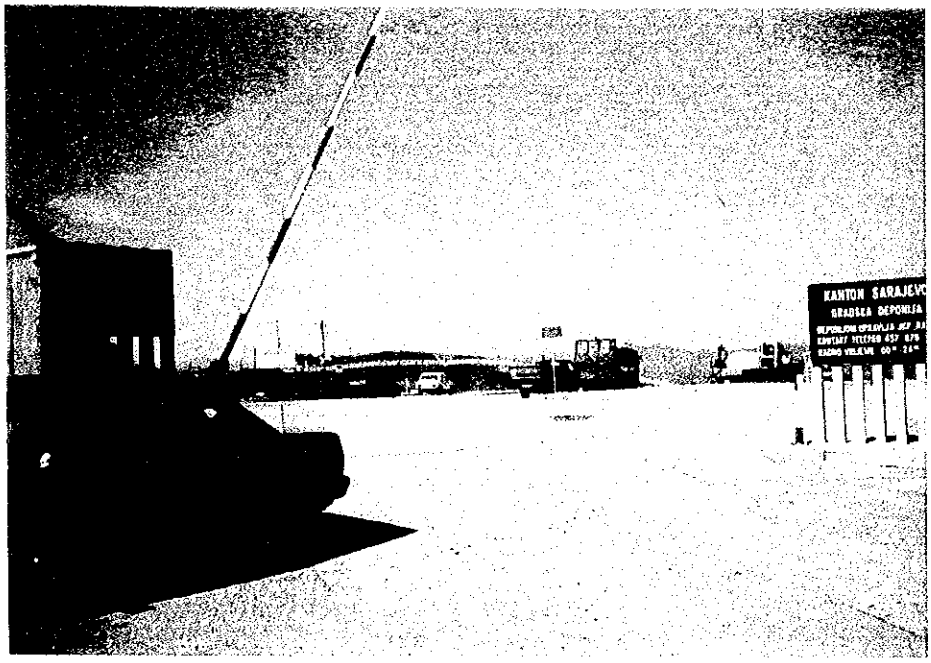


Raw Sewage Samples from Main Collector



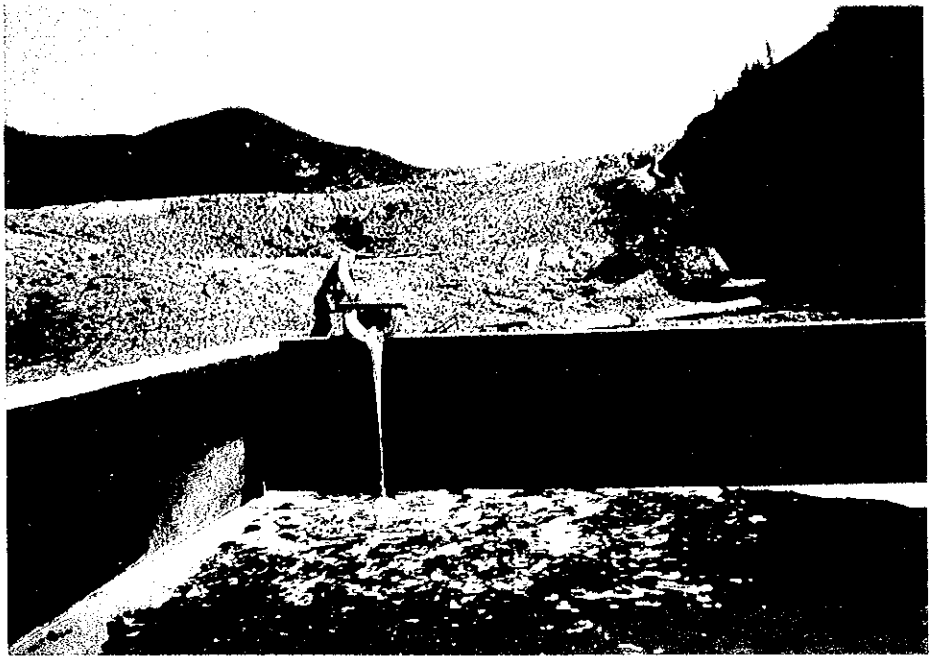
Water Quality Analysis at WWTP Laboratory

3. SOLID WASTE DISPOSAL AREA

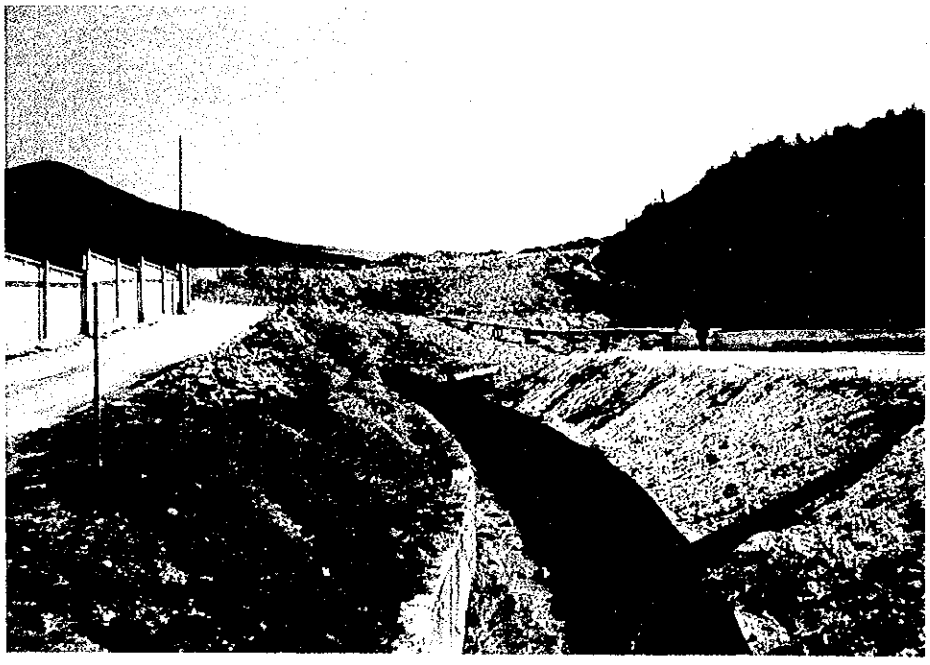


Entrance to the Landfill Site at Buca Potok

Landfill Site

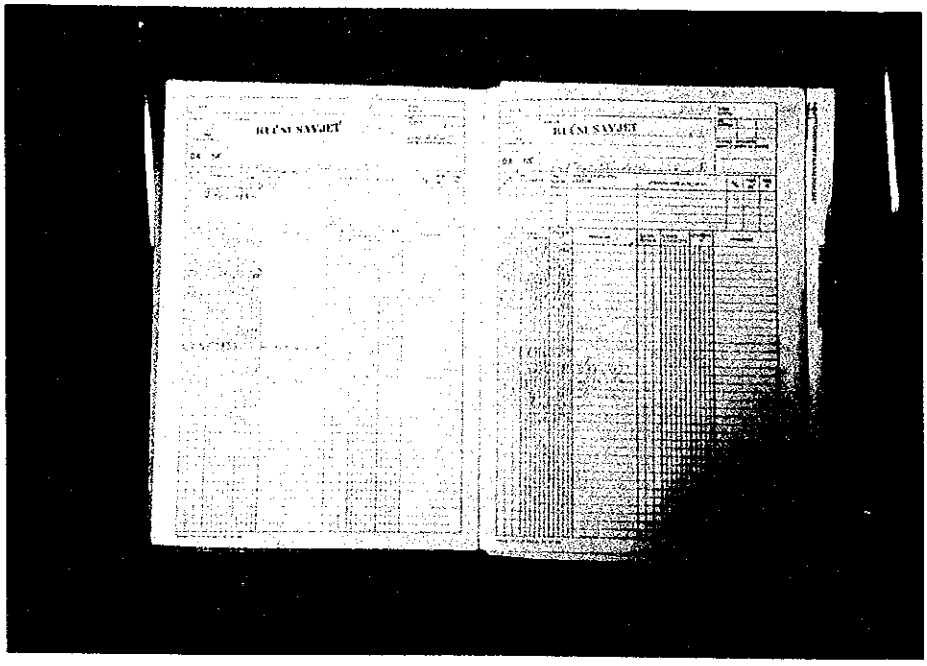


Leachate Collection from Lanfill

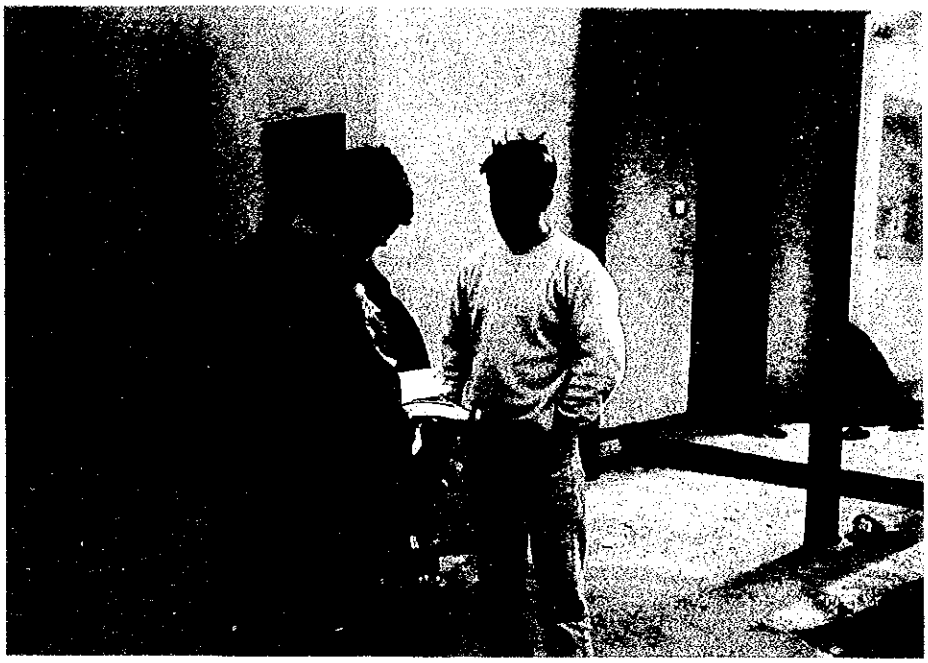


Discharge of Settled Leachate to Lepenica Stream

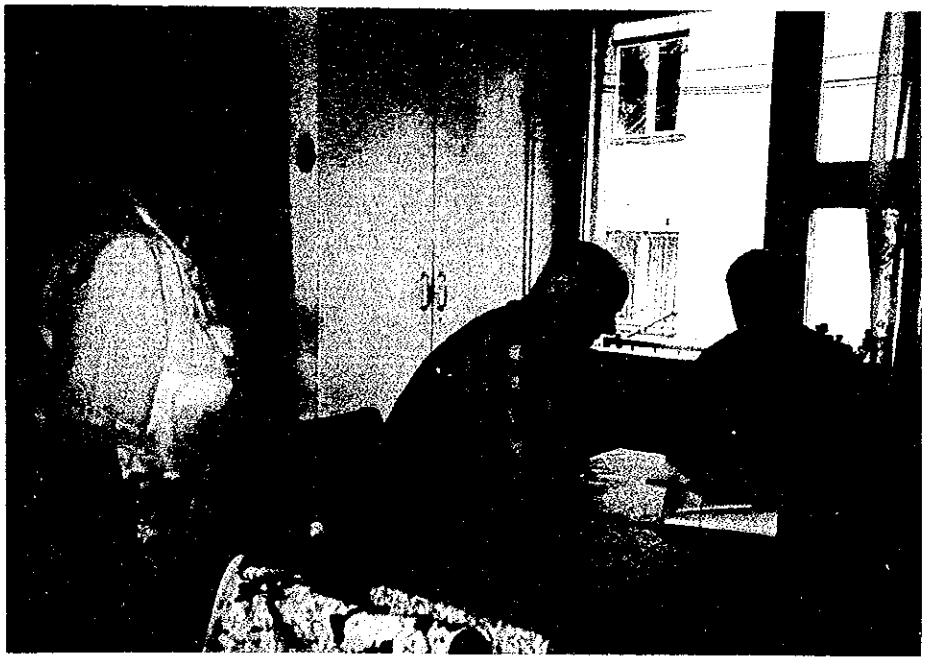
Street survey in front of a shopping center



Water meter reading log book (A4 size)

