2.10.2 Street Survey

In the street survey, 510 passers-by at 6 major flourishing spots were interviewed. The target composition of age and gender of the interviewees had been predetermined based on available demographic data.

The interviewers of street survey orally explained to interviewees the same three benefits as the door-to-door survey, showing photographs of real contamination scenes of Miljacka River. Actual questionnaire sheets and relevant information are presented in **Appendix F**.

Table 2.52 shows the results of the street survey. Average price of WTP is found to be 4.1 KM/month, which is obviously higher than the average WTP of 3.0 KM/month obtained by the door-to-door survey. This is understandable because the street survey is less complicated in terms of types of questions and makes interviewees less skeptical toward the survey, which may lead to generous WTP. A wide variance can be seen in average WTP depending on the survey locations. The highest average WTP is 6.3 KM/month, while the lowest is 2.9 KM/month. This may be attributable to characteristics of three surveyors engaged for the survey. Although those surveyor were trained together before commencing the survey, personal difference in approaching interviewees could have resulted in different answers. It is also noted that younger citizens show generally more WTP than elder citizens. The Average WTP of interviewees of those under 30 is 4.6 KM/month, while that of over 60 is 2.6 KM/month.

Table 2.52 STREET SURVEY RESULTS

Location *Lokacija*	# of male *# muskaraca*	# of female *# zena*	Total *Ukupno*	Average Age *Prosjek godina*	Av. KM *Prosjek u KM*
1. Skenderija	39	39	78	41.0	4.5 KM
2. Precednistvo	44	43	87	42.6	2.9 KM
3. Marsala Tita	42	44	86	42.6	3.2 KM
4. Ciglane	47	44	91	41.6	3.9 KM
5. Ferhadija	42	42	84	43.0	6.3 KM
6. Bascarsija	42	42	84	43.4	4.0 KM
Total / Average *Ukupno / Prosjecno*	256	254	510	42.4	4.1 KM

Age *Godina*	# of male # muskaraca	Average KM Prosjek u KM	# of female # zena	Average KM Prosjek u KM	# male + female # muskarci + zene	Average KM prosjek u KM
(15)～30	73	4.3 KM	74	4.9 KM	147	4.6 KM
31～59	138	4.4 KM	137	4.3 KM	275	4.3 KM
60～	45	2.8 KM	43	2.4 KM	88	2.6 KM
All age *Ukupno godina*	256	4.1 KM	254	4.2 KM	510	4.1 KM

Willingness to pay (WTP)	# of male # muskaraca	# of female # zena	# male + female # muskarci + zene
0 KM	22	22	44
1 KM	37	45	82
2 KM	41	29	70
3 KM	18	11	29
4 KM	25	26	51
5 KM	71	83	154
6 KM	2	2	4
7 KM	1	2	3
8 KM	3	0	3
9 KM	1	0	1
10 KM	32	29	61
15 KM	2	3	5
20 KM	1	2	3
Total / Average *Ukupno / Prosjecno*	256	254	510

2.10.3 Non-Domestic User Survey

Based on three months consumption data, major non-domestic users of ViK water supply were selected as sample candidates of the survey. Furthermore, a non-user of ViK water who is, however, a big user of ViK sewerage services was added. Those candidates aggregating about 50 included industrial, commercial, and institutional users. 33 of them (**Table 2.53**) co-operated the survey, providing their answers to the interviewer either by direct interview, fax, or telephone. Responsibilities of the persons who actually answered to the questionnaire varied from general management to specific area such as R&D, financing, and purchasing.

Their answers are totaled or averaged. The results are filled in the English translation of the questionnaire sheet that is shown in the subsequent part of this chapter. Actual questionnaire sheet in Bosnian language and relevant information are presented in **Appendix F**. Major findings of the survey are as follows:

- 16 out of 33 (48 percent of) sample companies belong to manufacturing industries including metal, shoes, and food;
- Average business sizes and utility expenses of those who answered are as follows. Water expense is roughly 30 percent of electricity expense and 70 percent of gas expense;

Number of employees	805 persons
Revenue	2.3 million KM/month
Water usage volume	9,305 m^3/month
Water usage amount	9,187 KM/month
Electricity	29,278 KM/month
Gas	12,780 KM/month
Telephone	7,349 KM/month

- Most of sample companies use ViK water and the major uses of water are cooking & dish washing, cleaning of buildings, producing goods, washing of machinery, and cooling of machinery;
- 24 sample companies discharge wastewater into public sewers without any treatment, and 10 companies discharge same after screening, scum trap or primary treatment;
- 5 sample companies discharge wastewater into river, and 1 of them discharges without any treatment;
- In spontaneous response to the question as to possibility to contribute any amount for WWTP, 16 of 33 sample companies answered "Yes"; 15 answered "No"; and 2 withheld the answer;
- In major Germany cities, wastewater tariff is considerably high when compared with water tariff. This situation can be understood by most of the sample companies and including those who answered "No" to the above question, 30 of the sample companies quoted average of 42 percentage points as maximum addition of wastewater tariff to present water tariff level.

Table 2.53 SAMPLES OF NON-DOMESTIC USER SURVEY

Name	Business Type	Water Billing (m3/month)
BOSNALIJEK -DD SAR.	Pharmaceutical	860
ENERGOINVEST ARMATURES LIVNICA	Metal (e.g. Pipe)	830
ENERGOINVEST - DIREKCIJA	Holding company	760
UPI AGROCULTURE BUTMIR	Agricultural Product	790
ASTRO DD SARAJEVO	Shoes Production	660
AUTOMECHANIC DD SARAJEVO	Car repair	500
SIPAD STANDARD	Furniture	500
ENERGOINVEST DD VMC	Metal (High power cable)	460
UNIONINVEST TTO	Air-conditioning Machine	410
SP UNIONINVEST DP UNIKLIMA	Air-conditioning Machine	330
VRANIV OOUR "2TMZ"	Metal	330
DD "MILCOS"	Milk	1,100
DP"KLAS"	Bakery	900
BITUMENKA DP	Chemical	660
UPI DD ZORA	Candy	660
UPI SERVICE FOR OBLIGINGNESS	Service	600
DP SPRIND	Food	330
SARAJEVO PIVO	Beer	0
ENERGOINVEST HOLDING "D.T.V."	Metal	830
JKP TRAM	Communal company (Tram service)	2,660
ZTO-STD-INHABITANTS	Railway	1,060
JKP RAD	Communal company (Solid waste)	930
PUT	Road construction & maintenance	430
JP RTV BIH	Radio & TV Broadcasting	3,000
OSLOBODJENJE	Newspaper	1,500
HOLIDAY INN	Hotel	1,630
AERODROME SARAJEVO	Airport	1,100
ALHOS DD EXPORT-IMPORT	Garment	830
UNIS-ENERGOTEHNIKA	Engineering	700
MERKUR TP SHOP TRZNIC	Supermarket	500
KCU SARAJEVO-TECHNICAL SERVICE	Hospital	13,420
STATE HOSPITAL SARAJEVO	Hospital	6,660
VETERINARY UNIVERSITY	School	1,330

'able 2.54 QUESTIONNAIRE SURVEY

REHABILITATION OF THE WASTEWATER TREATMENT PLANT OF SARAJEVO

WATER AND SEWERS SURVEY

The Japan International Cooperation Agency is carrying out this survey, in cooperation with Vodovod i Kanalizacija, Sarajevo in order to rehabilitate the wastewater treatment plant and improve the sanitary conditions of the city.

After the war, the Sarajevo WWTP has not yet been restored, thus, wastewater is discharged without treatment, into Miljacka River. Miljacka River not only runs through Sarajevo, but also flows into Bosna River and finally Danube River. If Sarajevo citizen pollute Miljacka river by discharge of sewage without treatment, it may affect the living condition of Sarajevo people and those who live along the downstream including European nations.

This project will surely result in the better environment for the habitants. Your company has been selected to represent community in this survey. There will be no policy implementation from questionnaire and we also guarantee the secrecy of the data collected.

Please CHECK your answer in ( ) unless specified.

1. NAME OF THE COMPANY OR INSTITUTION (SPECIFY)
   ( )

2. INTERVIEWEE'S RESPONSIBILITY IN THE COMPANY OR INSTITUTION (SPECIFY)
   ( )

3. INDICATE TYPES OF YOUR COMPANY'S OR INSTITUTION'S WORK (CHOOSE ONE OR MORE)
   a. (8) Industry (e.g. metal)
   b. (2) Industry (e.g. shoes)
   c. (6) Food Industry (e.g. tobacco, milk, corn, beer)
   d. ( ) Utility (e.g. electricity, gas, telephone)
   e. (3) Transportation (e.g. tram, bus, train)
   f. (3) Construction (e.g. road, building, engineering)
   g. (2) Hospital
   h. (7) Service (e.g. hotel, road cleaning, car repair)
   i. (1) Education (e.g. university)
   j. (1) Other (specify) Pharmaceutical

4. INDICATE THE NUMBER OF EMPLOYEES IN YOUR COMPANY OR INSTITUTION
   (805)

5. INDICATE THE WATER SOURCES AND MAIN USAGE USED IN YOUR COMPANY OR INSTITUTION (CHOOSE ONE OR MORE)

Usage	Source					
	Public Water Supply Service (ViK)	Private Water System Service	Wells	Water Truck or Tank	Rain Water	Other (specify)
Washing machinery	12	1		1		
Cooling of machinery	10	1		1		
Producing goods	13	1	1	1		
Cooking & dish washing (kitchen)	14	1	1			
Producing food (factory)	3					
Watering plant	3	1				
Cleaning Buildings	14	1	1			
Other (specify)	2					

6. INDICATE ANNUAL OR MONTHLY CONSUMPTION OF WATER AT YOUR COMPANY OR INSTITUTION (SPECIFY)

a. (m3) Annually
b. (9,305 m3) Monthly

7. INDICATE DISPOSAL METHOD OF WASTEWATER FROM YOUR COMPANY OR INSTITUTION (CHOOSE ONE OR MORE)

a. (9) Discharge into public sewers after primary treatment
b. (1) Discharge into public sewers after screening and scum trap
c. (24) Discharge into public sewers without any treatment
d. (4) Discharge into river after treatment
e. (1) Discharge into river without any treatment
f. (2) Septic Tank
g. ( ) Other (specify) ____________

8. INDICATE THE REASONS WHY YOU CONSIDER IT IS IMPORTANT TO HAVE WWTP TO PURIFY WASTEWATER (CHOOSE ONE OR MORE)

a. (4) To avoid bad odors
b. (6) To avoid the proliferation of mosquitoes, Germs and other plagues
c. (4) To avoid disturbing downstream European nations by discharging wastewater without treatment
d. (8) To be recognized as a member of responsible European nations by complying with the international standard of wastewater discharging quality
e. (1) To improve agricultural production
f. (14) To maintain drinkable water sources
g. (3) To maintain sufficient water for the industrial use (recycle)
h. (24) To conserve the ecosystem of animals and plants
i. (6) To avoid future environmental cost
j. ( ) There is no reason of importance
k. ( ) Not important
l. ( ) Other (specify) ____________

9. INDICATE ANNUAL REVENUE OF YOUR COMPANY OR INSTITUTION (SPECIFY ONE)
   a. (KM) Annually
   b. (*2,335,263* KM) Monthly

10. INDICATE ANNUAL OR MONTHLY COST OF <u>WATER</u>, (SPECIFY ONE)
   a. (KM) Annually
   b. (*9,187* KM) Monthly

11. INDICATE ANNUAL OR MONTHLY COST OF <u>ELECTRICITY</u>(SPECIFY ONE)
   a. (KM) Annually
   b. (*29,278* KM) Monthly

12. INDICATE ANNUAL OR MONTHLY COST OF <u>GAS</u> (SPECIFY)
   a. (KM) Annually
   b. (*12,780* KM) Monthly

13. INDICATE ANNUAL OR MONTHLY COST OF <u>TELEPHONE</u> (SPECIFY)
   a. (KM) Annually
   b. (*7,349* KM) Monthly

14. READ THE FOLLOWING SENTENCE THAT DESCRIBE THE BENEFITS OF WWTP AND ANSWER THE QUESTION

(1) PRESERVE THE ENVIRONMENTATAL CONDITION OF MILJACKA AND FURTHER IMPROVEMENT

It is considered that the current water quality of Miljacka river is not favorable, generating odor and unsanitary condition. Also, If we continue to discharge the wastewater without treatment, we will have worse condition of Miljacka. The WWTP will help to improve the environment of Miljacka at least to the Pre-war level.

(2) MAINTENANCE OF GOOD RELATIONSHIP WITH THOSE WHO LIVING DOWNSTREAM INCLUDING EUROPEAN COUNTRIES.

People living downstream are using the water that is a part of your wastewater for their livings, such as drinking and washing dishes. It will cost more for the people in downstream to purify when the water quality of Miljacka deteriorate. WWTP will prevent the potential future conflicts with downstream.

(3) TO BE RECOGNIZED AS AN RESPONSIBLE EUROPEAN STANDARD COMPANY OR INSTITUTION

It is one of the important criteria to have WWTP before discharging to an international river in order to be recognized as a responsible organization in developed European countries.

(4) REDUCTION OF FUTURE ENVIRONMENTAL COST

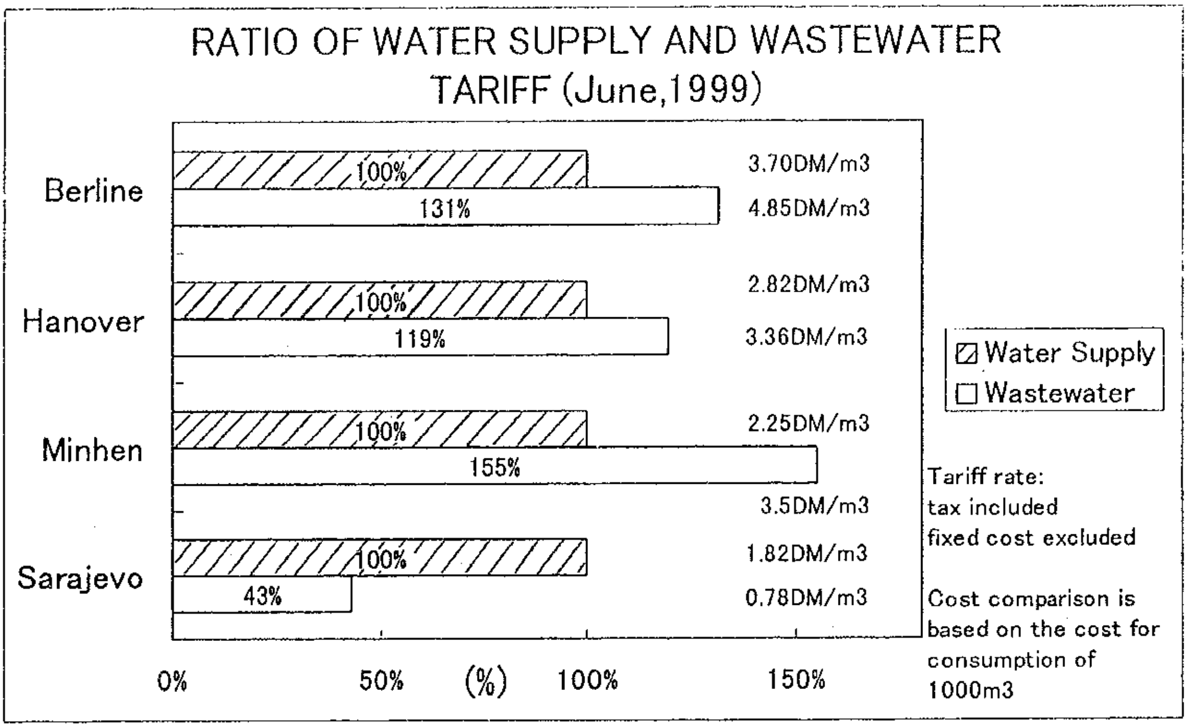
It is expected that the environmental cost, which might be covered by environmental tax, will increase in future if wastewater would be continuously discharged without treatment. It is certainly cheaper for you to have WWTP and preserve the environment in early stage before it gets worse.

IN ORDER TO FIX WWTP AND ACHIEVE THE ABOVE-MENTIONED PURPOSE, WILL IT BE POSSIBLE TO CONTRIBUTE SOME AMOUNT? (CHOOSE ONE)

a. (*16*) YES
b. (*15*) NO

15. READ THE FOLLOWING SENTENCE AND ANSWER THE QUESTION

Comparing to the water supply and wastewater companies in other European cities, ViK's tariff rate of wastewater is relatively small (See the table below). Currently the ratio of sewerage and water against total tariff is 43 to 100.



IN ORDER TO FIX WWTP AND ACHIEVE THE ABOVE-MENTIONED PURPOSE IN QUESTION 14, WHAT IS THE MAXIMUM ADDITIONAL PERCENT OF WASTEWATER TARIFF RATE (CURRENTLY 43%) IN THE ABOVE TABLE YOUR COMPANY OR INSTITUTION CAN ACCEPT PER MONTH? (SPECIFY)

a. (*4*) 10%
b. (*5*) 20%
c. (*7*) 30%
d. (*2*) 40%
e. (*6*) 50%
f. (*2*) 60%
g. ( ) 70%
h. ( ) 80%
i. ( ) 90%
j. (*3*) 100%
k. (*1*) 110%
l. ( ) 120%

Average 42%

CHAPTER 3. REVIEW OF THE PREVIOUS STUDIES AND PROJECT

CHAPTER 3. REVIEW OF THE PREVIOUS STUDIES AND PROJECT

3.1 OUTLINE OF THE SEWERAGE SYSTEM RECONSTRUCTION PROJECTS IN SARAJEVO

According to the Implementation of the Priority Reconstruction Program (issued in October 1998), which is the reconstruction and development plan of the Bosnian Ministry of Foreign Affairs (MOFA), reconstruction projects are currently being implemented by 49 countries and 13 international agencies (excluding NGOs). This aid amounts to US $ 4,765 million in total and can be broken down into 76% grant aid, 19% low-interest loans, and 5% commercial loans. Japan has pledged US $ 386 million (8% of the total) as was agreed from the second conference of donor nations held in Brussels in 1996, and Japanese grant aid and loans amount to US $ 230 million. This makes Japan the fourth largest donor behind the EU, USAID and the WB (see **Table 3.1**).

This paper gives an outline description of the results of interview surveys and site investigations that were carried out by the Study Team with respect to reconstruction projects for the rehabilitation and restoration of the sewerage system in Sarajevo, contained within the reconstruction and development plan (see **Figure 3.1**). The control and coordination of these survey results were validated and confirmed in a hearing conducted with the International Management Group (IMG), which has the overall control over the rehabilitation and development projects of donor nations, and the findings were also checked with the annual report for 1998 of the Water Supply and Sewerage System Public Corporation (ViK).

3.2 SEWERAGE SYSTEM RECONSTRUCTION PROJECTS OF EACH DONOR COUNTRY AND AID AGENCY

3.2.1 Kuwait Fund Project "Long Term Solutions of Water Supply and Wastewater Drainage and Treatment in the Canton of Sarajevo"

The Kuwait Fund is providing funding to the Ministry of Water Management Agriculture and Forestry (MOAWMF) to cover the development study costs of the Long Term Solutions of Water Supply and Waste Water Drainage and Treatment in the Canton of Sarajevo, for which the Water Resources Management Public Corporation (VBH) is acting as the executive agency. The VBH concluded a consultant contract with a joint venture composed of British, Kuwaiti and BiH consultants and started the project in June 1998, and the Final Inception Report (FIR) for the project was completed in February 1999.

This report gives a description of the Long Term Project for the Development of Water Supply and Waste Water Drainage and Treatment in the Canton of Sarajevo, for which 2015 is adopted as the target year. The Study Team intends to view this project as the superior plan when examining the framework for projects (the report was obtained via the ViK on March 6).

(1)	Financing agency	Kuwait Fund, the Government of Kuwait
(2)	Responsible agency	Ministry of Agriculture, Water Management and Forestry (MOAWMF)
(3)	Executive agency	Water Resources Management Public Corporation (VBH)
(4)	Implementing agency	Joint venture of British, Kuwaiti and BiH consultants (GIBB/KCIC/EE)

Table 3.1

STATUS OF CONTRIBUTIONS TOWARD RECONSTRUCTION IN 1998 (IN US $ MIL.)

DONOR	PLEDGE	FIRM	IN IMPLEMENTATION	COMPLETED	TOTAL
ALBANIA	0.02			0.02	0.02
AUSTRALIA	1.13			1.13	1.13
AUSTRIA	46.37	6.27	20.84	18.54	45.65
BELGIUM	20.67	8.76	7.67	4.24	20.67
BRUNEI	23.12		9.42	8.44	17.86
BULGARIA	0.01			0.01	0.01
CANADA	58.59	26.05	27.84	3.13	57.02
CROATIA	24.91		24.91		24.91
CZECH REPUBLIC	12.34	6.24		6.10	12.34
DENMARK	34.69	5.68	9.54	15.07	30.29
EGYPT	5.02			4.02	4.02
ESTONIA	0.18	0.10		0.08	0.18
FINLAND	19.10	4.82	4.84	9.44	19.10
FRANCE	40.20	15.10	9.00	16.10	40.20
GERMANY	111.34	22.60	28.49	60.25	111.34
GREAT BRITAIN	86.90		5.29	46.71	52.00
GREECE	25.40	6.02	4.40	6.98	17.40
HUNGARY	1.00			1.00	1.00
ICELAND	1.60	0.75	0.85		1.60
INDONESIA	3.08	0.08	2.00	1.00	3.08
IRELAND	10.50	1.61	0.49	7.61	9.72
ISLAMIC REPUBLIC OF IRAN	15.00				
ITALY	130.30	55.00	45.59	26.74	127.33
JAPAN	386.70		118.86	111.48	230.34
JORDAN	1.37	0.13	1.23		1.37
KUWAIT	46.55	45.35	1.15		46.50
LATVIA	0.09			0.09	0.09
LITHUANIA	0.16	0.08		0.08	0.15
LUXEMBURG	7.55	1.78	2.34	2.34	6.46
MACEDONIA	0.16			0.16	0.16
MALAYSIA	25.64		5.00	13.62	18.62
NETHERLANDS	259.53	118.39	72.44	59.06	249.89
NORWAY	134.02		41.60	80.77	122.37
POLAND	3.02			3.02	3.02
PORTUGAL	1.00	1.00			1.00
QATAR	10.14	1.77	2.51	5.86	10.14
ROMANIA	0.25		0.05	0.20	0.25
RUSSIA	50.00				
SAN MARINO	0.23			0.23	0.23
SAUDI ARABIA	75.00	5.00	10.29	30.09	45.38
SLOVAKIA	3.06	1.50		1.56	3.06
SLOVENIA	10.20		6.32	3.89	10.20
SOUTH COREA	3.10			1.70	1.70
SPAIN	45.70	28.94		6.45	35.39
SWEDEN	132.85	90.27	19.14	23.43	132.85
SWITZERLAND	133.30	35.72	65.68	31.88	133.29
TUNISIA	0.22			0.22	0.22
TURKEY	86.52	27.78	10.00	8.72	46.50
USA	766.61		188.14	339.31	527.45
YUGOSLAVIA	21.70	10.00		11.70	21.70
COUNCIL OF EUROPE	15.00	1.50	5.00		6.50
EBRD	97.01		85.69	11.32	97.01
EUROPEAN COMMISSION*	999.59	155.36	445.78	350.44	951.58
HIGH SAUDI COMMITTEE	4.25	1.25	3.00		4.25
IFAD	21.32	14.00		7.32	21.32
IMF	80.70	80.70			80.70
ISLAMIC BANK	20.64		7.17	12.87	20.04
OIC	3.00				
SOROS FOUNDATION	5.90		5.64	0.26	5.90
UNDP	19.01		16.50	2.51	19.01
WHO	1.48		1.48		1.48
WORLD BANK	621.40	88.00	217.63	315.77	621.40
TOTAL	4765.43	867.61	1533.83	1672.95	4074.39

Column PLEDGE includes funds pledged at Brussels conferences I, II, III, IV as well as funds pledged outside the donor conferences
Column FIRM specifies funds for which implementation documents or other confirmed documents are available
Column IN IMPLEMENTATION specifies funds already contracted, procurement undarway, announced tenders, works underway
Column COMPLETED specifies funds for goods delivered to the destination or works completed
Column TOTAL gives sum of the previous three columns (FIRM, IN IMPLEMENTATION and COMPLETED)

*Data taken over from the EC ASSISTANCE TO BOSNIA AND HERZEGOVINA "TABLEAU DE BORD" 1996, 1997, 1998.

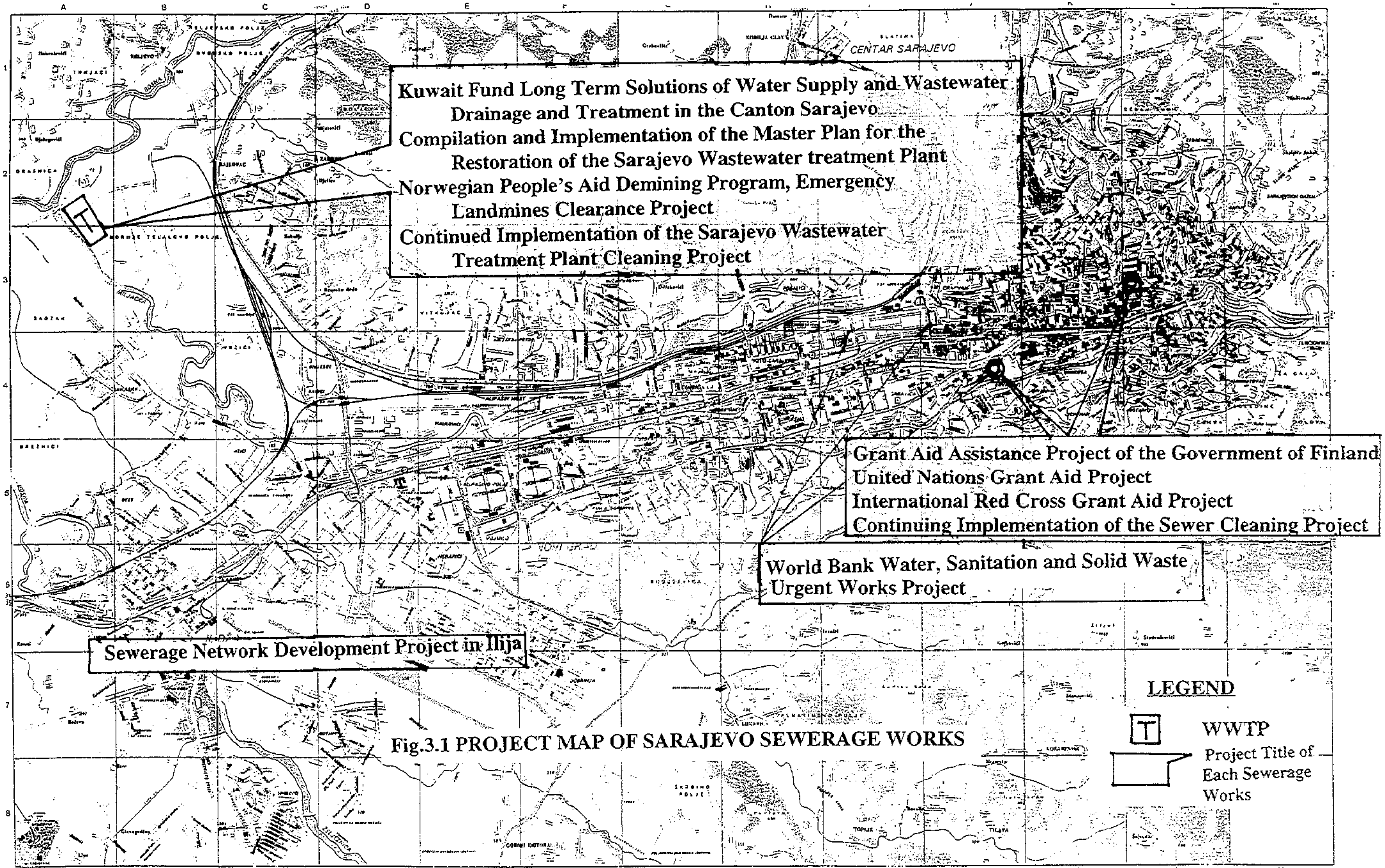


Fig.3.1 PROJECT MAP OF SARAJEVO SEWERAGE WORKS

3.2.2 Grant Aid Assistance Project of the Government of Finland

The Government of Finland in 1998 carried out equipment supply and the partial reinstallation of sewers as emergency ODA. The restoration works were implemented on Tekiya Soukbuhar Avenue in Sekenderiya, Avgus ja Bravha Avenue in Marindwall, and Didivovac Avenue in Bielabe. As a result of this assistance, which amounted to approximately DEM 0.48 million, approximately 500 m of sewers of diameter 300-800 mm have been installed.

(1)	Financing agency	Government of Finland
(2)	Responsible agency	Ministry of Agriculture, Water Management and Forestry (MOAWMF)
(3)	Receiving agency	Water Supply and Sewerage System Public Corporation (ViK)
(4)	Implementing agency	Finland Agency for International Development (FINIDA)

3.2.3 World Bank - Water, Sanitation and Solid Waste Urgent Works Project

The World Bank (WB) loaned approximately US $ 3 million as funds for the rehabilitation of trunk sewers to the Canton of Sarajevo Water Resources Management Public Corporation (Vodoprivreda BiH; VBH) and completed the Water, Sanitation and Solid Waste Urgent Works Project. The targeted sewers cover almost all sectors and have been divided into five schemes. The project activities consist of the purchase of equipment and materials, construction of a workshop, purchase of maintenance vehicles, and the reinstallation and new installation of sewers (incidentally, a German contractor was selected to carry out the sewer works as a result of the tender).