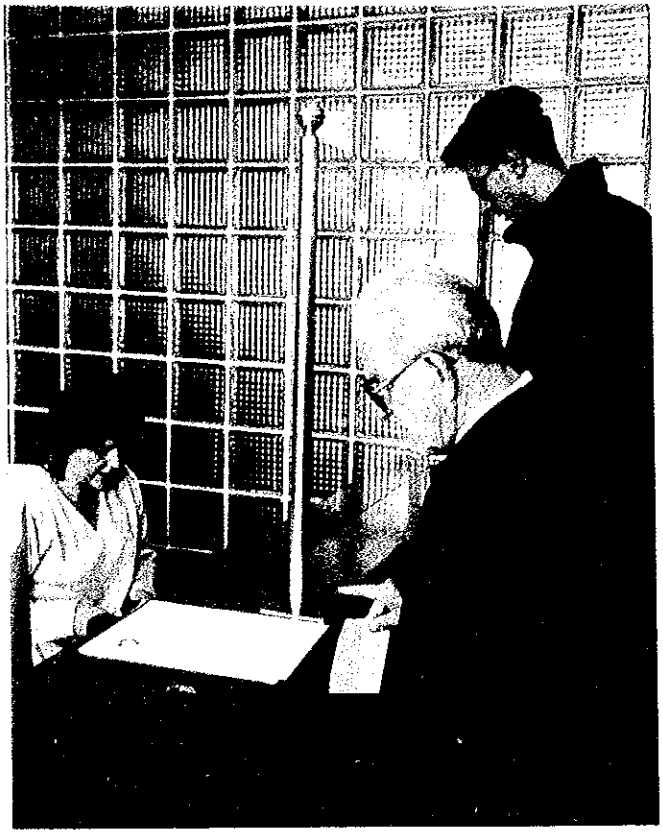


Door to door survey at an individual house

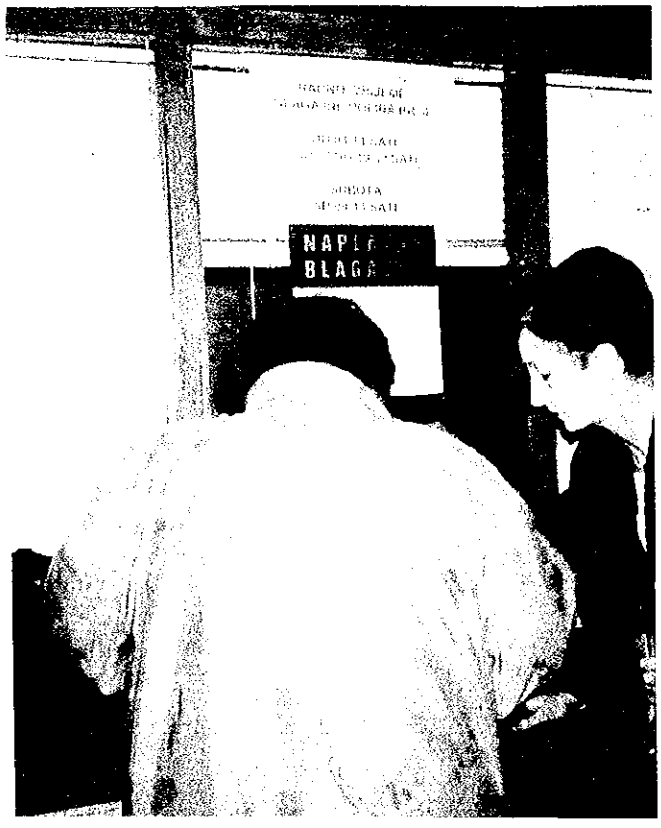


Door to door survey at a socially-owned apartment

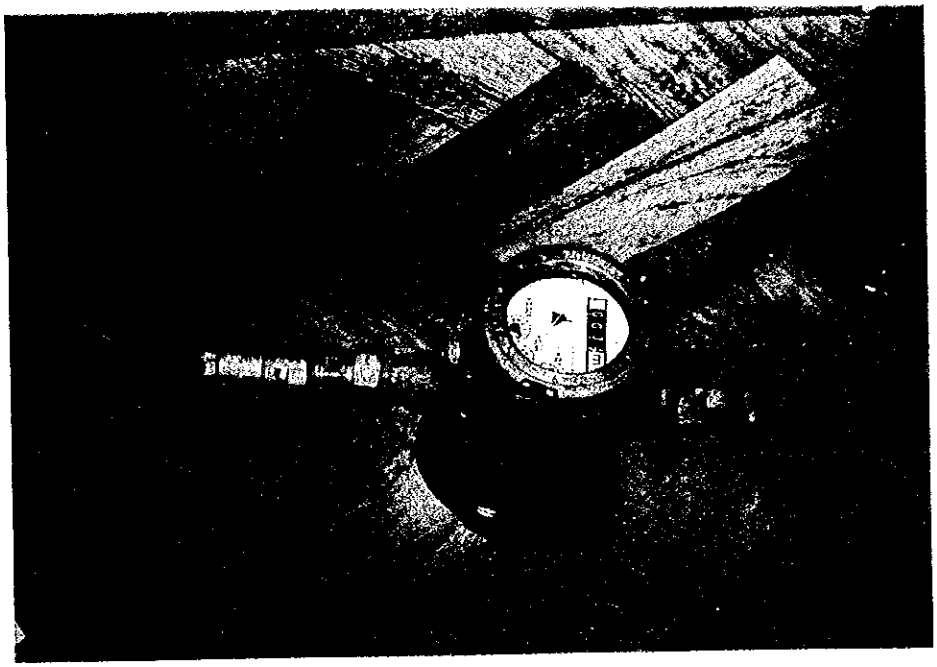
5. WATER BILL COLLECTION



Water bill collection place at ViK GIS office
Working hours 7:30 to 15:30 (Mon.-Fri.) and 8:00 to 16:00 (Sat.)



Social houses and utility bill collection place at Sarajevostan
Working hour 8:00 to 14:00 and 17:00 to 20:00 (Mon. - Sat)

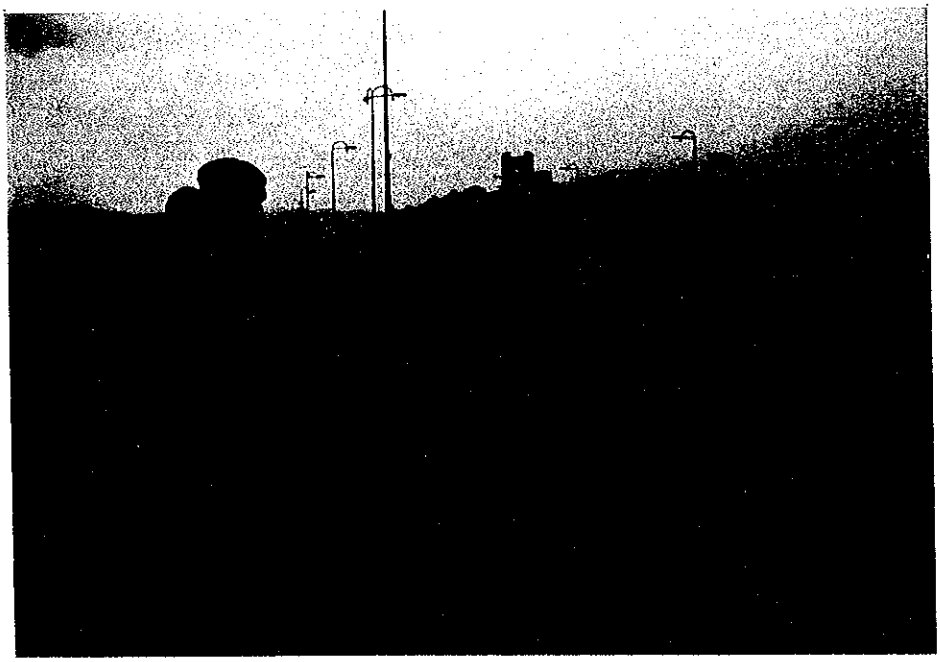


Damaged Water Meter at Kiosk in Bistrik Area

Discharged Point of Raw Sewage

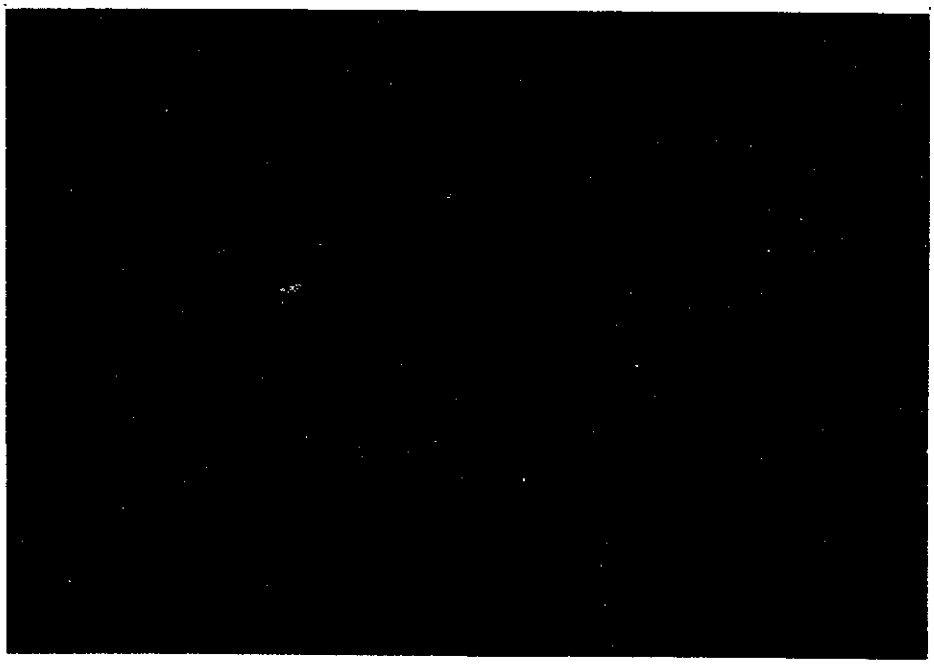
MANHOLES ALONG PEDESTRIAN SIDEWALK

MH No. D0-1A @ Dobrinja, Novi Grad



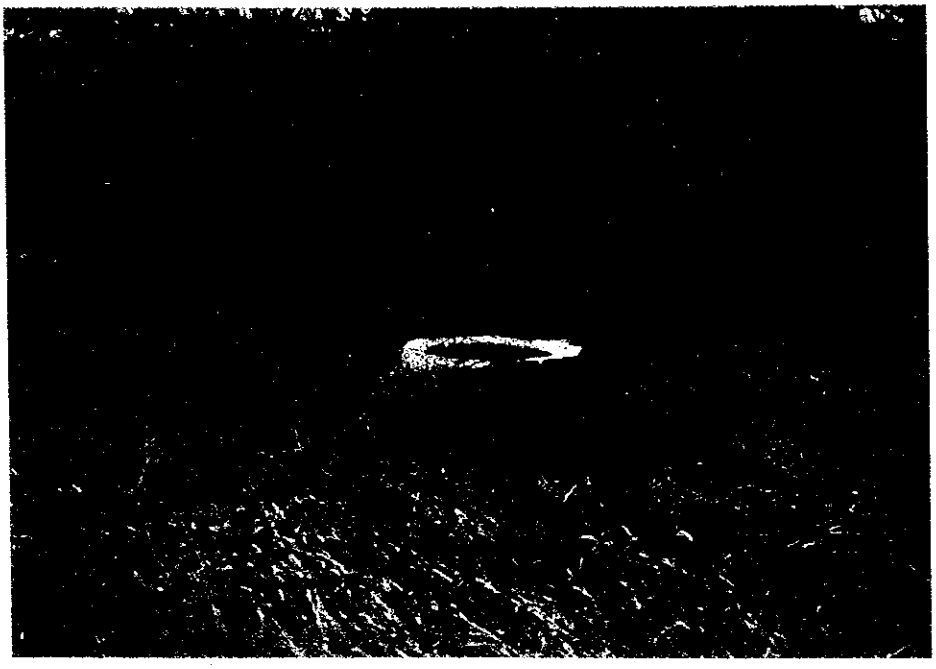
MH No. A8-9 @ Stup, Ilidza

Uncovered Manhole @ Butila

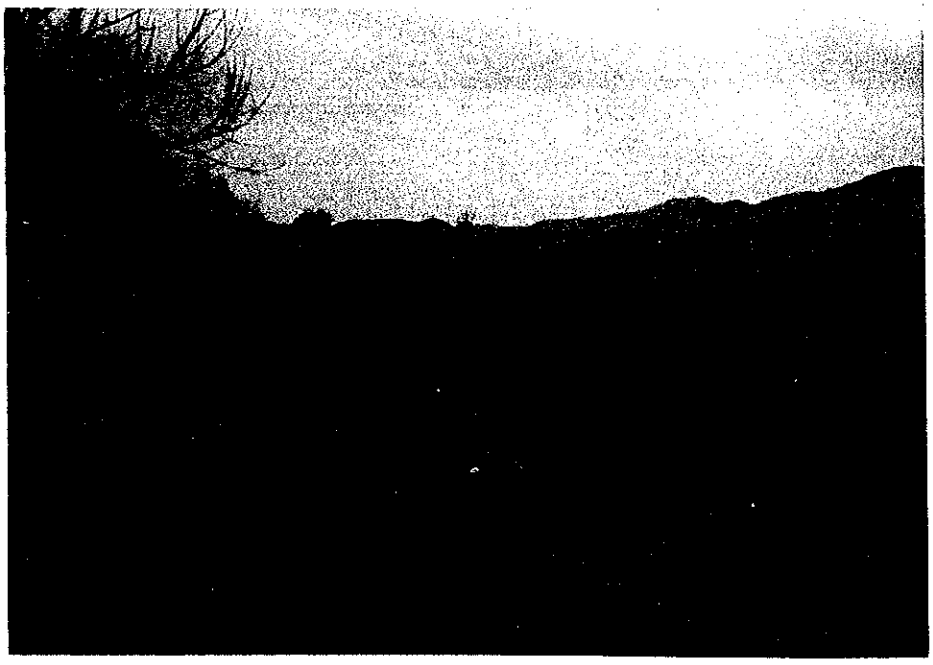


Broken Manhole Top Part @ Butila

MANHOLES LOCATED AT LAND MINES INFESTED FIELDS

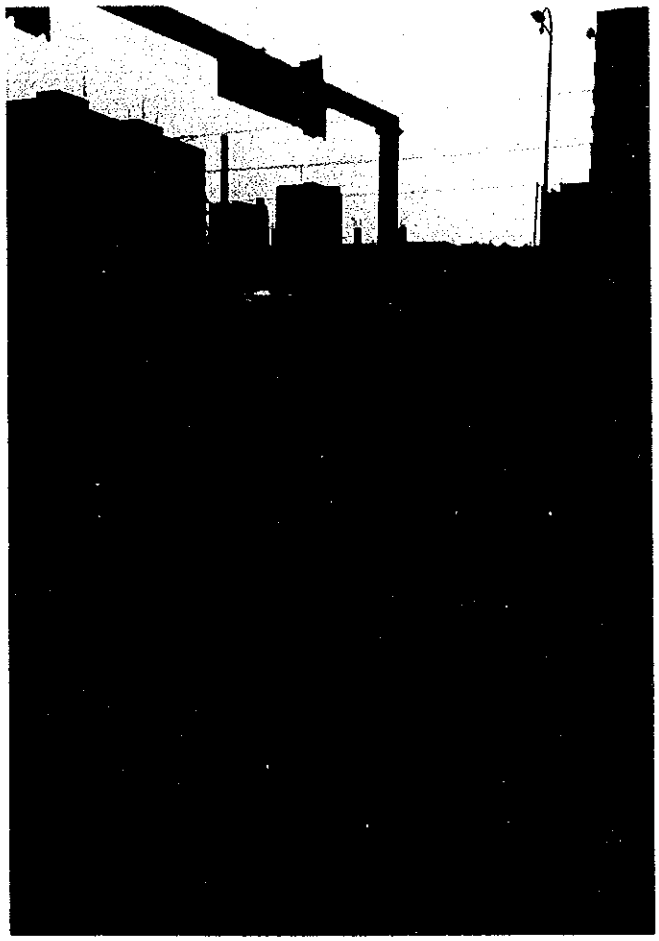


MH No. H0-1 @ Rajlovac, Novi Grad

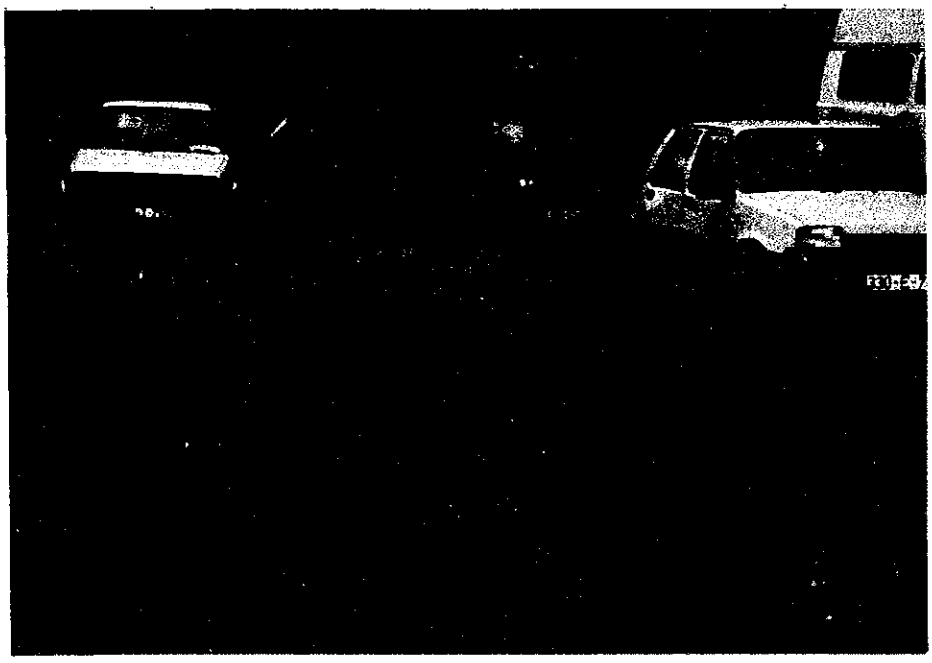


MH No. G2-F8 along banks of Bosna River Tributary (unlocated)