(1)	Financing agency	World Bank (WB)
(2)	Responsible agency	Ministry of Agriculture, Water Management and Forestry (MOAWMF)
(3)	Implementing agency	Water Resources Management Public Corporation (VBH)
(4)	Works execution agency	German contractor

3.2.4 Norwegian People's Aid Demining Program, Emergency Landmines Clearance Project

The Government of Norway, in a jointly financed undertaking with the Government of Austria and as part of its overseas development aid, is providing grant aid support for the Norwegian People's Aid Demining Program, Emergency Landmines Clearance Project. The actual landmines clearance work is being implemented by the Mine Action Center (MAC) of the European Commission (EC) with the support of the Civil Military Cooperation (CIMIC) of the NATO German Army Stabilization Force (SFOR). The result of this work depends on the future continuation of the work, however, since the targeted areas were not on the front line of fighting, not one mine has so far been cleared (interview with Planning Section Manager Mr. Jarnehed of MAC). **Figure 3.2** shows a zone in the target area that has been cleared of mines.

(1)	Financing agency	Governments of Norway and Austria
(2)	Responsible agency	EC/Mine Action Center (MAC)
(3)	Executive agency	Norwegian People's Aid (NPA)
(4)	Implementing agency	NATO German Army SFOR, Civil Military Cooperation (CIMIC)

3.2.5 United Nations Grant Aid Project

The United Nations (UN) in 1996 provided grant aid to the Directorate for Renovation of Sarajevo (DORS), which is a subordinate agency of the Canton of Sarajevo. The aid consisted of the cleaning of sewers in high priority districts and the replacement of window sashes in the construction office of the ViK. The cleaning of sewers has been continuing for about three years through the self efforts of the ViK.

(1)	Financing agency	United Nations (Trust Fund through DORS)
(2)	Responsible agency	Canton of Sarajevo, Directorate for Renovation of Sarajevo (DORS)
(3)	Implementing agency	Water Supply and Sewerage System Public Corporation (ViK)

3.2.6 International Red Cross Grant Aid Project

The International Red Cross, in cooperation with the German Red Cross, has supplied vehicles to the BiH side in a joint grant aid project. One sewer cleaning vehicle has been supplied to ViK.

(1)	Cooperating agency	International Red Cross and German Red Cross
(2)	Receiving agency	Water Supply and Sewerage System Public Corporation (ViK)

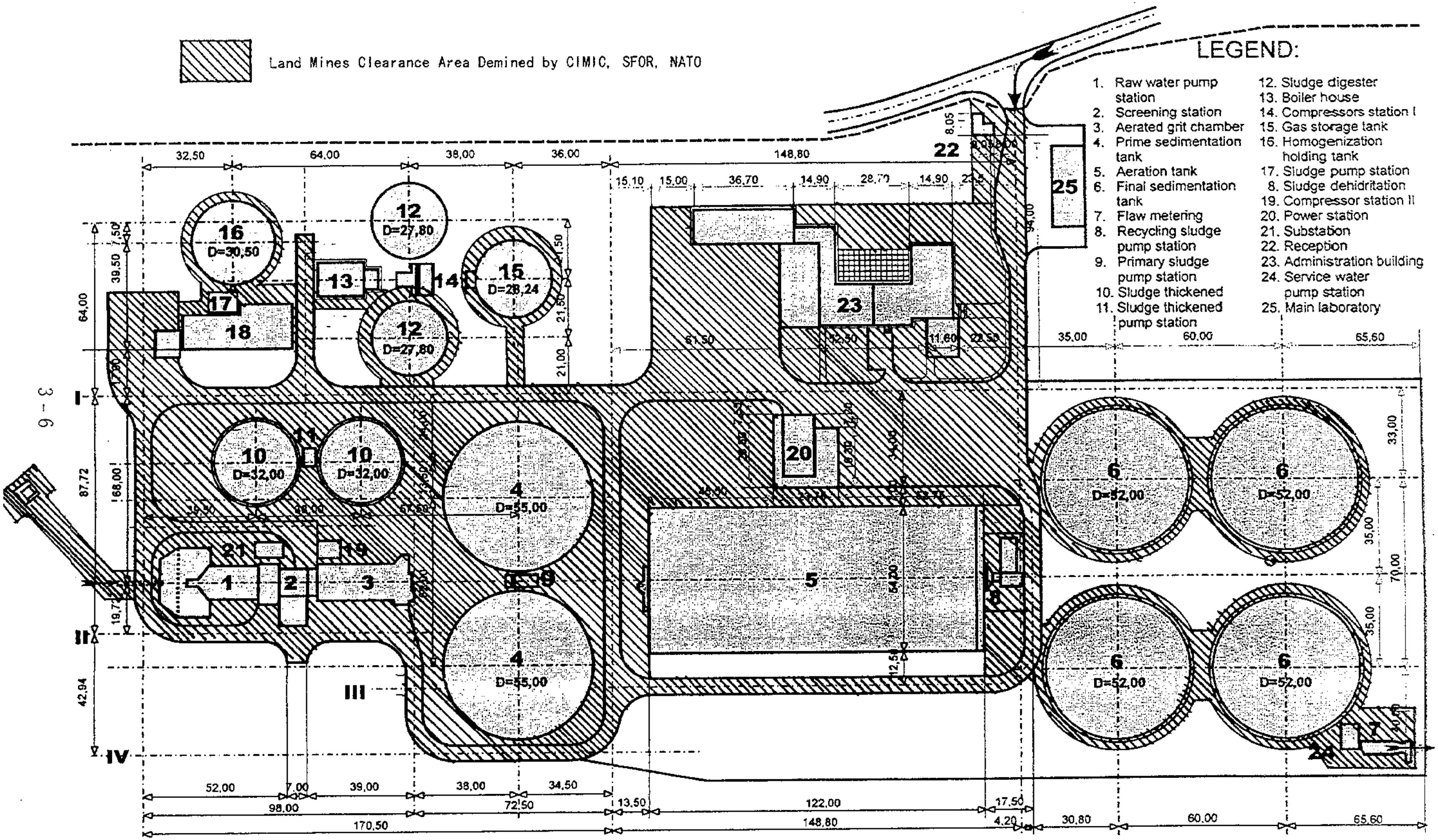


Fig.3.2 LAND MINES CLEARANCE AREA

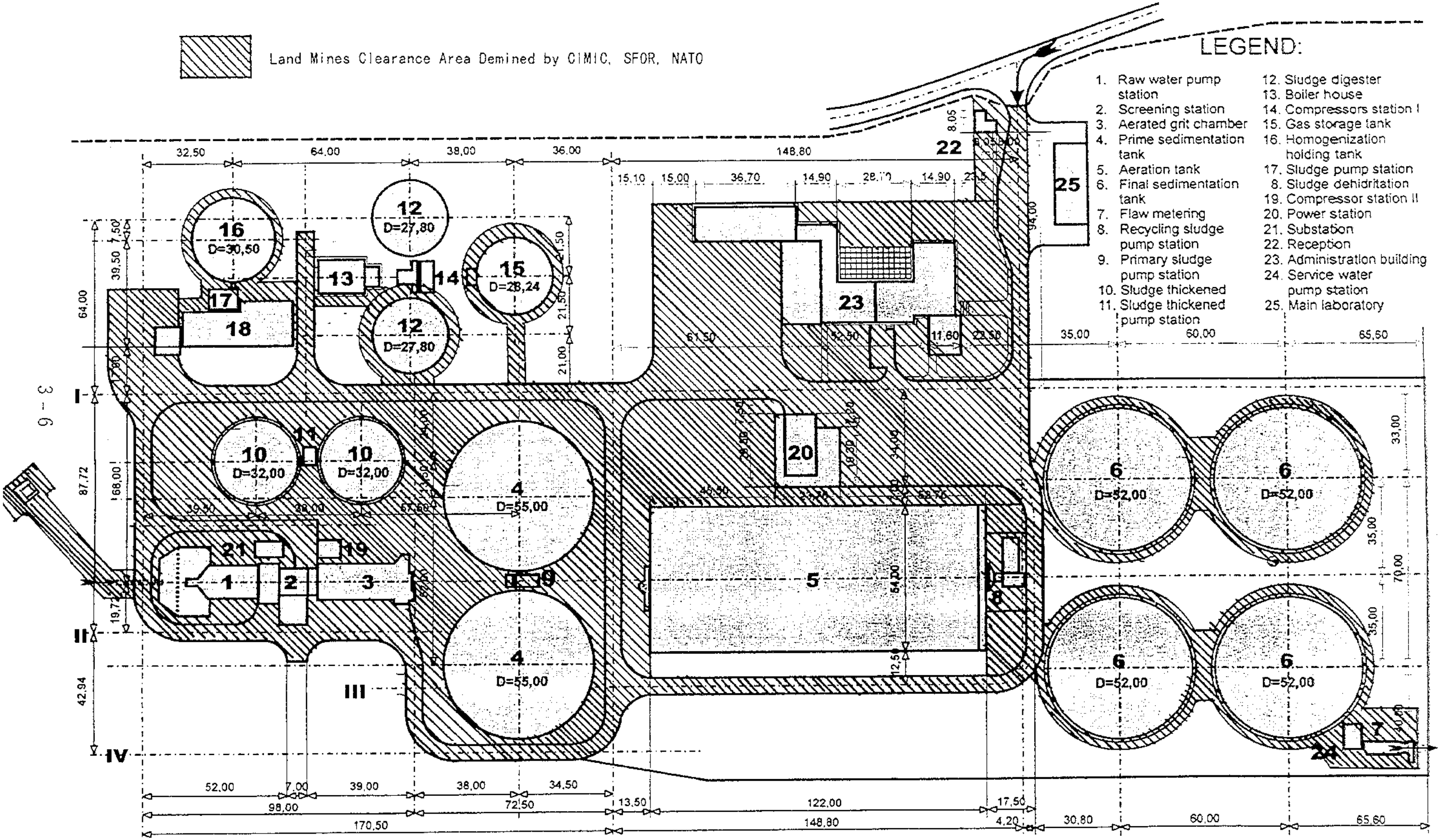


Fig.3.2 LAND MINES CLEARANCE AREA

3.2.7 Original World Bank Loan for Sarajevo WWTP

The Sarajevo WWTP originally started its operation in 1984, and due to the Bosnian war, the operation stopped in 1992. The construction of the WWTP was partly funded by the World Bank. The World Bank finance was a part of the Project "Protection of human environment" which covered water supply and sewer projects.

The loan comprised the principal part and the interest part, totaling roughly to US$94 million. Under the original loan condition, the interest rate was 8.5%; the borrower was ViK Sarajevo; the guarnator was the former Yugoslavia; and the repayment period was 20 years. The actual disbursement supposedly started in 1982.

Out of the total loan amount of US$94 million, the WWTP portion was about US$35 million. The remaining US$59 million was for water supply and sewerage projects. The repayments of the original loan were done as follows:

(US$)	Principal part	Interest part	Total
1982	45,000,000	49,353,100	94,353,100
Repaid by ViK untill 1990	10,805,000	29,295,068	40,100,067
Repaid by Yugoslavia bank* till 1991	3,860,000	5,575,310	9,435,310
Balance as of 1992	30,335,000	14,482,722	44,817,723

* Yugoslavia Bank took over the loan after the Republic of Bosnia and Herzegovina declared its independence.

Total amount outstanding as of 1992, or US$44.8 million was revaluated in 1992 because the loan was in fact, composed of DM, JPY, and SFr. And those currencies had been depreciated against US$ by 1992. The outstanding debt became US$68.6 million[1] after the revaluation. The portion allocated for the WWTP was presumably US$25.5 million (=68.6*35/94).

Since 1992, no repayment has been made for the loan. The debt was transferred from Yugoslavia Bank to the State of Bosnia and Herzegovina (BiH). Thus, ViK is not anymore the borrower of the loan. Although BiH is the guarantor of the loan, BiH itself is not able to repay the loan through its state current revenue. Instead, FBiH and/or Canton Sarajevo are supposed to perform actual repayments.

Under the new loan condition after the transfer, the interest rate is unchanged or 8.5%, and the repayment will start either in Nov. 2001 or Nov. 2002. The repayment has to be completed by Nov. 2025.

[1] Including this amount, the World Bank had outstanding old loans to BiH, totaling to US$589 million as of Nov. 1997. Incidentally, total external debts of BiH as of 1997 was US$4,076 million.

3.3 RESTORATION AND RECONSTRUCTION PROJECT OF THE WATER SUPPLY AND SEWERAGE SYSTEM PUBLIC CORPORATION (ViK)

3.3.1 Compilation and Implementation of the Master Plan for the Restoration of the Sarajevo WWTP

The Water Supply and Sewerage System Public Corporation (ViK) in May 1998 consigned the implementation of the Elaborate on Restoration of the Sarajevo Wastewater Treatment Plant (Contract K5103) to a local consultant, USB KEDLY DOO Co., and this was completed in September the same year

The said study is basically intended to formulate a feasible plan for the restoration of the Sarajevo Wastewater Treatment Plant to the state, it was before the conflict in 1992. It consists of a detailed description and restoration concept for each facility. The master plan is based on design of the plant at the time when it was in operation, and it is a valuable study in terms of understanding the conditions of operation when the plant was in service. This will prove extremely useful for the functional diagnosis work of the Study Team.

(1)	Project manager	Direct management by the Water Supply and Sewerage System Public Corporation (ViK)
(2)	Responsible agency	Water Supply and Sewerage System Public Corporation (ViK)
(3)	Contractor	USB KEDLY DOO Co.

3.3.2 On-ging Sewer Cleaning Project

The Water Supply and Sewerage System Public Corporation (ViK) started the sewer cleaning project under its direct management from January 1996 through December 1998. The work was carried out by staff of the ViK construction office, using equipment and materials supplied under grant aid from the Government of Finland and cleaning equipment purchased through a loan from the World Bank. The project targets sewers in all treatment districts and has so far resulted in the cleaning of 139 km of sewers. The cleaning of sewers is scheduled to be continued into the future with the work being managed based on a rotation system.

(1)	Project management	Direct management by the Water Supply and Sewerage System
(2)	Responsible agency	Water Supply and Sewerage System Public Corporation (ViK)
(3)	Implementing agency	Water Supply and Sewerage System Public Corporation (ViK)

3.3.3 On-going Cleaning Project of the Sarajevo WWTP

Following the signing of the comprehensive peace accord in Dayton, Ohio in 1995, the Water Supply and Sewerage System Public Corporation (ViK) started the Sarajevo Wastewater Treatment Plant cleaning project under its direct management. Existing staff of the plant have successively implemented partial renovation of the administration building and cleaning of the plant facilities. The internal cleaning (sludge removal) of digestion tanks was carried out at the start of March 1999.

start of March 1999.

(1)	Project management	Direct management by the Water Supply and Sewerage System
(2)	Responsible agency	Water Supply and Sewerage System Public Corporation (ViK)
(3)	Implementing agency	Water Supply and Sewerage System Public Corporation (ViK)

3.3.4 Independent Surface Development Project (Newly Scheduled Project)

As a new project for 1999, the Water Supply and Sewerage System Public Corporation (ViK) has appropriated a budget for surface development under its direct management in the districts of Vogosca and Alipasino in the north of the city. Approximately DEM 1.4 million is scheduled tobe invested into this project.

(1)	Project management	Direct management by the Water Supply and Sewerage System
(2)	Responsible agency	Water Supply and Sewerage System Public Corporation (ViK)
(3)	Implementing agency	Water Supply and Sewerage System Public Corporation (ViK)

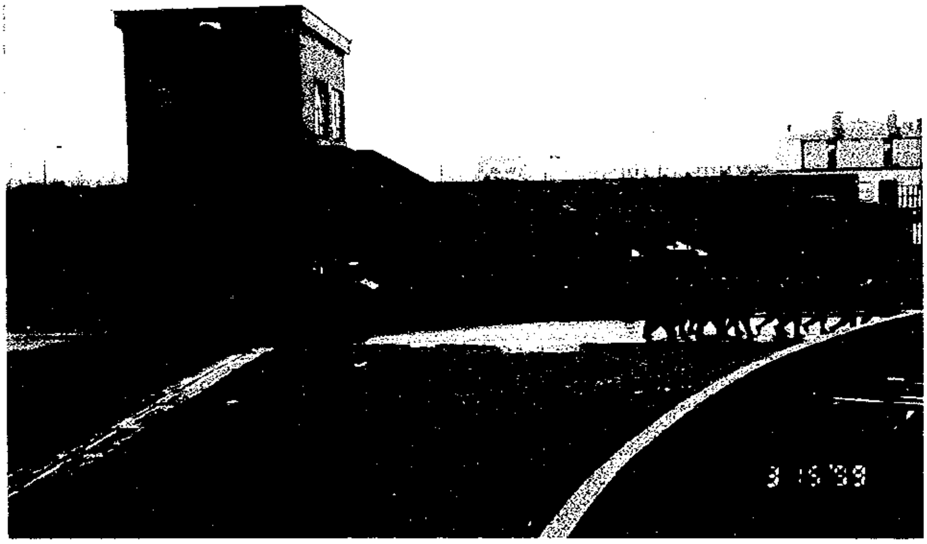
3.4 RESTORATION AND RECONSTRUCTION PROJECT SUBSIDIZED BY THE CANTON OF SARAJEVO

3.4.1 Sewerage Network Development Project in Ilidza

According to ViK Capital Investments data for 1999, a project subsidized by the Canton of Sarajevo is scheduled for implementation in 1999. The project involves surface development in the districts of Ilidza (Vrutci, Vrelo Bosna and Vreoce) on the west side of Sarajevo Airport and Faletici in the northern part of the old city. The subsidy from the Canton of Sarajevo is estimated to be approximately DEM 1.1 million.

(1)	Financing agency	Water Resources Management Public Corporation (VBH)
(2)	Responsible agency	Water Supply and Sewerage System Public Corporation (ViK)
(3)	Implementing agency	Water Supply and Sewerage System Public Corporation (ViK)

CHAPTER 4. ASSESSMENT OF SARAJEVO WWTP



CHAPTER 4 ASSESSMENT OF SARAJEVO WWTP

4.1 DESCRIPTION AND ASSESSMENT OF EXISTING TREATMENT PROCESS

4.1.1 Introduction

The treatment plant was designed and commissioned 15 years ago by the Degremont Company. A site plan of the treatment facilities is presented on **Drawing G1, Appendix M, Vol.VI**. The plant was designed to treat sewage from 600,000 inhabitants in the first stage and provision was made in the construction of certain facilities for expansion to serve 900,000 inhabitants (Refer to **Table 4.1**).

Table 4.1 ORIGINAL DESIGN PARAMETERS FOR TREATMENT PLANT

DESIGN CRITERIA	AS BUILT 1979 – STAGE 1		PROVISION FOR STAGE 2	
	Raw Wastewater	Treated Wastewater	Raw Wastewater	Treated Wastewater
Population	600, 000		900, 000	
Daily flow	186, 000 m^3/d		300 ,000 m^3/d	
Average daily flow	2.15 m^3/s 7 ,735 $m^3/hrs.$		3.15 m^3/s 12 ,600 $m^3/hrs.$	
Max dry weather flow	2.6 m^3/s 9, 360 $m^3/hrs.$		4.0 m^3/s 14, 400 $m^3/hrs.$	
Peak wet weather flow	12, 180 $m^3/hrs.$ 3.55 m^3/s			
BOD load (kg/day)	36, 000		54 ,000	
BOD concentration (mg/l)	194	20	180	20
TSS load (kg/day)	48,000		72,000	
TSS load (mg/l)	270	30		30
Fecal coliforms (MPN/100 ml)				

The following **Table 4.2** compares previous stage 1 design parameters to the flows and loading forecast by the JICA Study team for the year 2000 and 2015:

Table 4.2FORECASTED FLOW AND LOADING COMPARED TO ORIGINAL DESIGN

	AS BUILT 1979 – PHASE 1		JICA STUDY FORECAST FOR YEAR 2000		JICA STUDY FORECAST FOR YEAR 2015	
	Raw Wastewater	Treated Wastewater	Raw Wastewater	Treated Wastewater	Raw Wastewater	Treated Wastewater
Population	600,000		371, 600		506, 300	
Average dry weather	186, 000 m^3/d		120, 000 m^3/d		196, 200 m^3/d	

Flow(ADWF)	2.15 m^3/s		1.39 m^3/s		2.27 m^3/s	
Peak wet weather flow (PWWF)	12, 180 m^3/hrs. 3.55 m^3/s		7, 136 m^3/hrs. 1.98 m^3/s		11, 667 m^3/hrs. 3.2 m^3/s	
BOD load (kg/day)	36, 000		22, 294		37, 969	
BOD concentration (mg/l)	194	20	186	20	200	20
TSS load (kg/day)	48,000		29, 726		48, 094	
TSS load (mg/l)	270	30	248	30	245	30
Fecal coliforms (MPN/100 ml)				200		200

Table 4.2 indicates that flows and loads forecast for the year 2000 loads are less than those used for the design of the plant. For year 2015 the BOD load exceeds original design criteria by 5%. Process calculations prepared for the purpose of preliminary design indicate that the biological aeration process has sufficient capacity for the year 2015 BOD loading conditions. However, secondary sedimentation tanks will be slightly overloaded at peak wet weather flow. Therefore it will be necessary to add two more sedimentation tanks 52m in diameter.

The existing treatment process does not include disinfection and it is currently not required. However, a proposed National Effluent Standard is being discussed. If the standard is adopted it would require disinfecting effluent to reduce faecal coliform counts below 200 MPN.

4.1.2 Hydraulics

The civil works for the following structures were constructed to meet second stage flows and have sufficient hydraulic capacity for year 2015 conditions:

(1) Aerated grit chamber
(2) Primary sedimentation tanks
(3) Thickeners
(4) Digesters
(5) Gas tank
(6) Sludge holding tank

Schematic diagrams showing the flow regime of the existing WTP are shown in **Figure 4.1.** Hydraulic grade lines for the original plant are illustrated on **Drawing C1**.

Existing screens and grit chambers are designed to pass up to 5.2 m^3/s corresponding to 4 pumps in operation at the same time. The two primary sedimentation tanks are designed to operate properly up to 4 m^3/s (2 m^3/s each) which corresponds to three pumps operating at the same time. Flows in excess of 4m^3/s (1.2m^3/s) are automatically sent to the plant by-pass by means of an overflow structure at the outlet of the grit chamber. Flows by-passed at this stage receive preliminary treatment only.

The aeration tanks are designed to accept a maximum flow of 3.08m^3/s. Excess flows of 0.92m^3/s are automatically sent to the plant by-pass by means of an overflow structure located at the inlet to the aeration tanks. Flows by-passed at this stage receive primary treatment. The rest of the treatment process (aeration, and secondary sedimentation) is designed for maximum hydraulic flow of 3.08 m^3/s.

The rehabilitated treatment plant is expected to perform well under year 2000 and year 2015 flow conditions.

4.1.3 Treatment Process – Liquid Line

(1) Pumping Station (Facility No.1)

The existing plant layout is shown on **Drawing G1.** The water table is very high therefore structures were constructed above grade to reduce construction costs and problems associated with floatation and de-watering. For this reason wastewater is lifted to preliminary treatment facilities so it can flow by gravity through the treatment process to the Bosna River.

The raw wastewater arriving at the pumping station is conveyed through a 1,800 mm pipeline with invert elevation of + 481.0 m, approx. 5.2 m below grade. The water is lifted to level + 490.82 m to the head of the screening room. There are four Archimedean screws each with a capacity of 1.3 m^3/s. Three screw pumps were designed to deal with peak wet weather flows. The fourth screw pump is meant to be used as a standby. Screw pumps are driven by motor reduction gears located in a building to protect them from bad weather. The motors and drives are intact. Their condition is assessed in mechanical and electrical sections of the report.

The building also houses a motor control centre for the screw pumps and controls for the screens that were all destroyed during the war. The operation of the screw pumps is automatically controlled by sensing water levels in the wet well.

Concrete posts are located ahead of the pumps in the wet well to protect the screws and lower bearings against the entry of large objects. These posts are spaced at 30 cm and resulted in considerable operating problems because they collected rags that were constantly blocking the flow. The posts did not prevent large objects from entering the screws and operators installed a wire mesh in front of the concrete posts to catch large timbers. This mesh also gets fouled and requires considerable maintenance.

The installed pumping capacity of 5.2 m^3/s exceeds the maximum treatment capacity of the primary sedimentation tanks, which are sized to perform well with 3 pumps in operation (4 m^3/s).

(2) Screening Station (Facility No.2)

Wastewater lifted by the screw pumps is conveyed through a wide channel to the screening units. Screens are installed in two rows. The first row ensures coarse screening of the influent with a bar spacing of 50 mm. The second row of screens ensures medium screening with a bar spacing of 25 mm. Since there are four screw pumps, there are four screening channels 1.5 m wide each equipped with a one coarse and one fine screen. The screening station was designed to handle maximum flow of 5.2m^3/s.

Three channels can be isolated by manually operated sluice gates upstream and downstream of the screens. The fourth channel is equipped with a motorised sluice gate that is interlocked to operate automatically if a fourth screw pump is put into operation.

Flow velocities in the chamber between the lip of the screw pumps and the screen channel are less than 0.4 m^3/s at peak wet weather flow. These low velocities are insufficient to keep grit in suspension and significant deposits of silt and grit in this area were observed in the past.

(3) Aerated grit chamber (Facility No. 3)

Grit is removed by an aerated grit chamber that consists of 3 channels each 4 m wide, 4.4 m deep and 29 m long giving a total net volume of 1,200 m^3.

Grit is recovered in the lower part of each channel and evacuated by means of 3 air lift pumps installed on a travelling bridge moving over the length of the chamber. The air lift pumps are supplied with compressed air to continuously lift a water grit mixture which is discharged into a lateral trough on the East side of the chamber. Midway along the length of the trough, the grit is directed to a grit washer. The washed grit falls into a storage hopper for disposal at the sanitary landfill site.

Aeration is designed to maintain the lighter organic matter in suspension so that it does not deposit at the bottom along with the grit. Aeration also permits the grease present in the water to be emulsified and collected at the surface. The blown air will is produced by two blowers (plus a third as a standby) and fed at the bottom of each grit chamber by means of a manifolds equipped with air diffusers. Blowers, installed in the air blower building No.19 were completely destroyed during the war and will need to be replaced. Equipment details are discussed in mechanical and electrical sections of the report.

Collection of the grease takes place through a sluice gate located at the end of each chamber. Grease and scum are discharged to a static separator (collection pit) that must be pumped out by vacuum truck for disposal at the landfill site.

In 1984, during the WWTP commissioning phase, very large amounts of coarse grit were observed in the raw wastewater. Photographs taken at the time are presented in **Photographs 4.1 to 4.5.** The largest part of the grit settled at the inlet to the pump station, in the screenings channels and in the aerated grit chamber. The grit was in such large amounts that it stopped operation of the screens and overwhelmed the capacity of the grit removal system. Large quantities of grit where also observed in the outlet channel leading to the primary sedimentation tanks indicating that the existing grit chamber is unable to deal with the large quantities of sand and gravel that finds its way to the treatment plant particularly during peak wet weather flows.

(4) By-pass distribution

The flow leaving the grit chambers is directed to two primary sedimentation tanks. Flow is distributed evenly by means of overflow weirs located at the outlet of the grit chamber. Provision was made in the construction of the weirs for even distribution to a third primary sedimentation tank by modifying a partition wall. However, a third tank will not be required for year 2015 flows.

After screening and grit removal it is also possible to by-pass the entire flow or one of the primary sedimentation tanks.

After preliminary treatment the wastewater is directed to a sump at the outlet of the grit chambers and conveyed through two concrete pipes to an inlet structure. The inlet structure has two sluice gates that will stop the flow to either sedimentation tank. In the middle of this structure there is a stop log panel that remains in place during normal operation. After closing one of the sluice gates the panel can be removed to direct all the flow to one sedimentation tank if required.

(5) Primary Sedimentation (Facility No. 4)

After preliminary treatment, wastewater is fed to the centre of two primary sedimentation tanks. The tanks have the following dimensions:

1)	inside diameter:	52 m
2)	peripheral water depth:	2.80 m
3)	water depth at centre:	6.30 m
4)	useful surface area:	2,122.5 m^2
5)	volume of the tank:	7,510 m^3

Each sedimentation tank is equipped with a peripherally driven bridge supporting the bottom scrappers and the scum-collecting blade. The motor drive unit was removed during the war. Details of equipment rehabilitation are discussed in mechanical and electrical sections of the report.

The scum is collected in a hopper and directed to the wet well of the primary sludge pumping station. Sludge is deposited on the bottom and is pushed by scrapers towards the central collection pit from where it is conveyed by gravity through sludge collection pipes to the sludge pumping station. The clarified water overflows into an effluent launder located around the perimeter of the tank.

(6) Aeration Tanks (Facility No. 5)

Water from the primary sedimentation tanks is conveyed through concrete pipes to an inlet structure were the flow is distributed evenly between the two tanks by two weirs. An overflow siphon is provided at the inlet structure to by pass flows in excess of 3.1 m^3/s during peak wet weather or maximum flow conditions (4 pumps operating).