MANHOLES ALONG BUSY STREETS



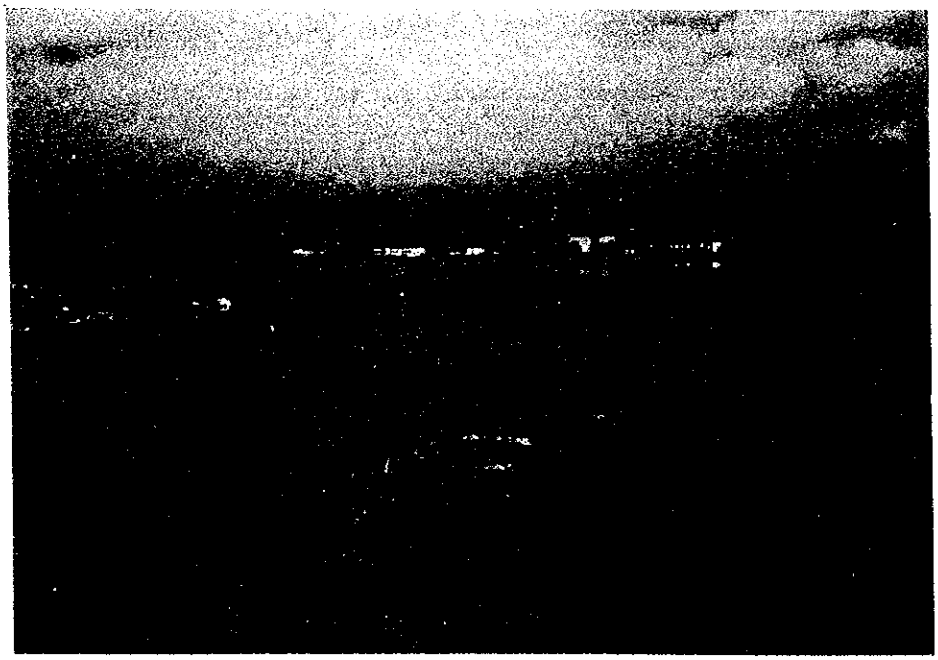
MH No. A5-6 @ Zmaja Od Bosne, Novo Sarajevo



MH No. A3-4 @ Marsala Tita, Centar

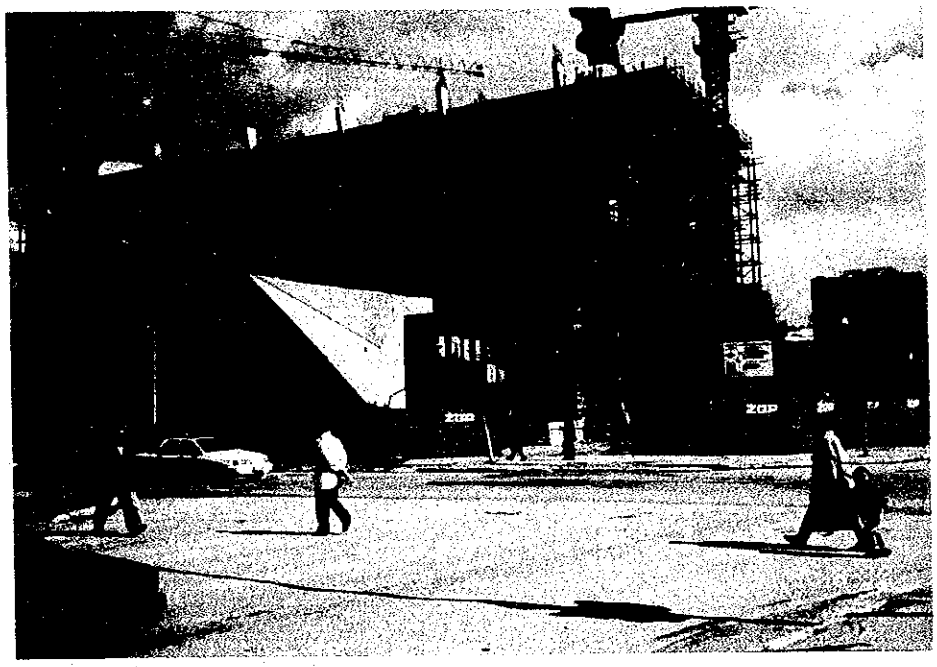
OVERFLOWING MANHOLES

MH No. A12-WWTP @ WWTP, Butila



MH No. A11-12 @ Butila

B. UNIT COST OF CONSTRUCTION



APPENDIX B. UNIT COST OF CONSTRUCTION

LIST OF TABLES

APPENDIX B. UNIT COST OF CONSTRUCTION

Table B.1 LABOR COSTS IN SARAJEVO

As of March 1999

Type of Labor	Unit	Cost (DEM)	Remarks *
Common Worker	day	19	
Concrete Mixer Operator	day	26	
Steel Worker	day	26	
Capenter	day	21	
Brick Builder	day	22	
Plumber	day	24	
Operator (construction machine)	day	26	
Electrician	day	23	
Welder	day	26	
Plasterer	day	22	
Site Engineer	day	33	
Site Manager	day	37	
Office Boy	day	20	
Driver (light vehicle)	day	23	
Driver (heavy vehicle)	day	24	
Typist	day	22	
Foreman	day	28	
Clerk	day	25	
Watchman	day	22	

* 1. Labor cost include the following items:
a) Food allowance = DEM 4/day
b) Transportation = DEM 40/month
2. Work experience is added to basic pay per month at the following rates:
a) Male worker = 0.5% per year
b) Female worker = 0.57% per year

Table B.2 UNIT PRICE FOR MATERIALS

* Note : The following unit prices are AT SITE IN Sarajevo basis as of March 1999, and the Exchange rates are as follows;

1 US$ = 116 JPY
1 US$ = 1.65 DEM

[A] DUCTILE CAST IRON PIPES

	DEM	UNIT COST/m
900 mm x 5.00 m	3,025	605
800 mm x 5.00 m	2,655	531
700 mm x 5.00 m	2,140	428
600 mm x 5.00 m	1,490	298
500 mm x 5.00 m	1,100	220
450 mm x 5.00 m	930	186
400 mm x 5.00 m	810	162
350 mm x 5.00 m	690	138
300 mm x 5.00 m	535	107
250 mm x 5.00 m	430	86
200 mm x 5.00 m	325	65
150 mm x 5.00 m	285	57
100 mm x 5.00 m	190	38

* Remarks : 1) Country of origin : Germany
2) Including cost of ductile cast iron fittings
3) Ductile cast iron pipes are subject to 1% Customs duty

[B] POLYVINYL CHLORIDE PIPES (PVC)

	DEM	UNIT COST/m
600 mm x 5.00 m	1200	240
500 mm x 5.00 m	700	140
450 mm x 5.00 m	650	130
400 mm x 5.00 m	445	89
350 mm x 5.00 m	365	73
300 mm x 5.00 m	270	54
250 mm x 5.00 m	180	36
200 mm x 5.00 m	130	26
150 mm x 5.00 m	125	25
100 mm x 5.00 m	90	18
75 mm x 5.00 m	50	10
50 mm x 5.00 m	30	6

* Remarks : 1) Country of origin : Croatia
2) Including cost of PVC fittings
2) PVC pipes are subject to 11% Customs duty

[C] ASBESTOS CEMENT (ACC) PIPES

	DEM	UNIT COST/m
900 mm x 5.00 m	1500	300
800 mm x 5.00 m	1360	272
700 mm x 5.00 m	1070	214
600 mm x 5.00 m	805	161
500 mm x 5.00 m	650	130
450 mm x 5.00 m	440	88
400 mm x 5.00 m	360	72
350 mm x 5.00 m	290	58
300 mm x 5.00 m	225	45
250 mm x 3.20 m	115	23
200 mm x 3.20 m	85	17
150 mm x 3.20 m	60	12
125 mm x 3.20 m	45	9
100 mm x 3.20 m	30	6

* Remarks : 1) Country of origin : Croatia
2) Including cost of ACC fittings
2) ACC pipes are subject to 1% Customs duty

[D] OTHERS

Type of Material	Unit	Cost (DEM)	Remarks
Crusher stone (0 to 5 m	m3	40.0	
Crusher stone (5 to 12 m	m3	35.0	
Crusher stone (12 to 20 r	m3	35.0	
Crusher stone (20 to 30 r	m3	30.0	
Manually Treated Stone	m3	30.0	
River Sand (Fine)	m3	100.0	
Rubble Stone	m3	50.0	
Rocks non Assorted	m3	40.0	
Sand	m3	60.0	
Asphalt - Prime Coat	m3	5.0	
Asphalt - Hot Mix	m3	8.0	
Cement Type I	Ton	180.0	
Caustic Lime	Ton	250.0	
Round Steel Bar	Ton	1,000.0	
Gasoline	liter	1.1	
Deisel	liter	1.0	
Gas (natural)	m3	0.4	
Gas (Profane-Butane)	Kg	1.3	
L.P.Gas	Kg	1.0	
Oxygen Gas	Kg	4.1	
Tap Water	m3	2.8	
Electric Bill - Commercia	Kwh	0.2	

Table B.3 UNIT CONSTRUCTION COSTS FOR COMPONENT WORK

As of March 1999

Type of Labor	Unit	Cost (DEM)	Remarks
Excavation – Sand (up to 2 m depth)	m3	5.9	
Excavation – Sand with rock	m3	9.5	
Excavation – Rock	m3	65.0	
Backfilling	m3	8.7	
Banking	m3	6.1	
Soil Disposal (L= 20Km)	m3	26.6	
Sheeting by timber up to 3 m deep	m3	13.2	
Sheeting by timber deeper than 3 m	m3	18.6	
Sheeting by sheet pile deeper than 3 m	m3	35.0	
Lean concrete (135kg / cm2)	m3	290.0	
Plain structural concrete (165kg / cm2)	m3	420.0	
Reinforced concrete (210kg / cm2)	m3	620.0	
Form work for substructure	m3	10.0	
Form work for super structure	m3	12 to 15	less than 10m
		20 to 25	more than 10m
Masonary work	m3	300 to 350	
Cement mortar plastering	m3	15 to 19	
Asphalt pavement (t = 5 cm)	m3	40.0	
Asphalt pavement (t = 11 cm)	m3	75.0	

Source : Vodovod i Kanalizacija

Table B.4 TARIFF OF ELECTRICITY

Season		Domestic	Other (higher power)			Other (lower power)	
			110kV	35kV	10(20)kV	Category 1	Category 2
Winter	Fixed Charge (KM)	4.50	24.30	27.00	27.54	20.25	20.25
	High hour (pf/kWh)	12.16	6.78	8.10	10.02	16.20	26.76
	Low hour (pf/kWh)	6.08	3.39	4.05	5.01	8.10	13.38
	Fixed meter (pf/kWh)	9.73					
Summer	Fixed Charge(KM)	3.00	16.20	18.00	18.36	13.50	13.50
	High hour (pf/kWh)	8.10	4.52	5.40	6.68	10.80	17.84
	Low hour (pf/kWh)	4.05	2.26	2.70	3.34	5.40	8.92
	Fixed meter(pf/kWh)	6.48					

Table B.5 **Unit prices used for Civil Works Cost Estimate**

Item	Basis for measurement		Unit price (DEM)
	Quantity	Unit	
Unskilled labor	time	hr	30
Remove ladders	L.S.	ea.	40
Remove railings	length	m	10
Remove concrete stairs and access walkways	area	m2	45
Remove 50mm concrete topping	area	m2	3
Repairing corroded steel			
Sand blasting steel	wall area	m2	12
Remove concrete over reinforcing steel	area	m2	20
protect steel with rust inhibitor	wall area	m2	10
epoxy mortar	volume	m3	860
Repairing cracks & construction joints			
epoxy injection	length	m	100
Repairing Expansion Joints			
remove existing seal	length	m	15
channel gasket for walls, synthetic rubber	length	m	50
channel gasket for effluent launder	length	m	60
bottom gasket for floors	length	m	45
polysulphide joint sealant, 2cm wide, 2 cm deep	length	m	20
New reinforced concrete			
Concrete topping on slabs and walls,air entrained mortar	volume	m3	530
New reinforced concrete walls and floors, normal density 30 Mpa	volume	m3	190
Modified formwork, one sided form tied to existing structure.	area	m2	44
Reinforcing steel, No. 15 - 16 mm	weight	kg	2.5
new reinforcing steel No.10 , .617kg/m	weight	kg	2
Protective epoxy coating at water line	wall area	m2	50
Rendering screed mortar	volume	m3	550
Appurtenances			
stairs, aluminium, open grate	L.S.	ea.	1000
maintenance catwalks 2m wide, open grate aluminium, with railings both sides.	length	m	750
maintenance catwalks, open grate aluminium, with railings both sides.	length	m	500
aluminium ladder into wet well	L.S.	ea.	500
aluminium open grating over well	area	m2	250
new railings, aluminium	length	m	100
Provide new wooden stop boards	L.S.	ea.	300
rehabilitate sluice gates	L.S.	ea	750

Unit prices used for Civil Works Cost Estimate

Item	Basis for measurement		Unit price (DEM)
	Quantity	Unit	
Earth works			
Backfill, granular	volume	m3	60
Miscellaneous items			
Heat tracing cable	length	m3	50
Disposal cost for construction waste	volume	m3	50
Cranes, Scaffolding and Falsework			
Crane 20 ton	time	month	25,000
Crane 100 ton	time	day	7,000
Scaffolding < 5 m high for demolition of aerator slabs	supported area	m2	75
Supporting falsework < 5 m high for aerator slabs	supported area	m2	125
Scaffolding for digester work > 8m high	tank surface are	m2	175
Insulation and cladding			
100 mm expanded polystyrene	surface area	m2	50
75 mm expanded polystyrene	surface area	m2	40
Metal cladding, pre-finished metal	surface area	m2	150
Roofing membrane	surface area	m2	100
Protective coatings			
tar epoxy chemical resistant coating to inside of dome	surface area	m2	100
epoxy paint outside of dome	surface area	m2	100
silicone pore lining treatment	surface area	m2	50