The tanks are equipped with 36 mechanical surface aerators with vertical spindles. These can be rehabilitated and put back into operation. Details of load tests and equipment rehabilitation needs are discussed in mechanical and electrical sections of the report. The power of the aerators is based on oxygen requirements for activated sludge and the need for mixing. Each 37 kW machine provides 43 kW/m^3 of power, which is more than adequate to ensure good mixing in the tanks. In total the machines can provide up to 48,000 kg O_2 per day which exceeds the calculated oxygen requirement for year 2015 of 21, 505 kg O_2 per day. Therefore the surface aerators have more than sufficient capacity to deal with future biological loads.

The tanks are designed to permit sludge re-circulation to the inlet at the North end of each tank. The inlet channel has 18 inlet valves (9 to each tank) that allow wastewater to be admitted in a step feed manner at different points in the tank depending on influent characteristics and operating needs:

1) Opening only the first valves (at the North end closest to returned sludge) allows mixing of the return sludge with the primary effluent.
2) Opening all the valves allows step feeding primary effluent along the length of the tank
3) Closing the first valves allows returned sludge to be oxygenated and thus re-activated before mixing with primary effluent

The mixed liquor is discharged to the secondary sedimentation tanks by means of overflow weirs whose length controls the operating level in the tank to ensure proper immersion of the aerator blades so they operate within their best efficiency range.

The operation of a number of aerators is automatically controlled according to dissolved oxygen concentration to be maintained in the aeration tanks. Dissolved oxygen sensors in each tank provide readings for control. For additional flexibility it is possible for operators to manually override automatic controls to make adjustments in response to changing oxygen demands.

(7) Final Sedimentation Tank (Facility No. 6)

The biologically activated mixed liquor from the aeration tank is conveyed to four final sedimentation tanks through 4 separate concrete pipes. The tanks have the following dimensions:

1)	inside diameter:	52 m
2)	peripheral water depth:	3.0 m
3)	useful surface area:	2,124 m^2
4)	volume of the tank:	7,390 m^3

The total volume for four units is 29,560 m^3 and the total surface area is 8,495 m^2.

Each sedimentation tank is equipped with a diametric, centrally driven scraper system fitted with hydraulic sludge-extraction tubes to help remove the sludge quickly as possible. Scrapers alone would not satisfy the requirement for quick removal since the tanks are large. Sludge retention time is kept as short as possible to keep the sludge fresh and prevent anaerobic conditions which cause floatation that impairs the quality of the final effluent. The drive unit was removed during the war and will need to be replaced. Equipment details are discussed in mechanical and electrical sections of the report.

The sludge is sucked into the pipes using hydrostatic head from the bottom of the sedimentation tanks and discharged through telescopically adjustable overflow valves. The valves are located in the centre, in a revolving tank that is equipped with a slip joint and collects the sludge for discharge into an 800 mm diameter pipe located in the central column. In addition each sedimentation tank is equipped with a surface scraper to remove any scum or debris that might reduce treated water quality.

(8) Flow metering (Facility No. 7)

Treated water is discharged from the secondary sedimentation tanks over weirs into a peripheral effluent launder. The water flows by gravity to the Parshall flume chamber. The rate of flow is measured by reading the water level in the flume.

(9) Recycled Sludge Pumping Station (Facility No. 8)

Sludge collected from the secondary sedimentation tanks is conveyed by gravity to the wet well of the recycled sludge pump station. This station is equipped with 2 Archimedean screw pumps with a unit capacity of 2 m^3/s. One screw pump is used as a standby unit therefore the maximum recycle flow with one pump operating is 2m^3/s. Sludge is lifted to a level slightly higher than the aeration tanks to allow sludge to re-circulate by gravity into the tanks.

The screw pumps are driven by motor reduction gears located in the building to shelter them from bad weather. The building also houses motor control centre. The motors and drives are intact. Their condition is assessed in mechanical and electrical sections of the report.

Two submersible pumps located in the wet well remove waste (excess) sludge. Waste sludge is settled with primary sludge in the primary sedimentation tanks. This mixture of primary and biological sludge, referred to as "mixed" sludge, is directed towards the primary sludge pumping station.

(10) Primary Sludge Pumping Station (Facility No. 9)

Mixed sludge collected in the sedimentation tanks is directed by gravity to the wet well of the primary sludge pumping station. The pumping station has two centrifugal pumps installed in a dry pit with access from ground level. One pump is used as a standby unit. Pumps were removed and valves damaged during the war.

The end of the sludge collection pipe in the wet well is equipped with a manual isolating valve and a telescopically adjusted valve for controlling the sludge withdrawal rate. Each pipe is also equipped with a rapid opening valve for periodic flushes of the sludge collection pipe. All sludge pipes in the plant are equipped with a 4 bar pressure water delivery system for clearing blockages.

A programmable timer that can be adjusted to meet operational requirements and desired sludge concentrations controls pumps.

4.1.4 Treatment Process – Sludge Line

(1) Sludge Thickeners (Facility No.10)

The first step in the sludge treatment process consists of thickening mixed sludge. Sludge is pumped from the primary sludge pumping station to two thickeners. The thickeners have the following characteristics:

1)	inside diameter		30 m
2)	perimeter depth		3.5 m
3)	invert slope		20%
4)	useful surface area	706.5 $m^2 \times 2$ =	1,413 m^2
5)	volume	3,110 $m^3 \times 2$ =	6,220 m^3

Sludge is pumped at 150 m^3/hrs.and a concentration of 10 g/l from the primary pumping station to the thickeners. Each sedimentation tank is equipped with a diametric, centrally driven scraper system. The drive units were removed during the war and need to be replaced. Details of equipment rehabilitation are described in mechanical and electrical sections of the report.

The supernatant in each thickener is recovered in a peripheral effluent launder equipped with weir plates anchored to the wall. The supernatant is piped and re-circulated to the pump station by gravity.

(2) Thickened Sludge Pumping Station (Facility No.11)

Thickened sludge is removed using two pumps with a capacity of 60 m^3/hrs. each (one pump is standby). The equipment in the sludge pumping station was destroyed during the war and will need to be replaced. Equipment details are discussed in the mechanical and electrical sections of the report.

The end of the sludge collection pipe in the wet well is equipped with a manual isolating valve and a telescopically adjusted valve that controls the sludge withdrawal rate. Each pipe is also equipped with a rapid opening valve for periodic flushes of the sludge collection pipe.

(3) Digesters (Facility No. 12)

Digestion is mesophilic single stage type operating at 35^0 C.

The digesters have the following dimensions:

1)	diameter		27.8 m
2)	straight height		14.83 m
3)	depth of the central bottom hopper		2.8 m
4)	maximum liquid depth		16.7 m
5)	surface area		607 m^2
6)	volume	9,000 $m^3 \times 2 =$	18,000 m^3

The thickened sludge is discharged to a distribution box built between the two digesters at the top of the staircase leading to the roof. Two weirs achieve even distribution. The sludge is conveyed from the distribution box to the bottom of the digesters though a pipe.

The sludge in each digester is mixed by digested gas injected through stainless steel pipes located on the roof. There are 24 pipes for each digester, each pipe being equipped with a flow indicator and an adjustment/isolating valve. Good mixing on a continuous basis is very important to ensure sludge homogenisation (quality and temperature) and prevent the formation of a scum blanket at the top (mainly cellulose). Operators confirm that these gas-mixing pipes were frequently blocked by grit that was not removed in the aerated grit chamber during peak wet weather flows.

Discharge valves located at the base of the digesters are exposed to cold weather and have all broken as a result of freezing. All valves need to be replaced.

(4) Bio-Gas Production

The gas produced by anaerobic digestion is collected at the top of each digester and directed to:

1) 3 compressors that supply sparging tubes for digester mixing, and
2) a 5,000 m^3 gas storage tank for use by boilers and engine generators.

Bio-gas is produced at the approximate rate of 1 Nm^3 per kg of VSS destroyed. Therefore the quantity of bio-gas estimated in the previous design was approximately 15,000 m^3/day.

(5) Sludge Heating (Boiler House Facility No. 13)

To obtain proper digestion the temperature inside the digester must be maintained at a constant 35℃. Therefore the incoming sludge must be heated from a temperature that varies from 8℃ in the winter to 18℃ in the summer. The existing boiler plant was completely destroyed during the war and all new equipment is required. Two boilers were provided each with a capacity of 900,000 kcal/hrs. The sizing of the boilers assumed heat recovery from the cooling circuit of the engine generators. These engines did not operate because gas production was insufficient. A third boiler was added later because operators could not keep the digesters at 35℃.

(6) Gas Compressor Station (Facility No. 14)

Efficient sludge mixing requires that digester gas be injected at a rate of 1m^3/hrs./m^2 of surface area of the structure. With a surface area of 607 m^2 for each digester a volume of approximately 600 m^3/hrs.of gas must be injected into each digester at a pressure of 2 bars. Two dual fuel engine generators located in the Power House (facility No. 20) also required gas at 2 bars pressure.

Three gas compressors (1 standby) were installed in the gas compressor station for the purpose of digester mixing. A fourth compressor was dedicated to the supply of the engines. These compressors were damaged during the war and need to be replaced. Equipment details are discussed in mechanical sections of the report.

(7) Gas Storage Tank (Facility No. 15)

Gas produced in the digesters is conveyed by piping in the digester roof to the digester mixing compressors and a 5,000 m^3 gas storage The container has a floating steel roof that is sealed with water and gas is kept at a pressure of approximately 160 mm HG. Gas from the storage tank is fed directly to the boilers. Excess gas is compressed at the gas compressor station (facility No.14) for use by the engine generators. The storage tank has adequate capacity for excess gas storage under year 2015 conditions.

(8) Homogenised Sludge Holding Tank (Facility No. 16)

Digested sludge is delivered to the holding tank by gravity. The tanks are sized to balance fluctuations in sludge production and de-watering operations. The sludge is pushed towards the centre of the structure by means of a centrally driven, diametric scraper. The scraper is equipped with a vertical metal picket fence that ensures gentle stirring and elimination of trapped gas. The drive unit was removed during the war and needs to be replaced. The structure has the following dimensions:

1)	diameter	30 m
2)	straight height	4.3 m
3)	invert slope	10%
4)	surface	706.5 m^2
5)	volume	3,675 m^3

Using forecast design flows this provides 6.0 days of storage in the year 2000 and 3.71 days of storage in the year 2015. The tank's capacity makes it possible to stop the de-watering process for maintenance or weekend periods.

(9) Sludge Pumping Station (Facility No.17)

The digested sludge is extracted from the bottom of the tank and directed to a wet well at the sludge pumping station (Facility No. 17). From the wet well the sludge is extracted by positive displacement pumps and sent to the belt filter presses. The pumps were destroyed during the war and will need to be replaced.

Sludge is withdrawn from the holding tank at the rate of 60 m^3/hrs.(total of 800 m^3/day). One pump is required for each filter press. The unit capacity of the pumps should be adjustable from 6 to 25 m^3/hrs.to provide operating flexibility. Equipment details are discussed in mechanical sections of the report.

(10) Sludge De-Watering (Facility No. 18)

Sludge de-watering is designed to use 5 filter belt presses (4 duty, 1 standby) with a unit belt width of 3m . The building has space for a total of seven filter presses. Before dewatering the sludge is conditioned with cationic polyelectrolyte "polymer" to improve dewatering performance. The polymer is prepared in two identical dilution tanks, one being used on-line, while the other serves to prepare the next batch of solution. The polymer solution is applied by dosing pumps to the sludge, with one pump serving one filter press. Dewatered sludge is collected on a conveyor belt and sent to a storage hopper. The sludge is disposed of at the landfill site.

During filtration the filter press belt must be washed continuously. For this reason a pressure wash system is provided. The water is taken from the treated effluent because a large quantity is required. A pump station is located at the Parshall flume to provide pressurised wash water. Wash water is collected by a channel beneath the filter and sent to the inlet of the plant.

The filter belt presses and polymer feed equipment were damaged during the war and need to be replaced.

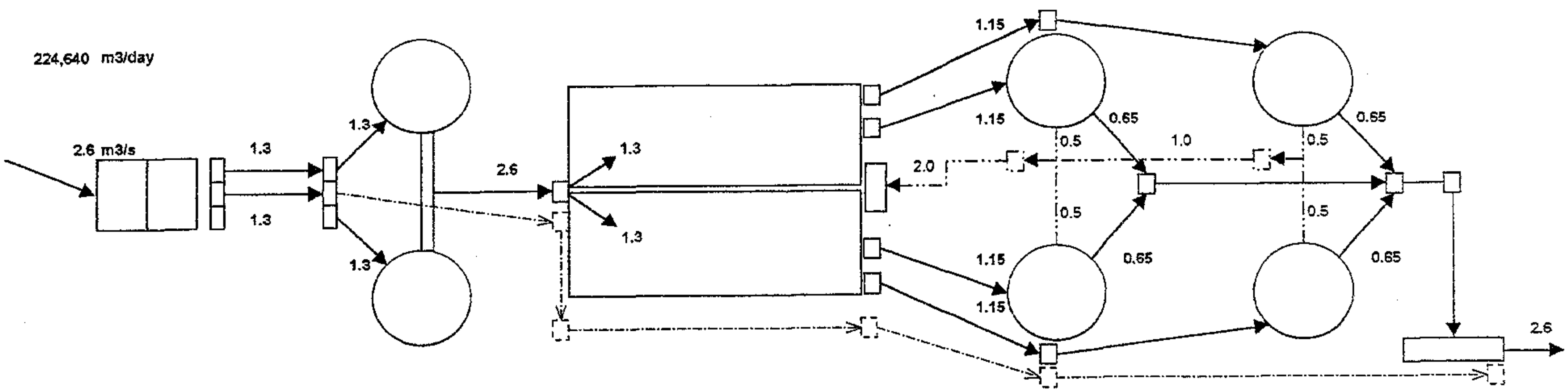
(11) Service Water Network

A service water network using treated effluent was installed to reduce the amount of potable water used for process equipment:

1) unblocking the sludge extraction pipes
2) cleaning the rooms, pumps houses and filtration units
3) watering

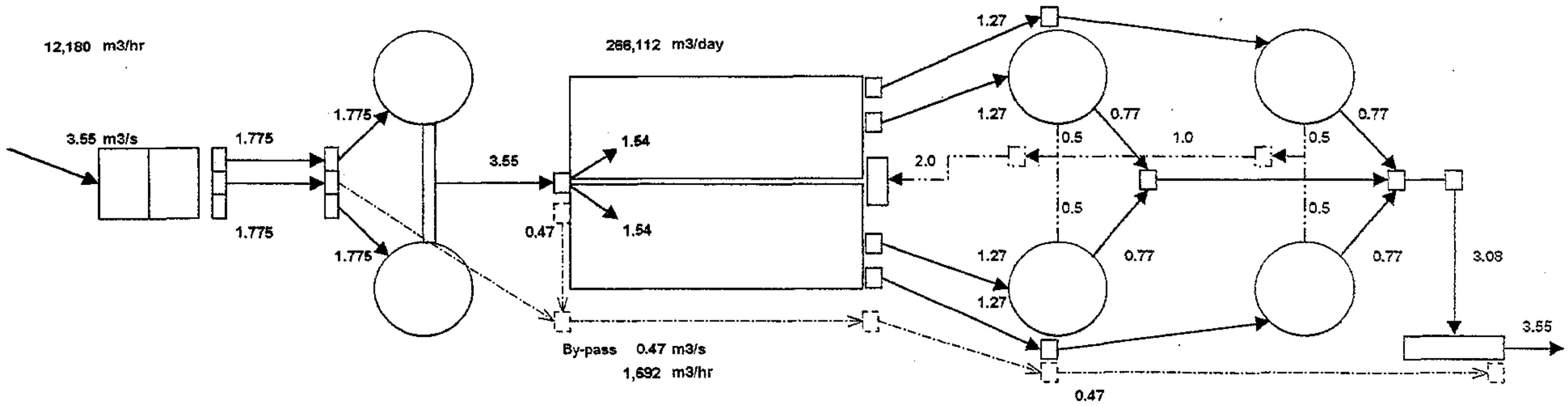
This service water is supplied from a booster unit that recovers water at the inlet to the Parshall flume and pumps it a pressure of 4 bars to the dewatering building.

The design and arrangement of the pumps caused many problems in the past. The pumps lose their prime when they stop operating and priming them again is difficult and time consuming. The effluent water contains suspended solids that lead to clogging in the pipes and difficulties in downstream processes.



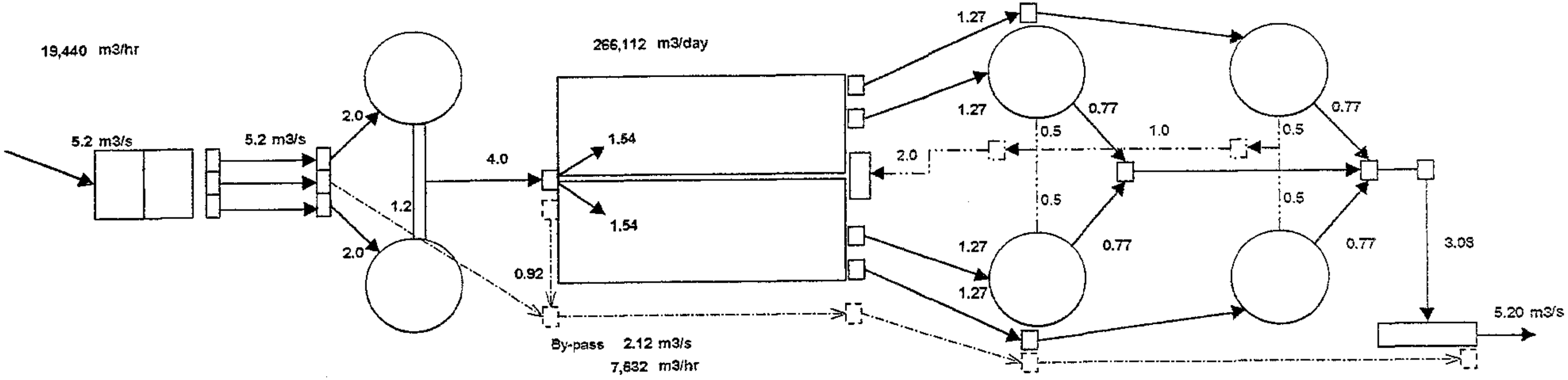
Peak dry weather flows (m³/s) with 2 pumps operating

Figure 4.1 (1/3) HYDRAULIC CAPACITY OF EXISTING TREATMENT PLANT



Peak wet weather flow (m^3/s) with 3 pumps operating

Figure 4.1 (2/3) HYDRAULIC CAPACITY OF EXISTING TREATMENT PLANT



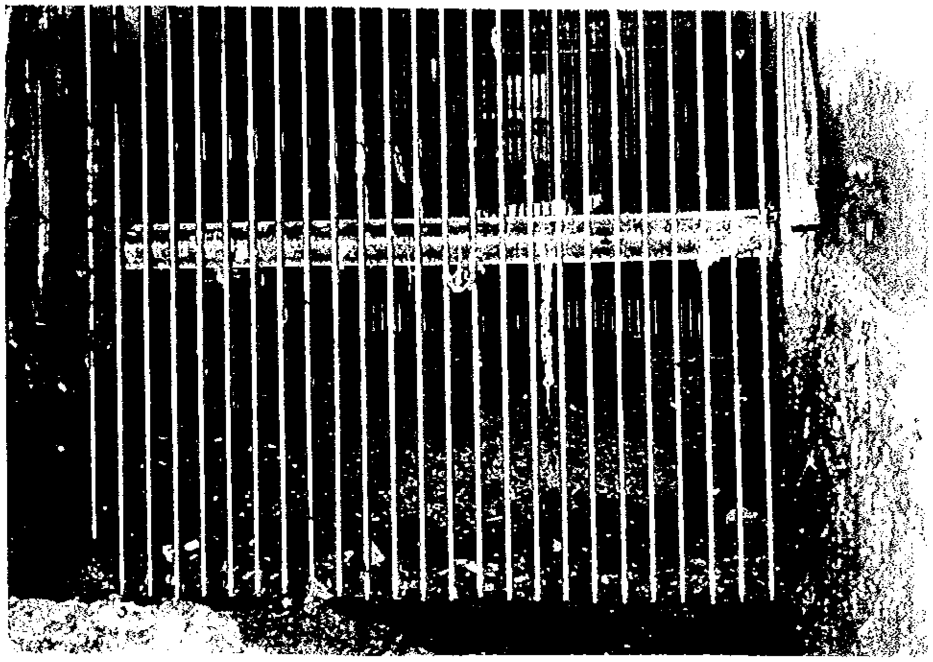
Peak wet weather flow (m^3/s) with 4 pumps operating

Figure 4.1 (3/3) HYDRAULIC CAPACITY OF EXISTING TREATMENT PLANT

Photo documentation of grit removal problems

Facility No:	2	**Name:**	Screening room
Location	Inlet to screens		

Photo No.4 .1



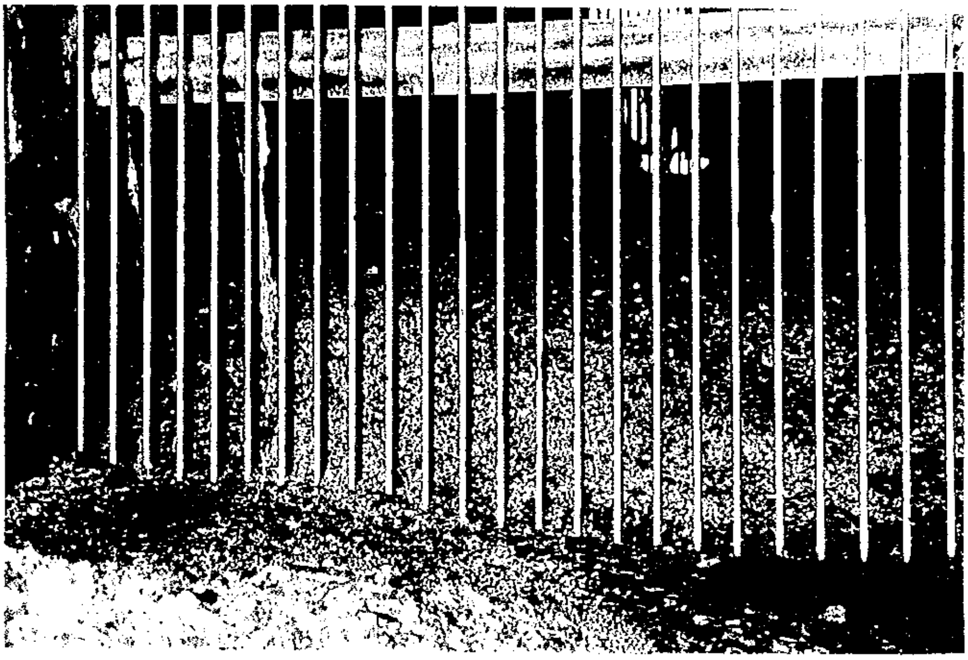


Photo documentation of grit removal problems

Facility No:	2	**Name:**	Screening room
Location	Inlet to screens		

Photo No. 4.2

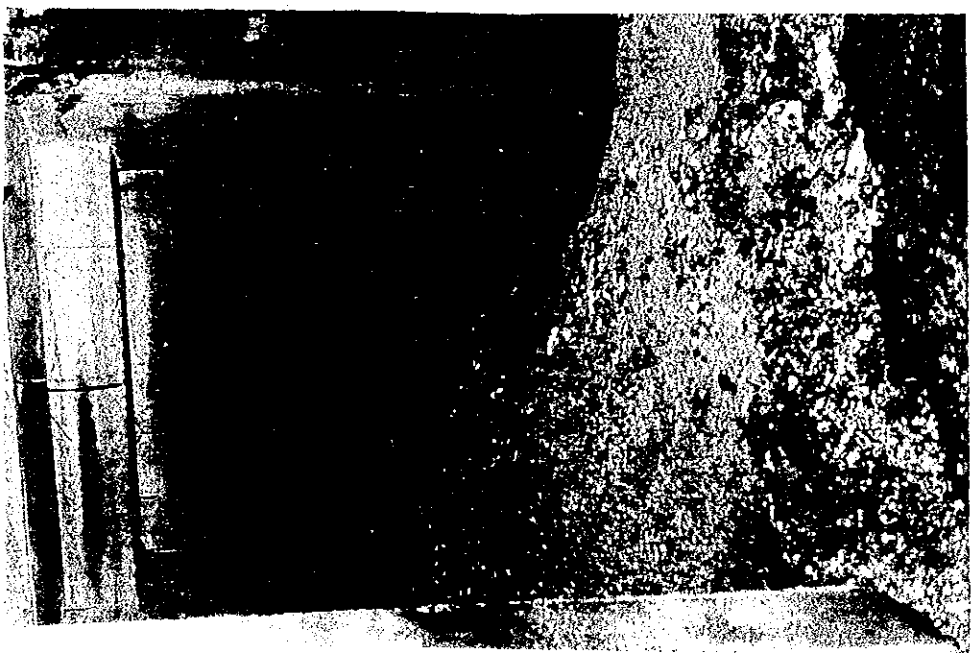
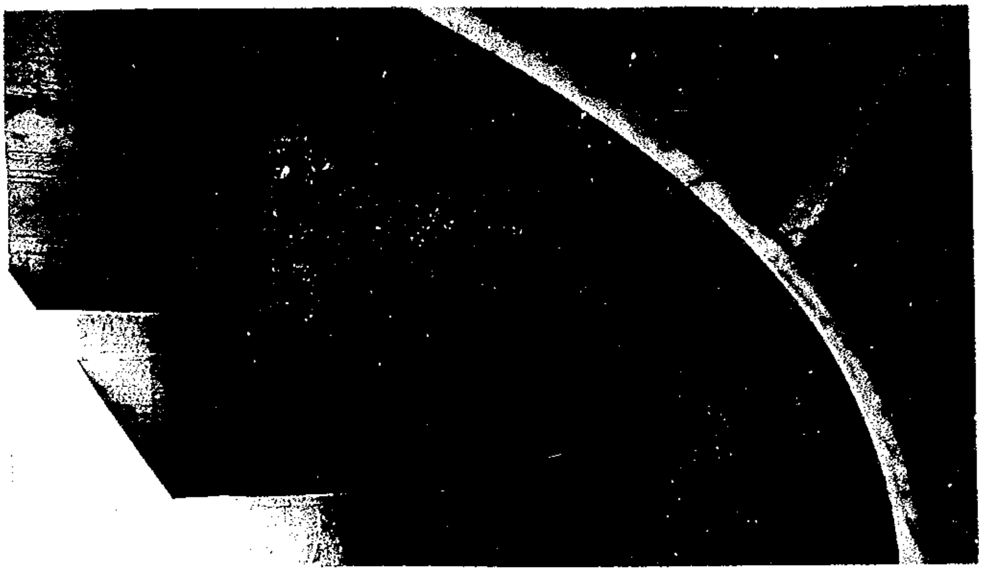


Photo documentation of grit removal problems

Facility No:	2	**Name:**	Screening room
Location	Outlet of Screens		

Photo No. 4.3



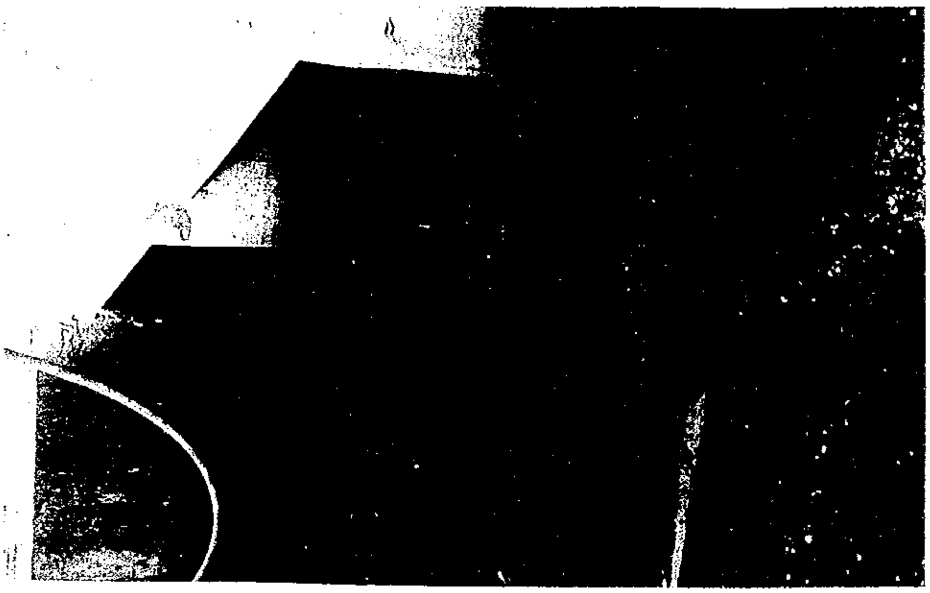
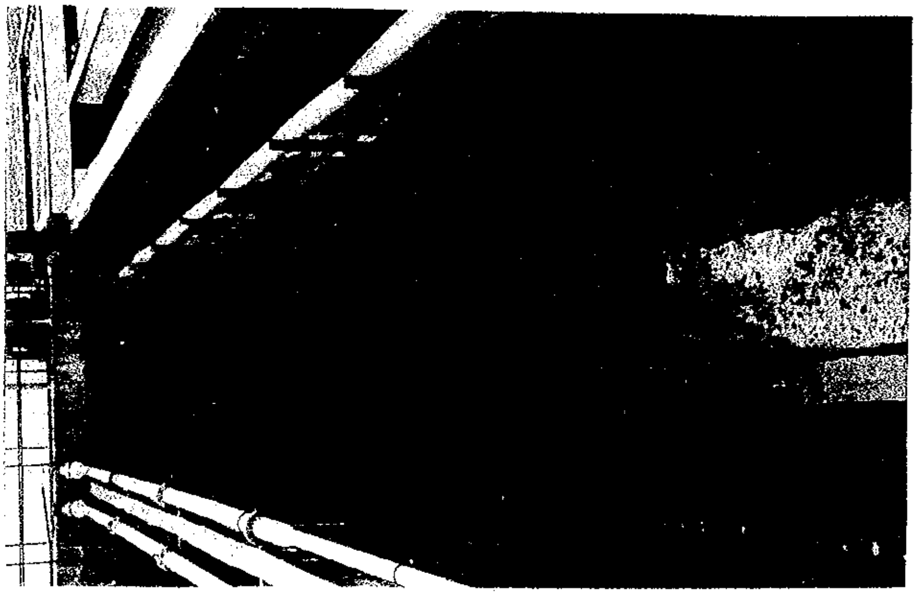
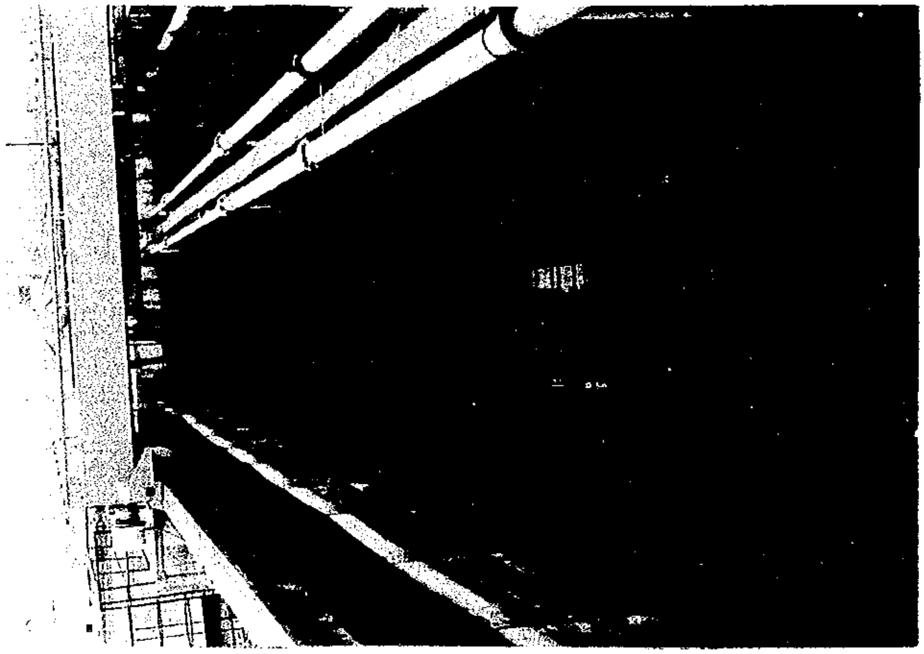