Unit prices used for Civil Works Cost Estimate

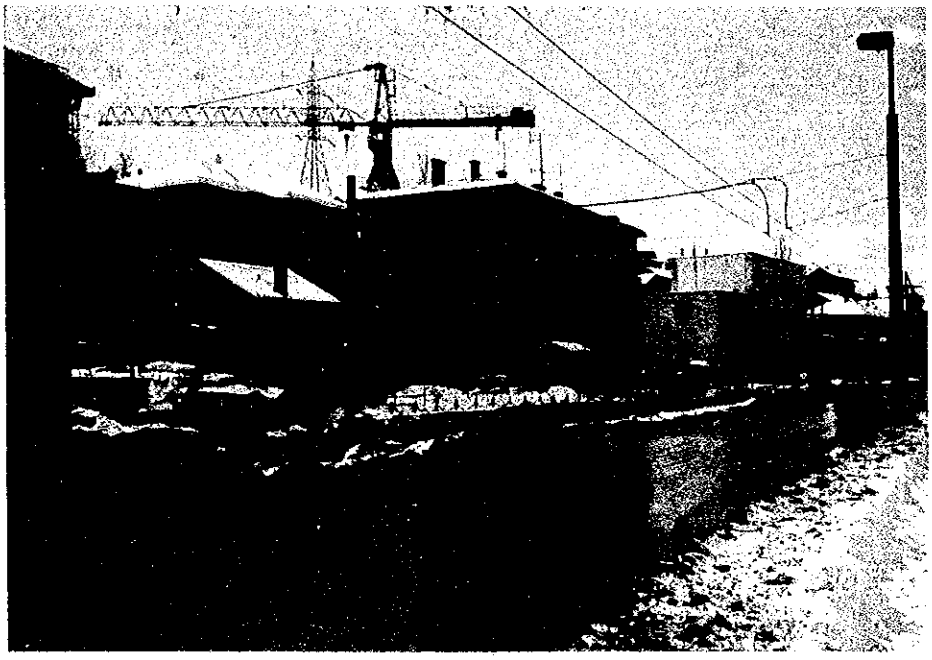
Item	Basis for measurement		Unit price
	Quantity	Unit	
Unskilled labor	time	hr	30
Remove ladders	L.S.	ea.	40
Remove railings	length	m	10
Remove concrete stairs and access walkways	area	m2	45
Remove 50mm concrete topping	area	m2	3
Repairing corroded steel			
Sand blasting steel	wall area	m2	12
Remove concrete over reinforcing steel	area	m2	20
protect steel with rust inhibitor	wall area	m2	10
epoxy mortar	volume	m3	860
Repairing cracks & construction joints			
epoxy injection	length	m	100
Repairing Expansion Joints			
remove existing seal	length	m	15
channel gasket for walls, synthetic rubber	length	m	50
channel gasket for effluent launder	length	m	60
bottom gasket for floors	length	m	45
polysulphide joint sealant, 2cm wide, 2 cm deep	length	m	20
New reinforced concrete			
Concrete topping on slabs and walls,air entrained mortar	volume	m3	530
New reinforced concrete walls and floors, normal density 30 Mpa	volume	m3	190
Modified formwork, one sided form tied to existing structure.	area	m2	44
Reinforcing steel, No. 15 - 16 mm	weight	kg	2.5
new reinforcing steel No.10 , .617kg/m	weight	kg	2
Protective epoxy coating at water line	wall area	m2	50
Rendering screed mortar	volume	m3	550
Appurtenances			
stairs, galvanized steel, open grate	L.S.	ea.	1000
maintenance catwalks 2m wide, open grate galvanized steel, with railings both sides.	length	m	750
maintenance catwalks, open grate galvanized steel, with railings both sides.	length	m	500
galvanized steel open grating over well	area	m2	250
new railings, galvanized steel	length	m	100
Provide new wooden stop boards	L.S.	ea.	250
rehabilitate sluice gates	L.S.	ea	750
Earth works			
Backfill, granular	volume	m3	60

Unit prices used for Civil Works Cost Estimate

Item	Basis for measurement		Unit price
	Quantity	Unit	
Miscellaneous items			
Heat tracing cable	length	m3	50
Disposal cost for construction waste	volume	m3	50
Cranes, Scaffolding and Falsework			
Crane 20 ton	time	month	25,000
Scaffolding < 5 m high for demolition of aerator slabs	supported area	m2	75
Supporting falsework < 5 m high for aerator slabs	supported area	m2	125
Scaffolding for digester work > 8m high	tank surface are	m2	175
Insulation and cladding			
100 mm expanded polystyrene	surface area	m2	30
75 mm expanded polystyrene	surface area	m2	25
Metal cladding, pre-finished metal	surface area	m2	150
Roofing membrane	surface area	m2	75
Protective coatings			
tar epoxy chemical resistant coating to inside of dome	surface area	m2	100
epoxy paint outside of dome	surface area	m2	100
silicone pore lining treatment	surface area	m2	50

Notes: all unit prices include OH&P, installation and site preparation

C. COLLECTED DATA AND INFORMATION



APPENDIX C. COLLECTED DATA AND INFORMATION

LIST OF FIGURE

APPENDIX C. COLLECTED DATA AND INFORMATION

Table C.1 COLLECTED DATA AND INFORMATION

1. MAPS & DRAWINGS

No.	Name	Year of Publication	Size	Original or Copy	Sources	Remarks
M1	1/25,000 Geographical Map of Sarajevo、(4 sheets)	1984		Original	Institute on Land Survey	Donated
M2	1/10,000 Drawings of Urban Development Plan (16sheets)	1988	A1	Copy	Institute for City Planning, Sarajevo	Donated
M3	1/200,00 Industrial Distribution Map	1988		Copy	Institute for City Planning, Sarajevo	Donated
M4	1/50000 Drawing of Wastewater Treatment Plan in Sarajevo	1996	A0	Copy	Energoinvest	Donated
M5	Drawing of Wastewater Network of Sarajevo (16 sheets)	1988.12	A1	Copy	Institute for City Planning, Sarajevo	Donated
M6	Design Drawing of Wastewater Treatment Plant	1984.4		Copy	Vodovod I Kanalizacija	Donated
M7	Drawing of Wastewater Development Plan	1997.4	Bo	Copy	Energoinvest Engineering Co.,Ltd.	Donated
M8	Detail Design Drawing	1980.5	A4	Original	Vodovod I Kanalizacija	Donated

2. WASTE WATER

No.	Name	Year of Publication	Size	Original or Copy	Sources	Remarks
S1	Legislation on Water of Sewerage	1984.4	A4	Copy	Vodovod I Kanalizacija	Donated
S2	Long Term Solutions of Water Supply and Wastewater Drainage and Treatment in The Canton of Sarajevo	1999.2	A4	Copy	Vodovod I Kanalizacija	Donated
S3	Water Sector Institution Strengthening, Final Report	1999.4	A4	Copy	Hydro-Engineering Institute	Donated
S4	Water Protection and Sustainable Development	1999.3	A4	Original	Vodovod I Kanalizacija	Donated

3. RELATED REPORT

No.	Name	Year of Publication	Size	Original or Copy	Sources	Remarks
R1	The World Bank Priority Reconstruction Projects (Update)	1999.4	A4	Original	World Bank Resident Mission Sarajevo	Donated
R2	Classification of Rivers	1967.4	A4	Copy	Ministry of Water Management	Donated
R3	Water Network Analysis: Final Report "Consulting Services within Project Water Distribution Network Rehabilitation in Sarajevo	1997.6	A4	Copy	Vodovodo I Kanalizacija	Donated
R4	Strategy of Water Supply Implementation of the City of Sarajevo	1998.4	A4	Copy	Institute for City Planning	Donated
R5	Bosnia and Herzegovina –From Recovery to Sustainable Growth-	1997.5	A4	Copy	The World Bank (Ministry of Foreign Affairs)	Donated
R6	The World Bank Priority Reconstruction Projects	1998.4	A4	Copy	Ministry of Foreign Affairs	Donated

4. ENVIRONMENT & SANITATION

No.	Name	Year of Publication	Size	Original or Copy	Sources	Remarks
H1	Hydro-engineering Institute, Sarajevo,1997-1998 Annual Report	1998.12	A5	Original	Hydro-engineering Institute, Sarajevo	Donated
H2	Kontrola Procesa Preciscavanja-Znacajan Segment Zastite Voda od Zagodenja	1997.12	A4	Copy	Hydro-engineering Institute, Sarajevo	Donated
H3	Meteorology data (1989-1998)	1998.11	A4	Copy	Meteorology Institute	Donated
H4	Hydrologic data for Miljacka and Bosnia Rivers (1926-1974)	1978.4	A4	Copy	Meteorology Institute	Donated
H5	Izvjestaj o Radu Sarajevskoh Postrojenja Za Preciscavanje Oppadnih Voda	1990.3	A4	Copy	"Zavod Za Vodoprivreda"	Donated
H6	Izvjestaj O Obredjivanju Ebs-a Vredjaja Za Precis Ca Vanje Otpadnih Voda Grada Sarajeva	1990.3	A4	Copy	"Zavod Za Vodoprivreda"	Donated

5. POPULATION ORGANIZATION & ECONOMY

No.	Name	Year of Publication	Size	Original or Copy	Sources	Remarks
E1	Annual Report 96	1996.2	A4	Original	Vodovod I Kanalizaciya	Donated
E2	Annual Report 97	1997.2	A4	Original	Vodovod I Kanalizaciya	Donated
E3	Annual Report 98	1998.2	A4	Original	Vodovod I Kanalizaciya	Donated
E4	Company Plan Report 99	1996.2	A4	Original	Vodovod I Kanalizaciya	Donated
E5	Statistical Data on Economic and Other Trends	1999.2	A4	Copy	Ministry of Foreign Affairs (Federal Institute of Statistics)	Donated
E6	Constitution of Bosnia & Herzegovina	1996		Copy	Ministry of Foreign Affairs	Donated
E7	Census and Estimated Population of Canton Sarajevo	1998	A4	Copy	Federal Institute of Statistics of City Planning, Sarajevo	Donated

6. OTHER

No.	Name	Year of Publication	Size	Original or Copy	Sources	Remarks
O1	Material and Labor Cost	1999.3	A4	Copy	Vodovodo i Kanalizaciya	Donated

O2	Model 50.0 Pista Grit (Vortex) Chamber Technical Specification	1991.4	A4	Copy	Smith & Loveless Kamsas. USA	Donated
O3	Sarajevo WWTP –Gradient Line Computation-	1979.11	A4	Copy	Degremont	Donated
O4	Sarajevo WWTP –Technical Specificatio -	1979.11	A4	Copy	Degremont	Donated
O5	Survey Report of Mining Clearance	1999.7	A4	Copy	Norwegian People's Aid	Donated

D. SITE SURVEY AND ASSESSMENT

APPENDIX D. SITE SURVEY AND ASSESSMENT

LIST OF TABLE

APPENDIX D. SITE SURVEY AND ASSESSMENT

1. ASSESSMENT OF THE TREATMENT FACILITY

Table D.1 RESULTS OF ASSESSMENT OF THE TREATMENT FACILITY

Name of facility	Type of process	Diagnosed facility	Status of the facility and results of the sight inspection	Problems/issues
1. Raw water pumping station	Civil engineering work	Storm outfall facility	The storm water facility is located at the point where the untreated waste water is discharged into from the ϕ 2000mm main sewer before it enters the WWTP. The raw sewage is then discharged from the overflow weir into the River Miljacka. Since the inflow pipe is full, several intermediary ducts up are under pressure, which results to overflow of raw sewage. The structure itself presents no particular problem despite the fact that the surface of the floor panel is rough.	The structure is unknown and the pipe height cannot be checked. For this reason, inflow, outflow and storm outfall pipe (by-pass pipe) must be investigated using some method.
		Inflow duct	The inflow duct is structurally made up of combine ducts diameter 2,000 mm and 800 mm so as to prevent inflow into the pump tank. The raw sewage from the 800 mm diameter duct overflows prior to the inflow duct and is directly discharged into the passageway of the compound. The surface of the inflow duct structure is rough and damage to the inflow gate has been left unrepaired. The same is true to the opening in the floor plate where repairs are required. Details of the structure are not known and the status with respect to blockage in the raw sewage inflow is not grasped.	With respect to the floor plate, the balance weight of the inflow gate needs to be checked. The duct needs to be emptied in the secondary on-site inspection to obtain information detailed.
		Inflow weir	There is no emergency gate valve on the inflow weir, thus this function is performed at the inflow duct prior to the inflow weir. From the onto appearance, the surface of the upper where portion of the walls and the stairway show wear where half of the steel railings are damaged. Moreover, the steel reinforcement is exposed in some sections that lead to rusting.	The stairway railings are under water and it is not possible to confirm the strength of this structure. Details of the structure need to be investigated after water has been drained. Sediment on the floor and in the inflow pipe needs also to be confirmed.
	Mechanical work	Propeller pumping	From outer appearance, the propellers are not rusted and are generally in good condition. Howevery the lower bearings are submerged in water and cannot be inspected. Moreover, the blades of the propeller are not worn. The pumping drive is rusted and partially broken.	The bearings need to be inspected after the inflow weir has been drained.

Name of facility	Type of process	Diagnosed facility	Status of the facility and results of the sight inspection	Problems/issues
	Electrical work	Propeller pumping	The motor is partially destroyed and none of the power belts are in satisfactory condition. The electronic control panels have all been removed and there are no cables.	The motors are completely destroyed and detailed inspection needs to be performed at the next stage.
2. Screening station	Civil engineering work	Screening station	On sight inspection, both the inner and outer walls are in satisfactory condition with apparent marks showing cracks have been repaired. Cleaning in the inflow section prior to the screening station is completed. Moreover, the structure of the screening station itself is in satisfactory condition.	Since the section prior to the screening station is prone to sediment deposit, to the structure needs to be reviewed, in order to ensure minimum flow velocity.
	Construction work	Screening station	Most part are in satisfactory condition. While degradation can be seen in the finishing the outside wall, there seems to be no problem structurally. Window panes are all broken. The travel crane has no cables and is apparently not operable. Moreover the retrofit digestion system is completely destroyed. Electrical equipment is all destroyed and nonexistent.	Water proofing of the roof needs to be checked in the next inspection.
		Electrical station	The structure itself is in satisfactory condition but the equipment is all destroyed.	Equipment needs to be reviewed.
	Mechanical work	Screening station	The manual gate valve is not severely damaged but is wholly rusted. The mechanical screen is completely superannuated and accessory equipment is broken.	The manual gate valve needs to be checked to ascertain opening and closing operation. The mechanical screen needs to be diagnosed in detail.
	Electrical work	Electrical station	The power cables and plants show signs that these had been removed.	
		Screening station	As above.	
3. Aerated grit chamber	Civil engineering work	Silting basin	The bottom plate and walls are in satisfactory condition. However, the surface of the floor plate is partially worn and rough, which show signs of cracks been repaired. The handrails are rusted, wooden flash-boards are rotten. Cleaning of sediment has been completed.	Repaired cracks and scaled joints could be ascertained by performing water leak test.
	Constructi on work	Blower station	While most part of are in satisfactory condition. The finishing and window panes are not. Electric equipment are missing.	An overall check needs to be performed.

Name of facility	Type of process	Diagnosed facility	Status of the facility and results of the sight inspection	Problems/issues
3. Aerated grit chamber	Mechani-cal work	Silting basin	The diffuser is rusted and the nozzles will not last for the next 6 months. There are no motors on the pumping well and the drive is rusted.	The system needs to be tested whether still function.
	Electrical work	Silting basin and electric station	There are no cables and the facility is completely devastated.	Precision check of motors needs to be performed.
4. Primary sedimentation tank	Civil engineering work	Primary sedimentation tank	The above ground structure in satisfactory. While there are repaired cracks and construction joints, the overall condition is well maintained. Cleaning is also satisfactory. However the top sections of the walls are worn and the surface is rough. There are signs of water seepage from the construction joints.	Water seepage from the construction joint needs to be confirmed in the leak test performed by filling water.
	Mechani-cal work	Primary sedimentation tank	The outer appearance is generally in satisfactory condition but the drive equipment such as motors, are missing.	Functional check of the clarifier unit needs to be performed.
	Electrical work	Primary sedimentation tank	There are no cables and motors.	
5. Aeration tank	Civil engineering work	Aeration tank	The structure, both the interior and exterior walls, is in satisfactory condition. While there are signs of repairs on cracks and dowel drive processing, the finishing the work is satisfactory. However, the floor plate is completely worn and steel reinforcements are exposed in certain parts. The inflow weir is partly damaged and partly non-existent. Most part of the bypass is in satisfactory condition, but the wooden flash-boards are rotten.	It is necessary to check leakage from construction joints by performing water leak test. Moreover, opening and closing operation of the tank discharge gate valve also needs to be checked. A loading test needs to be conducted on the floor plate.
	Mechanical work	Aeration tank	Generally, the manual gate valve is in satisfactory condition. The emanator itself is in satisfactory condition from the visual inspection but the motors are generally in poor condition.	
	Electrical work	Aeration tank	There are no cables for all 36 motors. The condition of the interior of the motor is unknown.	The possibility of a loading test needs to be considered in order to ascertain the overall condition when load is applied.

Name of facility	Type of process	Status of the facility and results of the sight inspection	Problems/issues
6. Final sedimentation tank	Civil engineering work	The structure of the final sedimentation tank is maintained in a significantly satisfactory condition. Although the upper walls show wear as in other cases, the condition is satisfactory.	Leakage needs to be checked by water leak test.
	Mechanical work	Although there are no motors on the drive mechanism, the clarifier is, for the most part, in satisfactory condition. All 4 gratings on the platform are in satisfactory condition.	Detailed inspection of the clarifier itself needs to be performed.
	Electrical work	There are no power cables or motors.	
7. Flow metering	Civil engineering work	Both the floor plate and walls of the structure are in satisfactory condition but as with other facilities, the upper portion shows some wear.	There are certain aspects of the structure that are not known and detailed inspection needs to be performed.
	Mechanical work	The flow meter has been removed.	Review of flow metering equipment utilizing the current structure needs to be performed.
8. Recycling sludge pumping station	Civil engineering work	From outer appearance, both the interior and exterior walls show no signs of wear seen in the floor plate. The railings are severely rusted and the gates cannot be operated. The mortar finish of the stairs has peeled off.	
	Construction work	The structure is in satisfactory condition but there are no window panes or glass. Moreover, there are no electrical installations.	A detailed check of the roof needs to be performed.
	Mechanical work	The propeller is in satisfactory condition from outer appearance but the condition of the lower bearings is unknown. The drive mechanism is in poor condition and seems to be inoperable. The travel crane is inoperable.	A detailed check of the drive mechanism needs to be performed.
	Electrical work	There are no switch panels or cables and the motors are destroyed.	A detailed check of motors and related equipment needs to be performed.

Name of facility	Type of process	Status of the facility and results of the sight inspection	Problems/issues
9. Primary sludge pumping station	Construc-tion work	The overall condition of the structure is satisfactory but there are no window panes, glass or electrical equipment.	Inspection on conformance to the specifications of the primary sedimentation tank needs to be performed.
	Mechani-cal work	There are no plants. Supplementary materials are rusted.	
	Electrical work	This is the same as in the mechanical work.	
10. Sludge thickened	Civil engineeri ng work	The condition is about the same as in the primary sedimentation tank.	Inspection based on initial specifications needs to be performed.
	Mechani-cal work	The condition is the same as for the clarifier in the primary sedimentation tank but it is unclear whether the equipment is operable and blocking can be expected in sludge removal.	
	Electrical work	The motors are destroyed and cables have been removed.	
11. Sludge thickening pumping station	Con-struction work	While there are no particular problems in the outer appearance, there are no windows or window panes. The condition of the roof waterproofing is unknown.	Inspection based on initial specifications needs to be performed.
	Mechani-cal work	All removal pumps are destroyed and there are no supplementary materials.	
	Electrical work	There are no motors and power cables.	
12. Sludge digester	Civil engineer-ing work	External wall heat insulation mortar is peeling of certain section and the reinforcing steel is partially exposed. The roof waterproofing mortar is severely damaged and the safety shelf is partially collapsing.	Detailed inspection on all aspects needs to be performed.
	Con-struction work	The exterior wall of the stairwell is partially damaged and almost all window panes are destroyed. There are no window glasses. The condition of the interior walls is not good.	As above
	Mechani-cal work	All mechanical facilities such as humidifier, receiving equipment and removal equipment are inoperable. Moreover, all piping is believed to be blocked.	A detailed inspection needs to be performed.

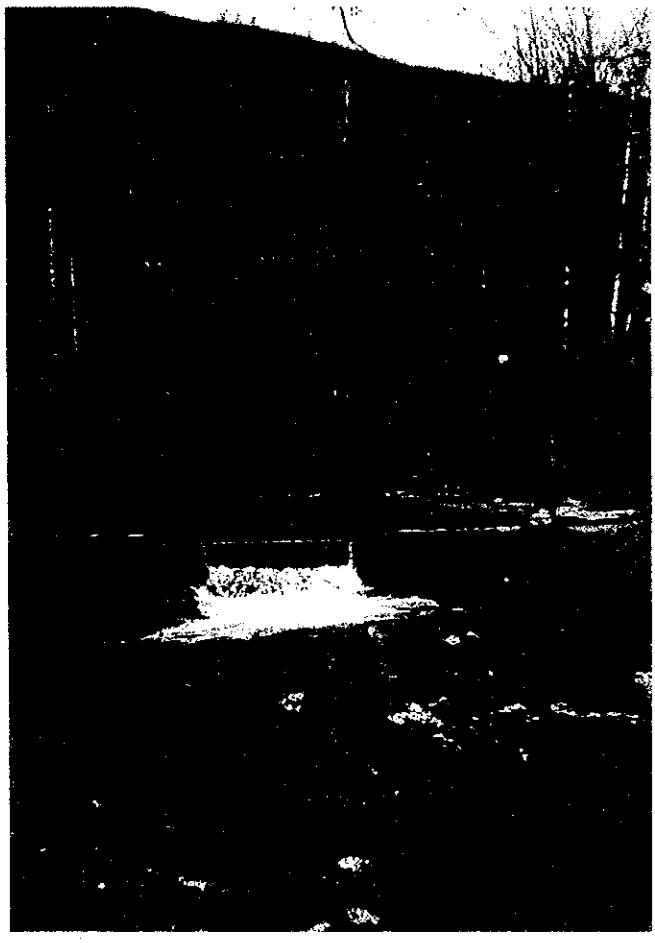
Name of facility	Type of process	Status of the facility and results of the sight inspection	Problems/issues
	Electrical work	There are no power cables. The condition is extremely poor.	As above.
13. Boiler house	Con-struction work	Both the interior and exterior of the structure is in poor condition with sanitation facilities and electrical facilities almost all destroyed.	A detailed inspection needs to be performed.
	Mechani-cal work	Humidifier equipment is all destroyed including supplementary materials.	
	Electrical work	The electric plant facility is close to complete destruction.	
14. Compressor station I	Con-struction work	Both the interior and exterior of the structure is in poor condition with sanitation facilities and electrical facilities almost all destroyed.	A detailed inspection needs to be performed.
	Mechani-cal work	Humidifier equipment is all destroyed including supplementary materials.	
	Electrical work	The electric plant facility is close to complete destruction.	
15. Gas storage tank	Civil engineer-ing work	There are no problems in the outer appearance of the structure and while the gas dome is rusted, the condition is satisfactory. The condition of the gas piping is unknown.	Detailed inspection on operation needs to be performed.
16. Homogenization holding tank	Civil engineer-ing work	The outer appearance of the tank interior and exterior is in satisfactory condition. While there are signs of cracks having been repaired, there are no indications of leakage.	A detailed inspection of the piping needs to be performed.
	Mechani-cal work	While the outer appearance of the clarifier itself is in satisfactory condition, there are no motors and the condition of the drive mechanism is unknown.	A detailed inspection needs to be performed.
	Electrical work	There are no motors and cables.	A detailed inspection needs to be performed.

Name of facility	Type of process	Status of the facility and results of the sight inspection	Problems/issues
17. Sludge pumping station	Con-struction work	The exterior wall is in somewhat satisfactory condition but the interior wall is not. There are no electrical facilities.	Inspection based on materials used when initially constructed needs to be performed.
	Mechani-cal work	There are no motors and pumps.	
	Electrical work	There are no motors and pumps.	
18. Sludge dehydration	Construction work	While the structure itself is in satisfactory condition, part of the walls (blocks) is destroyed. The waterproof condition of the roof is unknown but from sight inspection there seem to be no cracks. There are no window panes and glass and a part of the walls are like bee hives with bullet marks. Electrical equipment and sanitation equipment are all destroyed. The guide rail of the travel crane seems to be in working condition.	A detailed inspection needs to be performed.
	Mecha-nical work	The dehydrator together with supplementary equipment is destroyed and there is no equipment that is in working condition.	
	Electrical work	There are no power cables or wiring.	
19. Compressor station II	Con-struction work	While the structure itself is in satisfactory condition, there are no windows and doors. There are also no sanitation equipment and electrical equipment.	A detailed inspection needs to be performed.
	Mechani-cal work	While the compressor remains, it is believed to be inoperable.	
	Electrical work	There are no motors and power cables.	

Name of facility	Type of process	Status of the facility and results of the sight inspection	Problems/issues
20. Power station	Construction work	The structure (pillars) does not seem to have any problems. Only the skeleton of the roof remains. There are no windows and doors. Only the guide rail of the travel crane remains.	A detailed inspection needs to be performed.
	Electrical work	The two generators are both destroyed and without cables. There are also no supplementary materials.	
21. Substation		2. Refer to section on screening station.	
22. Reception	Construction work	Both the interior and exterior show no problems in the outer appearance. There are no problems with lighting fixtures and sanitation equipment and the windows and doors are in good condition. The heating equipment is in poor condition. Waterproofing and down pipes are also in satisfactory condition.	Inspection on the steam piping and the sanitation equipment needs to be performed.
23. Administration building	Construction work	While the front entrance is somewhat destroyed from outer appearance, the rest of the structure is in satisfactory condition. Most of the windows and doors, interior paint finish, lighting fixtures and sanitation equipment have been restored by the Vodovod I Kanalizacija's direct project. Some of the doors are defective. Heating equipment has been completely destroyed and the digestion equipment is in poor condition. Electrical facilities are not complete.	In the WWTP compounds, this structure has been restored mostly but detailed follow-up will be required to bring it back to the original condition.
24. Service water pumping station	Con-struction work	There are cracks in the outer appearance and the interior walls have also been destroyed.	A detailed inspection needs to be performed.
	Mechani-cal work	The pumps and motors have been left destroyed or in defective condition and the piping is also defective.	
	Electrical work		

Name of facility	Type of process	Status of the facility and results of the sight inspection	Problems/issues
25. Main laboratory	Construction work	Both the interior and exterior are damaged but the structure itself seems to be in good condition. Windows, doors and electrical equipment of sanitation facilities are completely destroyed. The condition of the roof waterproofing is not known but judging from the above, it is believed to be in satisfactory condition. Pumps and motors have been left destroyed or defective and the piping is also defective.	A detailed inspection needs to be performed.

E. WATER QUALITY SURVEY



Supporting Report E
Water Quality Survey

Table of Contents

Tables

Annex E

Figures

E1 INTRODUCTION

Water quality survey carried out during this Study and pollutant load analysis of Miljacka River based on the results are reported in this Supporting Report. Past results of water quality survey carried out in 1990 was compared with the current results.

E2 OBJECTIVE AND CONTENT OF THE SURVEY

Objectives of the survey are

a) investigate the quantity of wastewater discharged to the WWTP and the pollutant load at present, and
b) prepare basic water quality information, which will be required for assessing water quality improvement following the implementation of wastewater treatment

Survey was conducted twice, once during winter (March) and once during summer (June-July).

E3 METHODOLOGY

E3.1 SURVEY LOCATIONS

Eight locations were selected following site survey and review of past studies as described below:

1) on Miljacka River, upstream of Sarajevo City and on Bosna River, downstream of Sarajevo City- 2 locations
2) domestic wastewater discharges to Miljacka River in the city - 2 locations
3) industrial wastewater discharge to Miljacka River - 1 location
4) on Miljacka River, upstream and downstream of WWTP discharge - 2 locations

Figure 2.8.1 of Main Report shows the schematic of survey locations and the notations used.

E3.2 SAMPLING AND ANALYTICAL METHODS

Samples were collected from 6:00 hrs to 22:00 hrs, for every two hours at all sampling locations except for industrial wastewater discharge. Grab samples were analyzed for domestic wastewater discharges and composite samples were made for all other locations for laboratory analysis.

Table E1 WATER QUALITY PARAMETERS AND ANALYTICAL METHODS

Parameter		Method of Analysis	Remarks
Ambient Temperature	At the site	Thermometer	
Water Temperature	At the site	Thermometer	
pH	At the site	pH Meter	
Dissolved Oxygen (DO)	At the site	DO meter	Hydro-Engineering Institute
BOD_5 at 20°C	Laboratory	Incubation at 20°C, DO measured by DO meter	
SS	Laboratory	SS analyzer	
Fecal Coliform Count	Laboratory	Fecal Coliform Test	

Equipment shown in **Table E2** was provided by JICA for this Study and were used for analysis together with flow measuring equipment and DO meter from the Hydro-Engineering Institute. Technical staff of Hydro-engineering Institute, Sarajevo were drawn for sampling, flow measurement and assistance in analysis. Some of the staff were conducting similar work before war and are conversant with the work.

Table E2 LIST OF MAJOR EQUIPMENT USED

Item	Type	Quantity
(a) Analytical Balance	HM-200	1
(b) pH Meter	IOL-30	1 set
(c) DO Meter	DOL-40	1 set
(d) BOD_5 Tester	8053-02	1 set
(e) Incubator for BOD_5	IS400	1 set
(f) SS (suspended solids) Tester	SS-064	1 set
(g) Drying oven (for SS)	DV-400	1 set
(h) Water distiller	WS-23	1 set
(i) Water sampler	8052-251	1 set
(n) Thermometer	Alcoholic Liquid	2

Flow of Miljacka River was determined at Dariva downstream of Mesanica Potok and at the bridge at Most Kod Stupske Peilje. Flow through wastewater by-pass at WWTP was also measured. Flow in the Bosna River was not monitored at the gauging station near Reljevo (Sampling location B2) and the flowrate was obtained from the Hydrology and Meteorology Institute.