Photo documentation of grit removal problems

Facility No:	2	Name:	Screening room
Location	Grit Channel		

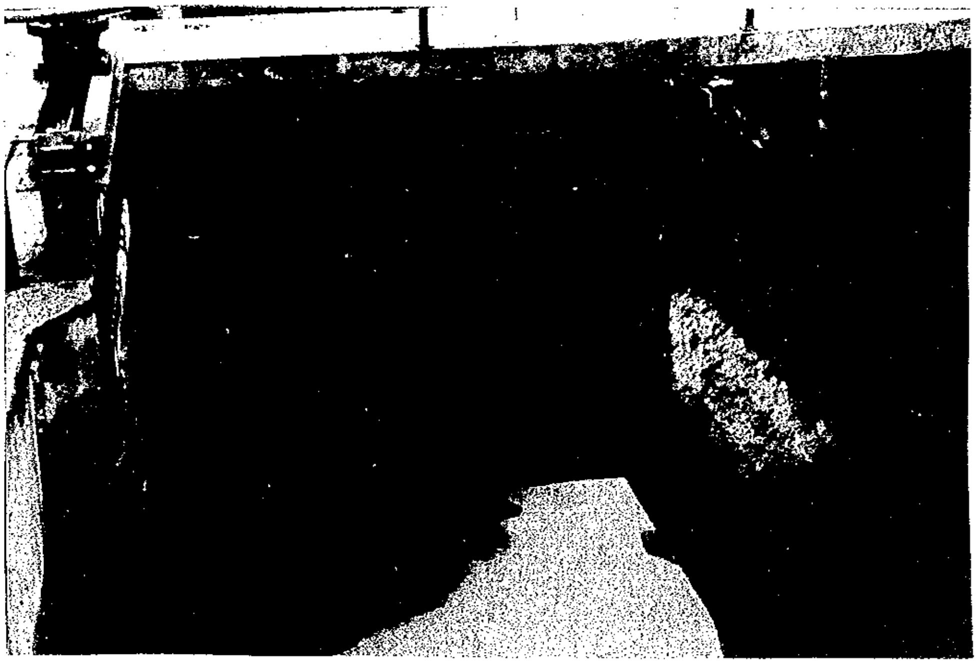
Photo No. 4.4





Facility No:	3	**Name:**	Aerated Grit Chamber
Location	Outlet		

Photo No.4.5



4.2 CIVIL WORKS

4.2.1 Introduction

The life of a concrete structure depends on the durability of its components. For a correctly designed structure and with good-quality materials and workmanship, a structure can last between 40 and 60 years. Some components of the structure, such as jointing materials, have a shorter life than the structural concrete and usually require renewal during the life of the structure.

Concrete structures need to be inspected regularly to examine the condition of the concrete for cracking, leakage, surface deterioration and settlement. Particular attention should be given to any rust stains that might indicate corrosion of the reinforcement. Defects that are detected during these routine inspections should be corrected as soon as possible to prevent the structure from being damaged or shortening the design life.

Liquid retaining structures at the WTP did not sustain any serious damage as a result of the war. Nevertheless, the structures show considerable signs of deterioration and distress:

(1) weathering of all exposed surfaces,
(2) extensive cracking in walls with signs of leakage and previous repairs,
(3) poor workmanship in joint construction and concrete finishes,
(4) inadequate cover over reinforcement and rust stains, and
(5) exposed and corroded reinforcement.

An assessment of all reinforced concrete liquid retaining structures was carried to answer the following questions:

(1) What is the cause and extent of the deterioration?
(2) Is the structure adequate for its intended purpose in respect of strength, serviceability and durability?
(3) What will be the future state of structural deterioration?
(4) What, if any, remedial works are required now or in the future?

The results of inspection and appraisal are presented in detail in the **Assessment Report, Vol. Ⅲ**. The main conclusions of the assessment are discussed in the following sections.

4.2.2 In-Situ Tests

In-situ tests were conducted during the second field survey to assess strength and durability of reinforced concrete and to assess leakage.

JICA study team experts carried out hardness tests on all structures. Strength and carbonation (corrosion) tests were conducted by the Institute for Materials and Structures (IMK), Faculty of Civil Engineering, University of Sarajevo. The local consulting firm of USB Kedley DOO was hired to fill the tanks with water and take leakage measurements. The gas storage tank was filled by ViK and tested by JICA study team members in the weeks that followed completion of the contractor's work.

(1) Carbonation depth

Carbonation of concrete by attack from atmospheric carbon dioxide results in a reduction in alkalinity of the concrete and increases the risk of reinforcement corrosion. Normally, in good quality concrete, carbonation is restricted to a surface layer of only a few millimetres. The extent of carbonation can easily be measured by treating with phenolphthalein indicator the freshly exposed surfaces of a piece of concrete that has been broken from a member. A purple red colour is obtained where concrete is good and the highly alkaline content of the concrete is unaffected by carbonation.

Tests were performed in three locations of the grit chamber and seven locations in the aeration tank. The depth of carbonation ranges from 10 mm to 20mm as follows:

1) 15 mm on walls
2) 10 mm on bottom slabs
3) 20 mm on columns of surface aerators

Results indicate a high risk of steel corrosion in many areas where concrete cover is less than 20 mm such as aerator columns and all internal wall surfaces of tanks. The visual condition survey confirms that steel corrosion is extensive. Contributing factors include:

1) inadequate concrete cover (less than 20mm)
2) porous concrete surfaces

(2) Surface Hardness

The quality of concrete was assessed through its hardness by the use of the Schmidt Rebound Hammer. The test is based on the principle that the rebound number of an elastic mass depends on the surface upon which it impinges. The rebound number recorded gives a measure of the relative hardness of the concrete tested.

Generally, the concrete structures of the Sarajevo WTP have the rebound numbers that correspond to a cube compressive strength and a cylinder compressive strength of 432 kg/cm^2 and 367 kg/cm^2, respectively. These values correspond well to compressive strength obtained by destructive testing of core samples.

(3) Concrete – Compressive Strength test

A total of 54 core samples were extracted from the aeration tank and 42 specimens were extracted from the grit chamber. Cores were taken from exterior walls and floor slabs in locations where likely minimum strength coincides with maximum stress. Tests were carried out on two structures only:

1) the aerated grit chamber and
2) the aeration tank

Compression testing was carried out on dry specimens. Compressive tests indicate that concrete compressive strength is within the range of 20 to 40 MPa (250-400 kg/cm^2) normally used for structural applications. Density tests indicate that concrete is "Normal Density" typically 2,400 kg/m^3.

(4) Steel – Tensile Stress test

Extraction and testing was performed on reinforcing steel to determine tensile strength characteristics. Three samples were extracted from 6 locations in walls and bottom slab of the grit chamber and aeration tank:

1) A1 and A2 from walls of aeration tank, exposed and corroded
2) A3 from the bottom slab
3) A4 and A5 walls of grit chamber, protected by concrete cover
4) A6 from slab of grit chamber

Samples were tested to provide yield strength by 1% elongation method and ultimate tensile strength at failure. Elongation was measured to provide strength strain curves.

Visual inspection of the specimens after extraction and during processing indicates that corrosion is insignificant and there is no loss of cross sectional area. Deformed steel bars were used as reinforcement in walls. Reinforcement used in slabs is welded wire fabric.

Test results indicate that deformed bars are nominal grade GA 240/360 that has the following characteristics:

1) Yield strength = 240 N/mm^2 (2,450 kg/cm^2)
2) Ultimate strength = 360 N/mm^2 (3,675 kg/cm^2)
3) Strain = 18%

Samples taken from aeration tank floor slab are of a higher grade welded mesh MGA that has the following nominal characteristics:

1) Yield strength = 500 N/mm^2 (5,105 kg/cm^2)
2) Ultimate strength = 560 N/mm^2 (5,715 kg/cm^2)
3) Strain = 6%

In general the steel is of acceptable quality and in good condition. Steel corrosion is insignificant even in areas where it is exposed without cover.

(5) Sludge Piping Material Tests

Sludge wasted from the recycle pumping station and the primary sedimentation tanks is conveyed to the thickeners through buried steel pipelines. In order to assess the condition of these pipelines samples where extracted at 4 locations. Examination consisted of, measurement of wall thickness, internal pipe diameter, and visual inspection to determine degree of encrustation and corrosion. Samples were tested using the Brinell method to evaluate ultimate strength.

Pipes from all four locations are in excellent condition and look like new. There is no corrosion of encrustation.

Nominal pipe diameters and thickness are as follows:

1)	C1, pipe from primary sludge pumping station to thickeners	□ 230×5.5
2)	C2, pipe form thickeners to digesters	□ 160×3.5
3)	C3, pipe from digesters to sludge holding tank	□ 220×7
4)	C4, pipe from sludge re-cycle pumping station to primary tanks	□ 230×5.5

Ultimate strength ranged from 530 N/mm^2 to 549 N/mm^2. Based on standard JUS C.B0.500, the steel is classified as CN 36-B_2, general use structural steel with middle stiffness.

(6) Leakage tests

A visual inspection of the structures carried out during the first stage of the study revealed that most of the structures had previously experienced significant cracking and leakage problems. It is apparent that many attempts were made to seal the cracks and leaks from the outside using epoxy. Serious concerns about the effectiveness of repairs and further deterioration of the structures prompted the need to carry out tests for liquid retention.

Tests for liquid retention were performed on the following structures:

1) No.3 grit chamber,
2) No.4 two primary sedimentation tanks,
3) No.5 aeration tanks, and
4) No.6 four secondary sedimentation tanks.
5) No.15, gas storage tank

Time constraints made it impossible to test every structure therefore only the ones representing the largest volumes were selected. Ideally the digesters should have been tested however it was not possible to do so because they are partly full of digested sludge. The sludge thickener tanks and the sludge holding tank were not tested because it was apparent from the visual inspection (walls are above grade) that these structures leaked extensively in the past and will require extensive leak sealing repairs to restore liquid tightness.

Leakage tests were carried in accordance with British Standard Code of Practice for Design of Concrete Structures Retaining Aqueous Liquids (BS 8007 section 9). Stabilisation and measurement periods for each structure were shortened from the recommended 1 week period to 4 days to accommodate the compressed study schedule.

Each structure was filled at a uniform rate to the normal maximum level by pumping water from the Miljaska River. When first filled, the liquid level was maintained by the addition of more water for a minimum of 4 days while absorption took place. After the stabilising period the drop in surface water level was recorded at 12-hour intervals for a minimum test period of 4 days. The drop in level was adjusted for rainfall and evaporation.

Although it is common for water retaining structures to be constructed of reinforced concrete they are never completely watertight because concrete naturally absorbs and then through evaporation, loses water. According to standard BS 8007 a structure can be considered watertight if the total drop in surface level does not exceed 1/500th of the average full tank depth or 10mm over the test period. The extent of absorption and leakage will depend on mix proportions used and the quality of construction. Where there are imperfections in the concrete, such as cracks or voids, water leakage can be substantial

Data and calculation sheets tabulated by the local consultant for the leakage test are presented in the **Assessment Report** and results are summarised as follows:

1) The grit chamber leaked at construction joints located between the outlet chamber and connections to outlet conduits. Several large cracks in the end wall allow water to leak in large quantities into the by-pass.

2) The primary sedimentation tanks leaked extensively at expansion joints and at the horizontal construction joint that runs along the full circumference of the tank.

3) The aeration tanks leaked but only a few large leaks were visible on the outside of the structure. Only a few of the previously repaired cracks were found to leak and only a few expansions showed signs of leakage. It is highly probable that much of the water leaked out the expansion joints of the bottom floor slab. Attempts to fill only one tank failed because leakage through the middle separation wall was too high. Heavy leakage was also observed through joints and cracks in the influent channel located between the two tanks. Internal migration of water from one tank to another is only a problem if one tank is kept empty and out of service.

4) The secondary sedimentation tanks leaked but the location could not be determined because the tanks are buried. Extensive leakage was observed at the inlet structure located at the end of the aeration tank. Large cracks in the sidewalls and along the front of each sluice gate leak extensively.