E4 RESULTS

E4.1 MILJACKA RIVER AND BOSNA RIVER

Table E3 through **E7** show the water quality of Miljacka River at sampling locations M1, M2 and M3 and that of Bosna River at sampling locations B1 and B2. In March '99, water quality of Miljacka River at M1 and Bosna River at B1 and B2 satisfied the Class II river category, in terms of BOD_5 and SS. However, Miljacka River at M2 and M3 did not satisfy the Class II and Class III river category in terms of BOD_5. In July '99, none of the sampling points satisfied the river category as expected due to lower river flowrates.

Following are the river classifications of Miljacka River and Bosna River.

Miljacka River	
From the spring to the Sarajevo WWTP	- Class II
Sarajevo WWTP to the confluence with Bosna River	- Class III
Bosna River	
From the confluence of Zeljeznica River to confluence of Miljacka River	- Class II
From the confluence of Miljacka River to confluence of Sava River	- Class III

Figure 2.8.2 of Main Report shows the pollutant loads at each survey location of Miljacka River and Bosna River. It also shows the results of May'90 and that of the trunk main by-pass at WWTP. Compared to May '90, pollution loads decreased significantly at M3 and at B2 due to lower pollutant load from trunk sewer by-pass at WWTP.

In March '99, pollutant load carried by Miljacka River due to direct discharges are 4,194 kg BOD_5/d (3,100 kg/d at M1 and 7,294 kg/d at M2) and 11,879 kg BOD_5/d (19,173 kg/d at M3) from trunk main by-pass. It should be noted that there is a difference of 2,559 kg BOD5/d compared to that measured at the trunk main (9,320 kg/d). SS load showed better agreement in balance than that of BOD_5.

In July '99, generally there was a decrease in pollutant load transported by the rivers compared to that measured in March '99 showing variation of pollutant load in winter season and in summer season.

Table E3 MILJACKA RIVER QUALITY - UPSTREAM OF SARAJEVO CITY AT DARIVA (M1)

Date & Time	Temperature, °C		Flowrate m^3/s	pH	DO mg/L	BOD_5 mg/L	SS mg/L	Fecal Coliform Count colonies/mL
	Ambient	Water						
17/03/99								
6:00	0.0	3.8	9.2	8.10	11.5	3.9	7	1.3×10^2
8:00	1.0	3.9	9.2	8.18	11.3			
10:00	1.0	4.0	9.2	8.23	11.4			
12:00	2.5	4.0	9.2	8.24	11.2			
14:00	2.8	4.2	9.2	8.25	11.4			
16:00	0.5	4.0	9.2	8.17	11.7			
18:00	0.5	4.0	9.2	8.18	11.9			
20:00	-1.0	3.8	9.2	8.20	11.9			
22:00	-1.0	3.8	9.2	8.18	11.6			
30/06/99								
6:00	16.0	14.0	1.92	8.01	8.3	5.8	42	3.3×10^2
8:00	17.0	14.5	1.92	8.07	8.5			
10:00	18.5	15.0	1.92	8.17	8.8			
12:00	19.5	16.0	1.92	8.31	9.0			
14:00	18.0	16.5	1.92	8.22	8.5			
16:00	19.0	16.5	1.92	8.24	8.5			
18:00	20.5	16.5	1.92	8.20	8.5			
20:00	16.5	15.5	2.20	8.26	8.4			
22:00	16.5	14.5	2.40	8.18	8.3			

Note: Flowrate increase on 20:00 hrs to 22:00 hrs on 30/06/99 was due to isolated storm event.

Table E4 MILJACKA RIVER QUALITY – UPSTREAM OF WWTP INFLUENT BY-PASS (M2)

Date & Time	Temperature, °C		Flowrate m^3/s	pH	DO mg/L	BOD_5 mg/L	SS mg/L	Fecal Coliform Count colonies/mL
	Ambient	Water						
17/03/99								
6:00	-1.0	4.9	12.6	8.02	10.6	6.7	19	5.4×10^2
8:00	2.0	4.8	12.6	8.00	10.6			
10:00	2.5	4.9	12.6	7.95	10.8			
12:00	3.2	5.4	12.6	8.04	10.5			
14:00	5.2	6.2	12.6	8.02	10.3			
16:00	2.2	6.1	12.6	8.12	10.6			
18:00	1.0	5.5	12.6	7.98	11.8			
20:00	2.2	5.1	12.6	7.96	11.8			
22:00	1.2	4.9	12.6	7.92	11.4			
30/06/99								
6:00	15.2	15.4	3.21	7.56	5.5	8.2	58	1.3×10^3
8:00	17.2	15.2	3.21	7.67	5.5			
10:00	21.2	15.8	3.21	7.78	6.7			
12:00	24.0	16.9	3.21	7.85	7.5			
14:00	19.7	18.1	3.21	7.71	4.9			
16:00	22.0	19.0	5.40	7.32	1.6			
18:00	23.0	19.8	5.40	7.32	1.6			
20:00	18.5	19.4	3.21	7.40	2.4			
22:00	17.8	18.8	3.21	7.50	3.3			

Note: Flowrate increase on 16:00 hrs to 18:00 hrs on 30/06/99 was due to isolated storm event.

Table E5 MILJACKA RIVER QUALITY – DOWNSTREAM OF WWTP INFLUENT BY-PASS (M3)

Date & Time	Temperature, °C		Flowrate m^3/s	pH	DO mg/L	BOD_5 mg/L	SS mg/L	Fecal Coliform Count colonies/mL
	Ambient	Water						
17/03/99								
6:00	-1.0	5.2	14.3	7.93	10.2			
8:00	2.0	5.2	14.6	7.94	10.3			
10:00	2.5	5.5	14.7	7.87	9.9			
12:00	3.2	6.0	14.8	8.03	9.4			
14:00	5.2	6.5	14.8	8.03	9.5	15.2	27	8.4×10^2
16:00	2.2	6.3	14.7	8.01	9.8			
18:00	1.0	5.8	14.6	7.88	11.0			
20:00	2.2	5.5	14.5	7.86	11.4			
22:00	1.2	5.2	14.4	7.84	10.9			
30/06/99								
6:00	15.2	14.6	4.81	7.55	5.4			
8:00	17.2	14.5	5.25	7.55	4.1			
10:00	21.2	15.2	5.32	7.56	4.8			
12:00	24.0	16.1	5.25	7.61	5.1			
14:00	19.7	17.4	5.18	7.47	2.7	30.0	107	6.1×10^3
16:00	22.0	18.0	7.6	7.32	1.6			
18:00	23.0	17.7	7.6	7.36	2.0			
20:00	18.5	17.4	5.12	7.41	2.5			
22:00	17.8	17.1	5.18	7.46	2.9			

Note: Flowrate increase on 16:00 hrs to 18:00 hrs on 30/06/99 was due to isolated storm event.

Table E6 BOSNA RIVER QUALITY – UPSTREAM OF CONFLUENCE WITH MILJACKA RIVER (B1)

Date & Time	Temperature, °C		Flowrate m^3/s	pH	DO mg/L	BOD_5 mg/L	SS mg/L	Fecal Coliform Count colonies/mL
	Ambient	Water						
17/03/99								
6:00	-1.0	5.0		7.85	10.3			
8:00	2.0	5.6		7.84	10.1			
10:00	2.5	5.6		7.88	10.1			
12:00	3.2	5.8		8.01	10.3			
14:00	5.2	6.0		8.11	10.9	3.9	7	0.7×10^2
16:00	2.2	6.1		8.13	10.6			
18:00	1.0	5.9		7.88	11.4			
20:00	2.2	5.6		7.80	11.2			
22:00	1.2	5.5		7.76	11.4			
30/06/99								
6:00	15.2	12.8	8.39	7.50	7.0			
8:00	17.2	12.7	7.95	7.53	7.3			
10:00	21.2	12.7	7.88	7.52	7.9			
12:00	24.0	13.3	7.95	7.58	7.8			
14:00	19.7	14.0	8.02	7.63	8.8	5.2	16	2.2×10^2
16:00	22.0	15.0	17.8	7.69	8.9			
18:00	23.0	15.8	9.0	7.67	8.3			
20:00	18.5	15.7	8.08	7.64	6.8			
22:00	17.8	15.9	8.08	7.61	7.2			

Note: Flowrate increase on 16:00 hrs to 18:00 hrs on 30/06/99 was due to isolated storm event.

Table E7 BOSNA RIVER QUALITY – DOWNSTREAM OF CONFLUENCE WITH MILJACKA RIVER-RELJEVO (B2) (DOWNSTREAM OF FUTURE TREATED WATER DISCHARGE)

Date & Time	Temperature, °C		Flowrate	pH	DO mg/L	BOD_5 mg/L	SS mg/L	Fecal Coliform Count colonies/mL
	Ambient	Water						
17/03/99			cm					
6:00	2.1	5.6	165	7.76	10.2			
8:00	2.6	5.8	165	7.78	10.0			
10:00	3.6	5.8	165	7.81	10.0			
12:00	5.4	6.1	165	7.81	10.1			
14:00	4.8	6.2	165	7.81	10.1	6.1	13	5.2×10^2
16:00	3.0	6.1	164	7.83	10.1			
18:00	2.8	5.9	162	7.78	10.2			
20:00	2.6	5.8	160	7.78	10.3			
22:00	1.2	5.7	159	7.76	10.0			
30/06/99			m^3/s					
6:00	15.0	14.0	13.2	7.37	3.70			
8:00	19.0	14.0	13.2	7.41	5.10			
10:00	23.2	13.5	13.2	7.46	5.40			
12:00	23.5	14.5	13.2	7.47	5.60			
14:00	23.5	15.0	13.2	7.48	4.70	7.5	67	2.3×10^3
16:00	23.0	17.0	25.4	7.37	1.70			
18:00	23.0	17.5	16.6	7.36	2.20			
20:00	20.5	16.5	13.2	7.43	3.70			
22:00	17.5	16.5	13.2	7.44	3.20			

Note: Flowrate increase on 16:00 hrs to 18:00 hrs on 30/06/99 was due to isolated storm event.

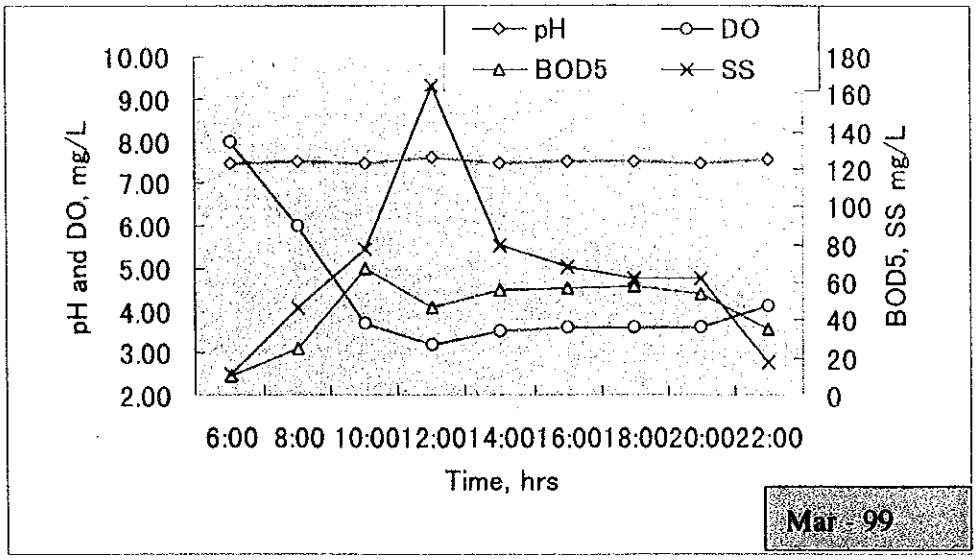
E4.2 DOMESTIC WASTEWATER DISCHARGE

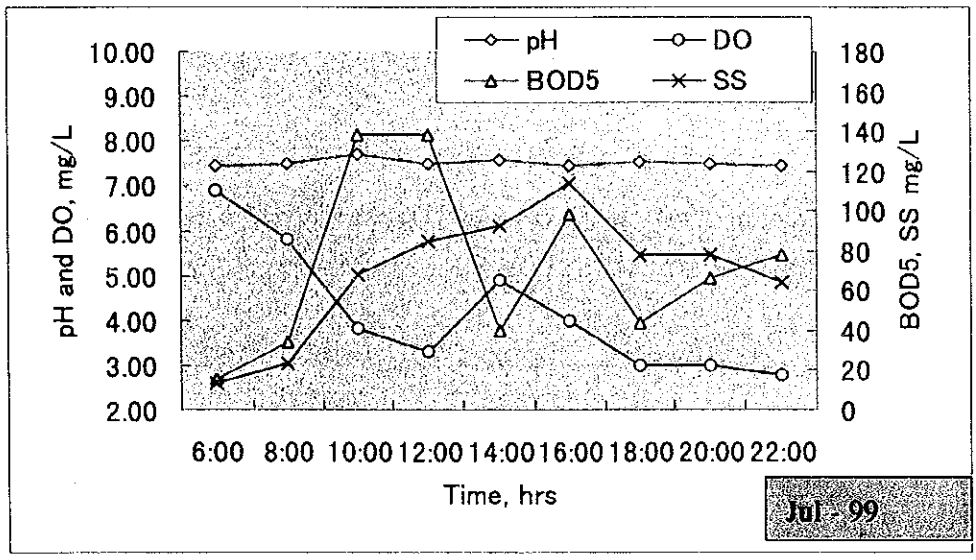
Table E8 shows the water quality data of raw wastewater flowing to WWTP which is being discharged to Miljacka River through a by-pass prior to WWTP inlet. In the absence of significant industrial activity it is considered as the domestic discharge. **Table E9** shows the summary of raw wastewater characteristics in this survey as wells as in May 1990. Following can be said from the field observation and analytical results.

1) Wastewater was very dilute and unlike of other wastewater discharges found in the city area which are discharged directly to Miljacka River. Average BOD_5 in May '90 was 131 mg/L (**Table E9**) while that of March '99 was only 54 mg/L and that in July '99 was 66 mg/L. However, SS didn't show a similar decline.
2) Flowrate in March '99 was 172,600 m^3/d and in July it was 170,700 m^3/d which is an increase compared to that of May '90 (151,500 m^3/d). Leakage in the water distribution system and infiltration must have contributed to the increase in wastewater despite the decline in both population as well as commercial/industrial activity. (refer to industrial wastewater discharge for discussion on infiltration/leakage)
3) In terms of pollutant load to WWTP, BOD_5 load decreased to almost half (9,320 kg/d in March '99 and 11,266 in July '99) from that in May '90 (19,847 kg/d). Decrease is equivalent to approximately about 150,000PE. However, although SS load also decreased (10,701 kg/d) it was not as much as that of BOD_5.
4) In March '99, peak BOD_5 occurred at 10:00 hrs while that of SS concentration was at 12:00 hrs. Flowrate showed maximum during 12:00 to 14:00 hrs. In July '99, peak BOD_5 occurred between 10:00 hrs and 12:00 hrs when flow was also higher. Highest SS concentration was at 16:00 hrs when there was a second peak of BOD_5. Compared to the data of May '90, flowrate showed much variation during the observation.
5) Fecal coliform concentration was one order smaller in March '99 than that measured in May '90 but was same order in July '99. Wastewater samples at 6:00 hrs and at 8:00 hrs were very much clear and the concentration of fecal coliform was an order smaller than that observed after 10:00 hrs in July '99.

Table E8 DOMESTIC WASTEWATER DISCHARGE 1 – WWTP BY-PASS (D1)

Date & Time	Temperature, °C		Flowrate m^3/s	pH	DO mg/L	BOD_5 mg/L	SS mg/L	Fecal Coliform Count colonies/mL
	Ambient	Water						
18/03/99								
6:00	-1.5	8.4	1.68	7.48	8.0	10.6	11	1.8×10^3
8:00	0.7	9.1	1.97	7.52	6.0	25.0	47	2.3×10^3
10:00	0.9	9.4	2.12	7.48	3.7	67.0	78	6.8×10^3
12:00	1.2	9.6	2.22	7.61	3.2	47.0	164	2.5×10^3
14:00	0.8	9.6	2.22	7.47	3.5	56.0	80	4.5×10^3
16:00	1.2	9.6	2.12	7.51	3.6	57.0	68	3.8×10^3
18:00	1.1	9.6	1.97	7.50	3.6	58.0	62	3.6×10^3
20:00	0.5	9.6	1.90	7.48	3.6	54.0	62	6.1×10^3
22:00	0.5	9.4	1.78	7.55	4.1	35.0	18	5.9×10^3
01/07/99								
6:00	14.9	13.2	1.59	7.43	6.9	15.3	14	2.7×10^3
8:00	16.2	13.4	2.04	7.49	5.8	34.5	23	6.9×10^3
10:00	22.0	13.8	2.11	7.69	3.8	138	68	2.1×10^4
12:00	23.1	17.1	2.04	7.48	3.3	138	85	1.8×10^4
14:00	22.3	11.5	1.97	7.60	4.9	40.0	92	1.7×10^4
16:00	24.0	12.9	1.97	7.47	4.0	98.0	114	2.1×10^4
18:00	23.0	14.5	2.18	7.54	3.0	44.0	78	1.1×10^4
20:00	23.0	13.9	1.91	7.49	3.0	66.0	78	1.9×10^4
22:00	19.2	14.0	1.97	7.45	2.8	78.0	64	2.0×10^4





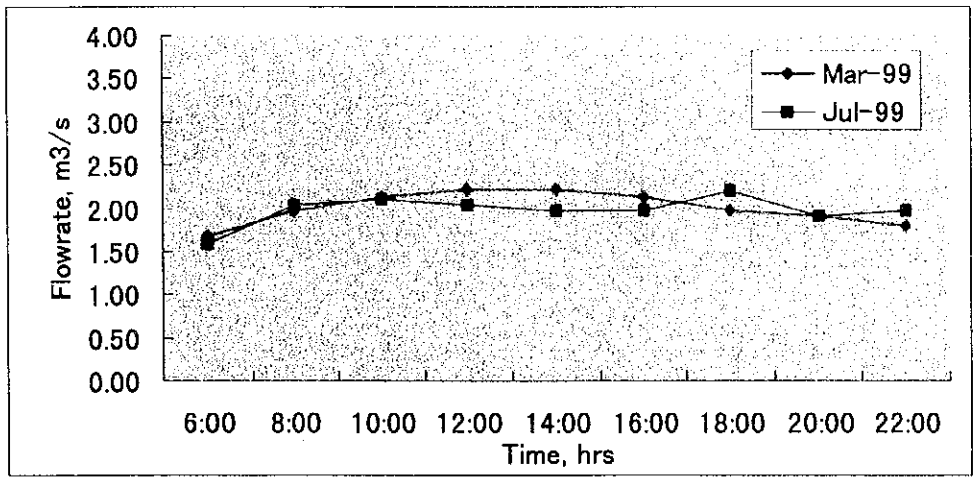


Figure E1 VARIATION OF RAW WASTEWATER CHARACTERISTICS IN THE MAIN COLLECTOR BY-PASS

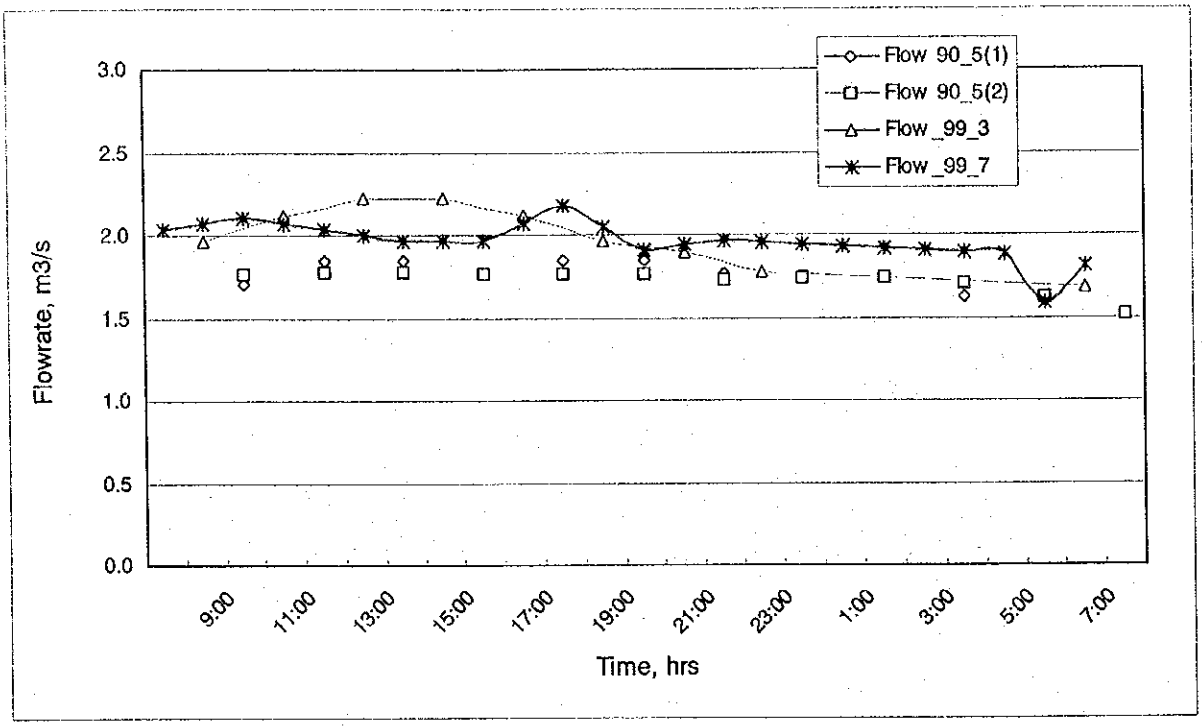


Figure E2 COMPARISON OF THE RAW WASTEWATER CHARACTERISTICS OF MAIN COLLECTOR BY-PASS (1/3)

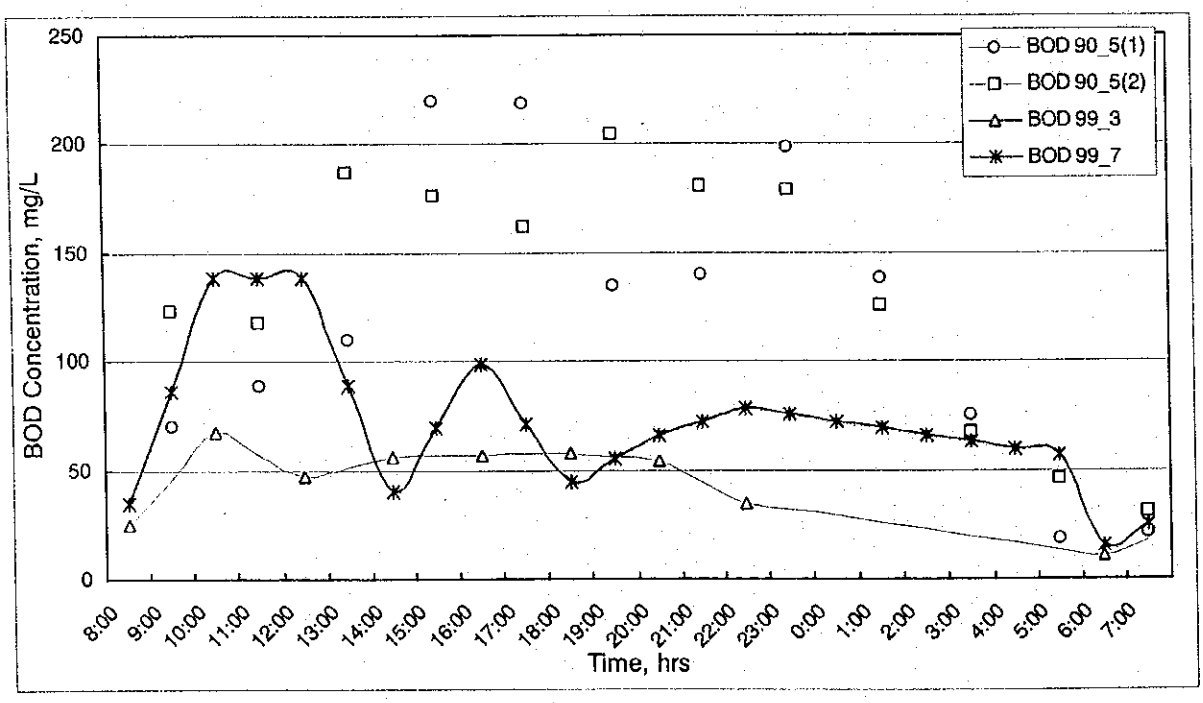


Figure E2 COMPARISON OF RAW WASTEWATER CHARACTERISTICS OF MAIN COLLECTOR BY-PASS (2/3)

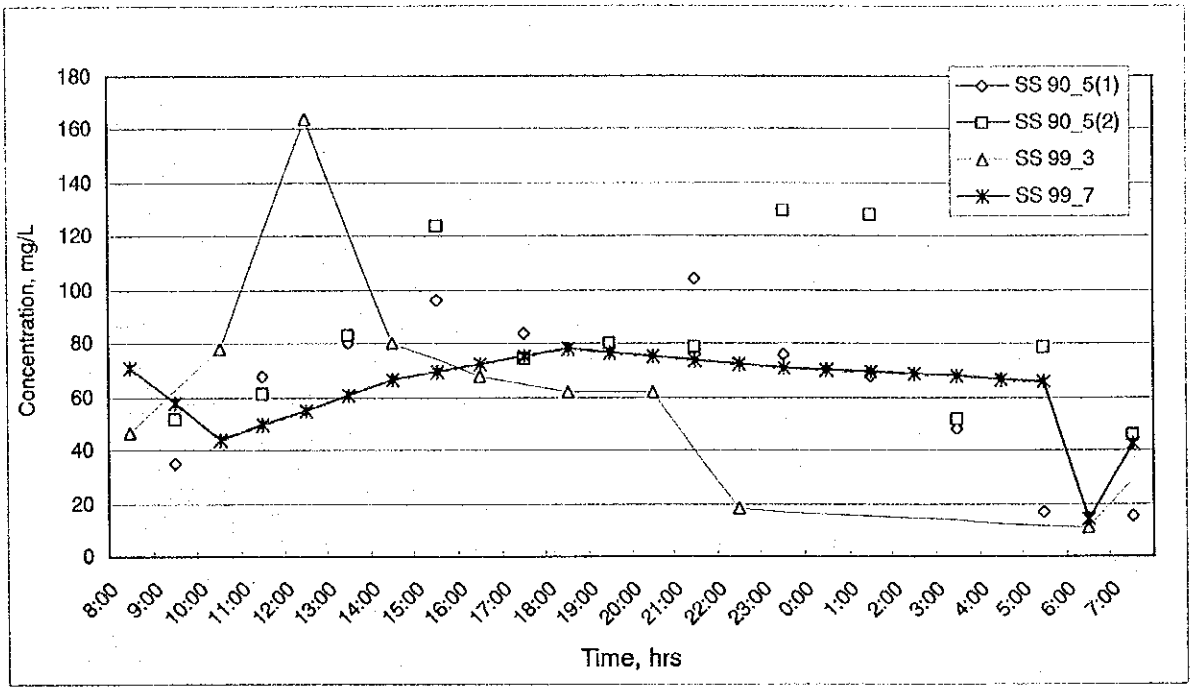


Figure E2 COMPARISON OF THE RAW WASTEWATER CHARACTERISTICS OF MAIN COLLECTOR BY-PASS (3/3)

Table E9 RAW WASTEWATER CHARACTERISTICS IN THE MAIN COLLECTOR

Parameter	May '90	March '99	July '99
Flow, m^3/d	151,500	172,600	170,700
BOD_5 , mg/L	131	54	66
SS, mg/L	78	62	78
BOD_5 Load, kg/d	19,847	9,320	11,266
SS Load, kg/d	11,817	10,701	13,315
COD, mg/L	218		
Fecal Coliform, N/mL	6.3E+04	3.8E+03	2.0E+04

Table E10 shows summary of raw wastewater quality data measured at the Collector during the pre-war period. Except for January 1988 data, there is a reducing trend for BOD5 and SS concentration. Considering the results in this investigation, improvements in the collection system is necessary to reduce infiltration and leakage in the water distribution system.

Table E10 RAW WASTEWATER CHARACTERISTICS IN THE MAIN COLLECTOR (1988-1990)

Date	BOD_5 (mg/L)	SS, (mg/L)	COD, (mg/L)	TKN, (mg/L)	T-P, (mg/L)	FC, (No./mL)	No. of observation	Source
Jan '88	35	90	111				1	1
Feb '88	200	225	316				1	1
Jan '90	149	133	241				1	2
Feb '90	208	135	316				1	2
Mar '90	220	181	347					2
Apr '90	140	104	160					2
May -Jun'90	157		238	27.0			22	2
8/10 May '90	131	78	218			6.3 E+04		3

Note : Source 1 : Distribucija Teksih Metala Izmedju cvrste I tecne faze muljeva postrojenja za otpadne vode u Sarajevu, Dr. Esma Velagic Habul and Mr. Zlatko Hofman

Source 2 : Izvjestaj o Radu Sarajevskog Postrojenja za Preciscavanje Otpadnih Voda (Januar – Jun 1990 godine), Zavod Za Vodoprivredu, Sarajevo (Dr. Mirko Popovic et. al.)

Source 3 : Izvjestaj o Odredjivanju EBS-a Uredjaja za Preciscavanje Otpadnih Voda Grada Sarajeva, Zavod Za Vodoprivredu, Sarajevo (Messrs. Zlatko Hofman and Skamo Dzevad)

Table E11 shows that of Potok Susica which receives domestic wastewater from septic tanks in unsewered area. Potok Susica is a tributary to Miljacka River. Unlike that of the trunk main by-pass, water quality showed sharp variation in Potok Susica which is a general characteristic of domestic wastewater from a relatively smaller area. It should be noted that previous Study on raw wastewater discharges to Miljacka River, BOD_5 concentration of Potok Susica was 380 mg/L (refer **Table E14** in **Annex E**). Investigation revealed that one of the pharmaceutical industry which was discharging to this stream has shrunk the production (equivalent population survey conducted by the Hydrotecnic Institute showed one eighth of the pre-war level) and has connected to the sewerage system.

Table E11 DOMESTIC WASTEWATER DISCHARGE 2 – POTOK SUSICA (D2)

Date / Time	Temperature, °C		Flowrate m^3/s	pH	DO mg/L	BOD_5 mg/L	SS mg/L	Fecal Coliform Count colonies/mL
	Ambient	Water						
18/03/99								
6:00	0.5	7.0	0.116	7.93	8.1	5.4	4	6.5×10^2
8:00	0.5	7.0	0.116	7.93	8.0	11.5	4	6.0×10^2
10:00	0.8	7.0	0.116	7.93	8.5	19.5	23	2.3×10^3
12:00	1.2	7.2	0.116	7.64	8.3	28.0	30	1.4×10^3
14:00	1.8	7.3	0.116	8.03	8.1	33.5	24	2.0×10^2
16:00	1.9	7.4	0.116	7.80	8.3	33.5	14	1.3×10^3
18:00	1.2	7.4	0.116	7.76	8.0	25.5	11	1.8×10^3
20:00	0.8	7.2	0.116	7.76	8.1	27.0	20	1.4×10^4
22:00	0.7	7.2	0.116	7.81	8.2	25.5	42	1.4×10^4
01/07/99								
6:00	17.0	15.0	0.043	7.92	7.6	3.5	15	5.0×10^2
8:00	16.5	14.5	0.043	7.93	6.5	13.7	25	1.7×10^3
10:00	21.5	15.0	0.043	7.86	5.4	34.0	24	1.0×10^4
12:00	21.5	15.0	0.043	7.83	4.9	36.5	13	6.2×10^3
14:00	26.0	16.0	0.050	7.79	5.2	29.0	12	6.9×10^3
16:00	24.0	15.0	0.043	7.80	5.1	24.5	19	4.4×10^3
18:00	21.5	15.0	0.050	7.67	2.2	21.5	17	4.2×10^3
20:00	20.0	15.0	0.050	7.74	3.1	29.5	16	3.6×10^3
22:00	19.5	15.0	0.043	7.77	3.6	21.5	13	2.3×10^3

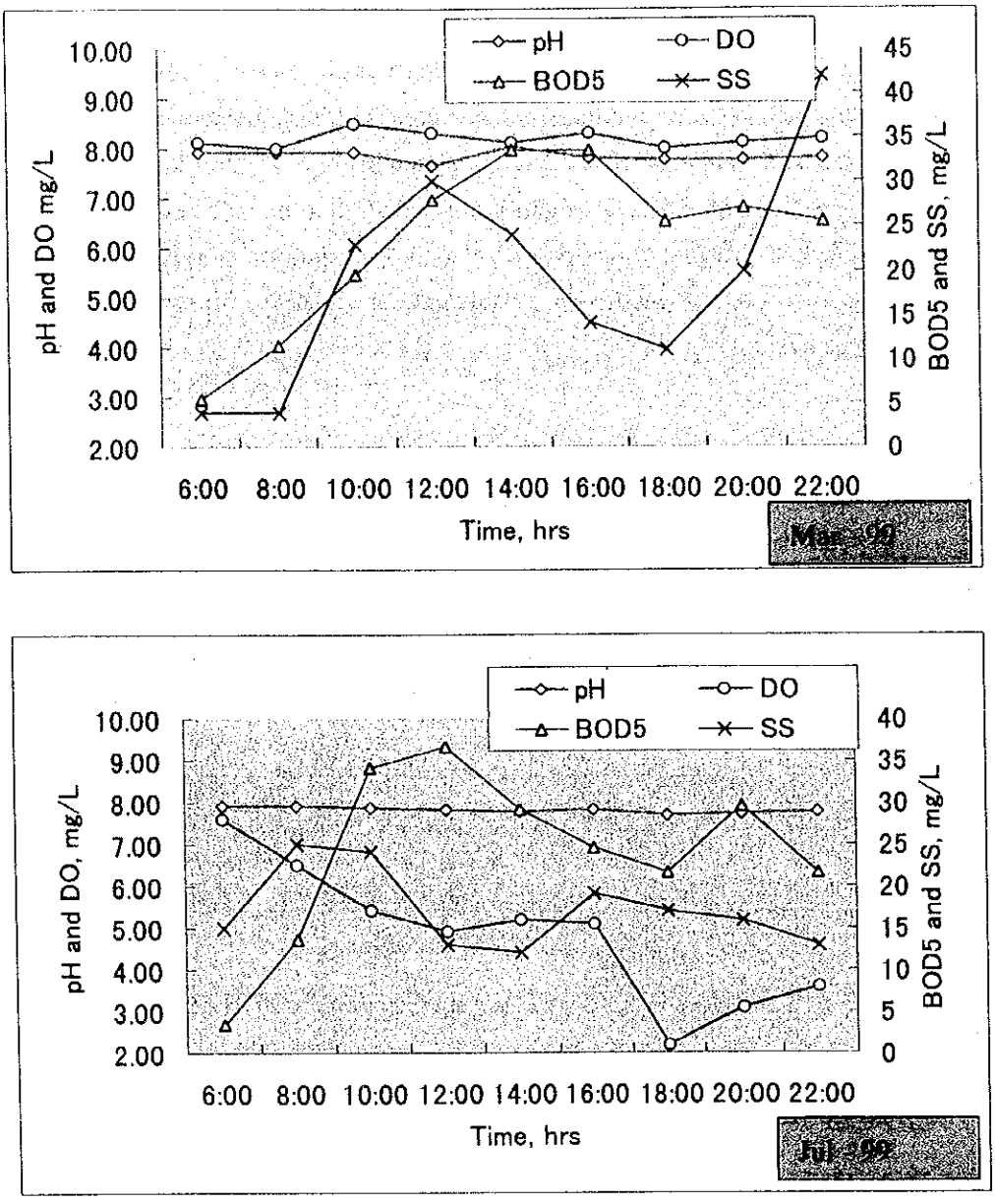


Figure E3 VARIATION OF WATER QUALITY OF POTOK SUSICA

E4.3 INDUSTRIAL WASTEWATER DISCHARGE

Table E12 shows the water quality data of wastewater discharge from an industrial area which is mainly for tile production and hardware yard. Wastewater is discharged directly to the Miljacka River at Alipasin Most (bridge). Currently, industrial activity has not resumed to pre-war level. Only small part is functioning and the wastewater is mainly of domestic origin from the workers.

BOD_5 and SS values are higher than the water quality measured at the trunk main by-pass at WWTP. Comparing these values with that observed at the WWTP and considering that industrial production is very limited, weak wastewater strength at the trunk main must be due to infiltration and leakage.

Table E12 INDUSTRIAL WASTEWATER DISCHARGE – INDUSTRY (I)

Date & Time	Temperature, °C		pH	BOD_5 mg/L	SS mg/L	Fecal Coliform Count colonies/mL
	Ambient	Water				
25/03/99						
9:30	8.0	11.0	8.45	196	178	1.45×10^3
12:30	13.0	12.0	8.41			
15:00	14.0	12.0	8.02			
22/07/99						
9:30	23.0	18.2	8.10	240	215	4.0×10^4
12:15	31.0	20.0	8.02			
15:15	35.5	19.8	8.05			

Table E13 WATER QUALITY OF MILJACKA AND BOSNA RIVER IN 1990

Parameter	Miljacka River prior to Trunk Main Discharge				Miljacka River prior to Confluence with Bosna River				Bosna River prior to Confluence with Miljacka River				Bosna River prior to Confluence with Miljacka River			
	n	X	std	c	n	X	std	c	n	X	std	c	n	X	std	c
pH	24	8.10			24	7.95			24	8.10			24	8.10		
Alkalinity, mg $CaCO_3$/L	24	185	19	10.3	24	212	23	10.7	24	170	12	6.8	24	182	14.0	7.5
COD, mg/L	21	47	30	64.6	21	120	69	57.8	20	18	9	47.2	20	29	11.0	38
BOD5, mg/L	23	22	9.5	42.6	23	75	35	45.3	23	6.5	2.2	34.2	23	16	5.9	37.6
Total Kjeldahl Nitrogen, mg/L	23	4.7	2.2	46.9	23	10.8	5.9	54.5	23	2.1	1.2	57.1	23	4.0	2.0	50.3
Standard Plate Count, 20°C	15	1.13E+05		13.8	15	2.05E+06		5.8	15	7.23E+04		6.5	15	2.68E+05		4.7
Standard Plate Count, 37°C	15	1.21E+04		10.1	15	1.65E+05		5.4	15	8.37E+03		9.7	15	2.46E+04		5.7
Fecal Coliform, N/mL	15	2.10E+03		17.4	15	9.11E+04		12.0	15	3.57E+02		16.1	15	3.04E+03		14.7

Note 1: n = number of samples, X = median value, std= standard deviation, and c = coefficient of variation (%)
Note 2: for the period of May - June 1990
Note 3: Izvjestaj O Radu Sarajevskog Postrojenja za Preciscavanje Otpadnih Voda, ZAVOD za VODOPRIVREDU, 1990

Table E14 POLLUTANT LOAD THROUGH SEWERE DISCHARGES AND POTOKS (BROOKS) TO MILJACKA RIVER IN 1990

No.	Name of Sewer/Canal Outfall	Flow L/s	COD mg/L	BOD_5 mg/L	BOD_5 Load kg/d	Population Equivalent
1	Rad barne	10	512	194	168	2,800
2	Pijaca	10	124	75	65	1,083
3	U1.I. M. Spanca	3.5	168	73	22	367
4	Ramica-potok	20	188	124	214	3,567
5	Careva cuprija	7	408	255	154	2,567
6	Bistricki potok	80	208	99	684	11,400
7	Cumurija most	15	348	212	275	4,583
8	Nize mosta Cumurije	2	272	148	26	433
9	Most Drvenija	3	724	396	103	1,717
10	Posta	7	140	48	29	483
11	Stari most Skenderija	0.6	204	125	6	100
12	Kosevski potok	175	164	82	1240	20,667
13	Skenderija	5	168	91	39	650
14	Direkcija "Kanalizacije"	15	228	180	233	3,883
15	Potok Susica	50	632	380	1642	27,367
16	Dacki dom, Lenjinova	1	152	41	4	67
17	Dolac Malta	8	312	176	122	2,033
18	Skola za retard. Djecu	2.5	776	460	99	1,650
19	80 m uzvodno od drv. m.	5	84	50	22	367
20	50 m nizvodno od drv. m.	2	308	225	39	650
21	50 m nize od skole "P. Dokic"	1	264	220	19	317
22	100 m nize od skole "P. Dokic	1	164	87	8	133
23	Toplana-Otoka	2	400	193	33	550
24	Buca Potok	40	36	20	69	1,150
25	RMK "Zenica" 1	12	120	88	91	1,517
26	RMK "Zenica" 2	60	172	29	150	2,500
27	Novi most N. Grad	30	180	65	168	2,800
28	Alipasin most	8	508	325	225	3,750
29	Kod "Butimenke"	60	428	195	1011	16,850
30	GRAS	1.5	44	28	4	67
31	GRAS-SIK	7	600	100	60	1,000
32	"Zora"-1	1	120	30	3	50
33	"Zora"-2	6	1640	1160	601	10,017
		651.1			7628	127,133

56,255 m^3/d

Note 1: Grab samples taken before noon during dry weather in May 1990?
Note 2: Population equivalent is assumed to be 60 g BOD_5 per head.
Note 3: Refer Figure for location of major discharges and potoks.
Source : Uznovod

Table E-15 Characteristics of Trunk Main Wastewater in 1990

a) Determination of Population Equivalent of Trunk Main

No.	Interval (hour)	Temperature °C	Flow m^3/s	SS mg/L	COD mg/L	BOD mg/L	COD/BOD	SS Load	BOD Load
1	08 -10	12.2	1.710	35	112	70	1.600	59.9	119.7
2	10 -12	13.0	1.843	68	212	89	2.382	125.3	164.0
3	12 -14	14.2	1.843	80	248	110	2.255	147.4	202.7
4	14 -16	14.8	1.768	96	240	220	1.091	169.7	389.0
5	16 -18	13.8	1.843	84	232	219	1.059	154.8	403.6
6	18 -20	14.0	1.843	80	252	135	1.867	147.4	248.8
7	20 -22	13.2	1.768	104	244	140	1.743	183.9	247.5
8	22 -24	12.8	1.739	76	212	199	1.065	132.2	346.1
9	24 -02	12.5	1.737	68	212	138	1.536	118.1	239.7
10	02 -04	11.5	1.625	48	132	75	1.760	78.0	121.9
11	04 -06	11.2	1.602	17	48	19	2.526	27.2	30.4
12	06 -08	11.5	1.512	15	40	21	1.905	22.7	31.8
			1.754	72	212	122.5	1.751	128.7	221.2
			151,500					11,123	19,113
13	08 -10	12.2	1.768	52	164	123	1.333	91.9	217.5
14	10 -12	13.2	1.773	61	228	118	1.932	108.2	209.2
15	12 -14	14.2	1.773	83	292	187	1.561	147.2	331.6
16	14 -16	14.2	1.768	124	272	176	1.545	219.2	311.2
17	16 -18	13.8	1.768	74	252	162	1.556	130.8	286.4
18	18 -20	13.8	1.768	80	292	205	1.424	141.4	362.4
19	20 -22	13.5	1.730	79	260	181	1.436	136.7	313.1
20	22 -24	13.0	1.739	130	192	179	1.073	226.1	311.3
21	24 -02	12.6	1.739	128	224	126	1.778	222.6	219.1
22	02 -04	11.7	1.710	52	112	67	1.672	88.9	114.6
23	04 -06	11.2	1.625	79	100	46	2.174	128.4	74.8
24	06 -08	11.5	1.512	46	56	31	1.806	69.6	46.9
			1.754	79	226	144	1.559	133.8	252.8
			151,500	78	218	131		11,556	21,839
								11,361	19,821

Note 1: Sampling was done at the main collector for 48 hours on 8th, 9th and 10th May 1990 to determine equivalent population.

Note 2: Population equivalent was determined to be 503,712 according to the method described in "Pravilnikom o vrstama, nacinu I obimu mjerenja I ispitivanja upotrebljene, iskoristene vode I ispustene zagadjene vode" ("Sluzbeni list SR BiH", br. 39, 30.12.1985

b) Characteristics of Trunk Main Wastewater during May-June 1990

Parameter	n	X	std	c
pH	24	7.90		
Alkalinity, mg $CaCO_3$/L	24	295	25	8.6
COD, mg/L	21	238	109	45.6
BOD5, mg/L	22	157	41	22.9
Total Kjeldahl Nitrogen, mg/L	23	27	7.6	28.2
Standard Plate Count, 20°C	14	1.96E+06		7.7
Standard Plate Count, 37°C	12	2.62E+05		10.0
Fecal Coliform, N/mL	14	6.34E+04		12.7

c = coefficient of variation (%)

Source : O Odredjivanju EBS-a Uredjaja za Preciscavanje Otpadnih Voda Grada Sarajeva, "ZAVOD ZA VODOPRIVREDU", May 1990