Leakage in all structures was substantially more than acceptable for liquid retaining structures. There are many possible reasons for the occurrence of leakage. The most common causes are:

1) cracks caused by shrinkage
2) voids below the reinforcement due to plastic settlement
3) voids below water bars at expansion joints
4) unsatisfactory construction joints
5) failure to adequately grout up holes provided for formwork ties
6) honeycombing or voids due to poor compaction or grout loss

Identifying the cause of leakage is never quite straightforward, as the place where liquid enters is seldom where leakage is apparent on the surface. Where possible, location on the exterior of leakage through cracks, expansion joints and construction joints was documented during the visual survey to provide an approximate idea of the extent of repair works that will be required.

(7) Conclusions from In-situ Tests

Based on the results of materials testing it would appear that materials used for construction have the properties required for good structural performance.

Widespread corrosion of reinforcement on the interior face of all tanks is a result of inadequate cover caused by poor workmanship. Corrosion has not yet reduced structural performance but some intervention will soon be required to prevent loss of reinforcement cross section and keep the structures in service. Carbonation has advanced to a significant depth and there is a high risk that corrosion will become more serious where cover is less than 25mm.

The leakage problem is substantial and widespread. Most of the visible leakage occurs at construction joints and expansion joints. It is highly likely that leakage is also occurring through expansion joints in the slabs. Most of the previously repaired cracks seem to be holding water but several are showing signs of distress and some are beginning to leak again. Previous repairs were carried out from the outside face and this practice is rarely effective for the long-term. It would be prudent to seal all cracks again. Any necessary remedial treatment of the concrete, cracks, or joints should where practicable, be carried out from the liquid face.

4.2.3 Visual Inspection & Appraisal

(1) Introduction

The visual condition survey is perhaps one of the most important aspects of any structural investigation. Combined with the results of materials tests it aims to provide information on the types, extent and seriousness of visible defects.

Each civil structure was inspected to assess the extent and severity of damage and quantify necessary repairs. Inspection was carried out during hydraulic leakage tests to spot leaks. Inspection focused in locations where signs of distress were evident, where previous repairs have been made and where surfaces are not buried or hidden by architectural finishes. The survey notes condition of concrete surfaces, cracks, expansion joints and signs of corrosion. Although not structural in nature other civil related items needing repairs were also noted: ladders, railings, stairs, sluice gates, thermal insulation on digesters and corrosion protection of steel roof on gas holder. Visual condition survey sheets for all liquid retaining structures and photographs documenting typical defects or rehabilitation needs are presented in the **Assessment Report.**

Typical structural defects encountered during the survey and their probable causes are listed in **Table4.3**. Observed defects that are common to all liquid retaining structures are summarised as follows:

1) Leaking expansion joints
2) Leaking construction joints
3) Cracks through wall sections resulting in leakage
4) Inadequate concrete cover resulting in corrosion of reinforcement
5) Weathering of exposed concrete surfaces

The general nature of these defects, their cause and an assessment of required remedial works are presented in the following sections.

(2) Expansion joints

Leakage was observed at many expansion joints. The problem occurs at all structures but was most severe at primary sedimentation tanks were water was gushing rather than dripping. Typically, expansion joints consist of a gap containing a compressive filler material (e.g. expanded polystyrene) and finished with a sealer (typically a mastic substance). Expansion joints

Table 4.3 SUMMARY OF TYPICAL CONCRETE DEFECTS IN LIQUID RETAINING STRUCTURES

No.	Defect	Location	Probable causes
1	leaking expansion joints	Walls of all liquid retaining structures	deteriorated seal, torn water bar, voids around the water bar
		Walls and floor of all overflow channels	
2	leaking construction joints	horizontal joint along full circumference of all circular basins; usually at base.	poor workmanship, absence of water bar or defective water bar
		horizontal joint between floor and walls of all overflow channels	
		vertical joints in walls of all inlet and outlet structures adjoining grit chamber, primary clarifiers, and aeration tank	
3	Deep cracks through wall sections resulting in leakage	walls of all liquid retaining structures	Shrinkage cracks and thermal movement
		walls of all overflow channels	
		walls of gas holding tank	
4	Cracks at 45^0 angle and occasionally in parallel	west walls of aeration slab symmetrically located either side of aerator slab connection	tension or compression along line of force
5	Inadequate cover over reinforcement resulting in corrosion and spalling of concrete	interior walls of primary clarifiers, aeration tank, secondary clarifiers, sludge thickeners, and sludge holding tank.	poor workmanship
		South and west face of columns supporting surface aerators	
6	Frost damage resulting in spalling concrete	top of all slabs and flat surfaces exposed to weather (walkways, aerator slabs, top of walls & stairs)	inadequate drainage and no air entrainement in concrete
		bottom of aerator slabs and top of columns at water level	splash damage
7	Weathering of exposed concrete	all exposed concrete wall surfaces	very porous finish not sealed to prevent moisture penetration

also incorporate a water bar. Leakage of water through expansion joints is a frequently occurring problem and may be caused by any of the following defects:

1) Rupture of sealant
2) Detachment of the sealant from the concrete
3) Puncture of the water bar
4) Defects in the concrete alongside the joint

These defects are normally the result of poor control during construction and are very difficult and costly to repair.

Water bars used in the construction of all water retaining structures on site appear to be polyvinyl chloride strips 250mm wide with a central bulb. In walls the water bar is located centrally following common construction practice. In floors the water bar is located in the middle depth. It is usually preferable to place the water bar below the main floor slab because it is difficult to ensure proper compaction of the concrete around a horizontal centrally placed water bar. Given the evidence of poor workmanship in other areas of the structures it is highly likely that compaction around the water bar was poor and that the water bar is not liquid-tight.

Identifying the location or cause of leakage is never quite straightforward, as the place where liquid enters is seldom where leakage is apparent on the surface. It is impossible to assess with precision if a joint should be repaired or will continue to perform well without repair. Since it is quite likely that most joints leak to some degree it is better to treat every joint as a potential source of leakage.

(3) Construction joints

Construction joints appear in many locations on all structures. Many of these joints contribute to significant leakage, which is particularly noticeable at the grit chamber outlet, and the outlet of the aeration tank

Construction joints have generally been provided when concrete operations were suspended during construction. Many construction joints appear in areas where the complexities of formwork made it easier for the contractor to place concrete in separate stages. The joints at junctions between horizontal surfaces and vertical walls are a typical example.

To obtain a watertight joint it is important to obtain a good bond between the old concrete and the new concrete when it is compacted against it. It appears that this bond was not achieved since most horizontal construction joints leak extensively. This type of defect is the result of poor design details, inadequate sight supervision and poor construction practices.

(4) Cracks

Structures that retain liquids at the treatment plant are subjected to severe exposure and require special consideration to ensure durability and control cracking. The presence of deep vertical cracks is predominant on all exposed wall surfaces and most numerous on the outside walls of effluent launders in the sedimentation tanks and sludge thickeners. The extent of the cracking indicates that there is insufficient reinforcing steel to control the tensile stresses created by shrinkage and temperature movement.

The temptation to fill every crack in a reinforced concrete structure must be resisted because filling does not always improve the situation. It is generally safe to fill cracks where the cause for cracking is no longer active. Non movement cracks can therefore be filled using the epoxy injection method. Cracks subjected to seasonal or diurnal movements are a special case. These cracks should be filled with a material that is flexible enough to accommodate the expected movement. All cracks should be filled from the liquid side of the structure to provide an effective seal.

(5) Corrosion of reinforcement

Corrosion of reinforcement is widespread and occurs predominantly at the liquid face of walls. In many large areas rust stains appear at the surface of the concrete and follow the line of reinforcement. Material tests show that corrosion has not yet resulted in the loss of steel from the reinforcing bars. Loss of section was detected in small areas of the sludge holding tank where steel is exposed.

Adequate cover is extremely important in protecting reinforcement. Cover is adequate only if it is of dense well-compacted concrete otherwise the concrete will carbonate and so lose its protective capacity. As confirmed by testing, the carbonation front has already advanced to a depth of 20 mm. As observed on site, the cover is inadequate on all interior wall surfaces (usually less than 25 mm and in many cases only a few mm) and the concrete is quite porous. These two factors have contributed to the corrosion observed on site. There is a significant risk of further and severe deterioration.

(6) Weathering of exposed surfaces

Sanitary engineering structures normally require special attention for durability. Specifications for concrete mix design and for construction should be drawn up to provide for dense, impermeable concrete which will resist to naturally occurring chemicals and have a smooth well formed surface finish. Dense, well-compacted concrete is rarely affected by frost.

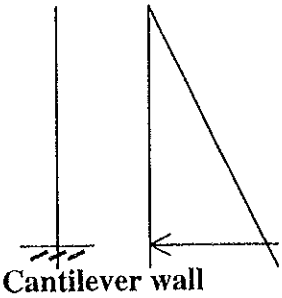
Concrete surfaces on all structures are porous, rough and do not repel water. Exposure conditions and severe weather causing freeze thaw cycles have affected the durability of concrete on site. Concrete on all flat surfaces such as floor slabs and top of walls where water has a tendency to pond have suffered severe damage. In several cases the damage has progressed to complete disintegration to deeper layers.

(7) Cracks in Aeration Tank Walls (Facility No.5)

The east wall of the aeration tank exhibits a cracking pattern that indicates a structural deficiency. The pattern is observed at every point where the concrete walkway is connected to the top of the wall. The cracks form a 45-degree angle starting at from the top of the wall extending down towards the centre where they become horizontal. In the middle of the wall span between two access ladders there is a long vertical crack. Understanding the mechanism that causes these cracks is important in order to propose a suitable repair. Simply sealing the cracks would not be effective since the forces that caused them in the first place will still be present and new cracks will form.

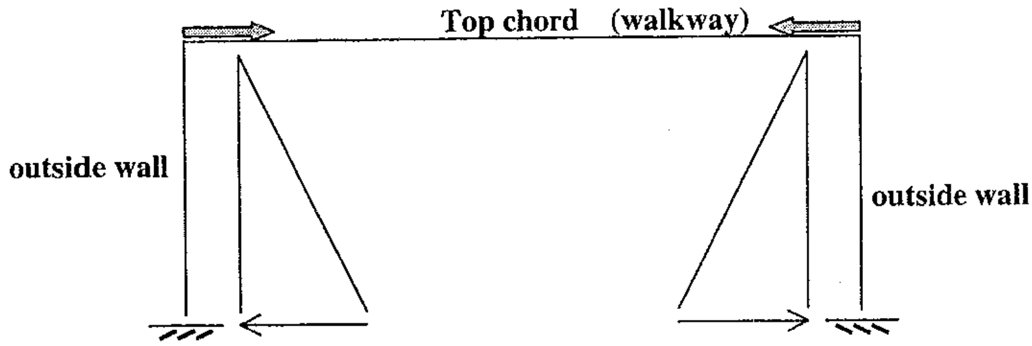
A review of design calculations shows that the walls were designed, as is common practice, for cantilever action with primary bending in the vertical plane.

$M_{max} = wl^2/6$



$w = 9.8 \times 3.75\ kN/m^2$

The cantilever model is not valid where the concrete walkway is attached to the top of the wall. The observed cracking can be explained by a simplified model assuming the concrete walkway acts as a top chord tying the two outside walls together as illustrated below.



The top chord prevents the walls from bending out at the top as they were designed for and the rigid connection between wall and walkway induces positive bending moments on the outside face in two locations:

1) Bending in the horizontal plane with a maximum in the middle span
2) Bending in the vertical plane with negative moments at the top and bottom of the wall and positive moments approximately 2 m from the top.

Reinforcing steel on the outside face is insufficient to resist positive bending moments. resulting in tension cracks under load.

These two models are simple assumptions and neither one accurately describes the actual stress and shear patterns in the wall. Precise analysis would require finite element modelling of the walls to determine how the wall plates actually behave under load. Nevertheless, for the purposes of finding an appropriate repair strategy the simplified assumptions are sufficient to confirm that filling these cracks with epoxy grout will not solve the problem. It is important to remove the restraint provided by the walkway and allow the wall to function as it was intended (i.e. as a cantilever wall). The change can easily be made by cutting out the existing slab and replacing it with an open-grate galvanised metal walkway freely supported at the wall.

(8) Surface Aerator – Slabs, Columns and Walkways

Slabs and columns will need extensive reconstruction if the decision is made to keep the present surface aeration system. There are several problems observed:

1) installation of aerator anchor bolts through the slab creates stress points that cause cracking
2) there is no pad for leveling screws
3) There is no vibration isolation pad between the machine and the concrete.
4) The concrete slabs and walkways are severely damaged by water and frost as a result of poor drainage. Reinforcement is exposed and corroded
5) The concrete fence walls are severely damaged by water and freezing action. The reinforcement at the base of the wall is exposed.
6) Columns are damaged at the water line by the action of turbulent water and freezing
7) Reinforcement in columns on the south and west faces is corroded.

The existing 150 mm slabs are not worth rehabilitating since the damage is deep and the slabs are thin. Adding a new topping of sufficient thickness to protect the steel is not feasible because it would lift the surface aerator above the surface of the water and the shaft length cannot be adjusted.

The cover over reinforcing steel in columns is insufficient on the South and West face. Corrosion of the reinforcing steel has produced rust stains on the surface in line with the reinforcement. The same defect is observed at every column, always on the same two faces. Lifting hooks on the North side of every column indicates that the columns were pre-cast then lifted into place. The lack of cover is probably caused by poor formwork during the fabrication of the columns. Corrosion is not yet severe and has not resulted in the loss of section. Therefore the steel should be exposed, cleaned and treated in the same way that is specified for the walls.

(9) Digesters

Anaerobic digesters are hermetically sealed containers in which liquid sludge is heated to undergo biological fermentation. As a result of this process the sludge is stabilized and transformed into biogas.

It was impossible to inspect the interior of the digesters because they are still 2/3 full of sludge. The insulation on the outside of the digesters conceals the concrete making it impossible to inspect for cracks and other structural defects. Thermal insulation and roofing will need to be replaced entirely. The inside of the digesters will need to be cleaned and inspected to ensure that protective coating is intact. After cleaning and before remedial works, the digesters should be tested for liquid and air tightness.

(10) Gas Storage Tank

The gas storage tank appears to be liquid tight although there are several cracks in the exterior concrete. The interior surfaces could not be inspected because the walls of the gas dome hide them. Inspection and any remedial works would require the complete removal of the dome.

The floating cover is steel and appears to be in good condition with only minor corrosion on the exterior. The inside surfaces of the tank could not be inspected but it is highly probable that the steel roof will need a new protective coating on the inside. The coating should be resistant to gas corrosion. During site inspections it was observed that the pressure relief valve at the top of the dome is broken allowing hot air to escape. This valve will need to be replaced to make the storage tank airtight.

The water inside the dome is heated to prevent freezing of the water seal between the walls of the concrete and steel roof. Piping located in the floor slab circulates hot water from the boilers. This piping is probably corroded and should be replaced. The roof will need to be lifted for remedial works to take place. This operation is discussed in more detail in the main report under construction issues.

(11) Primary Sedimentation Tanks - Footings

The footings on the primary sedimentation tank walls are only 0.5 meters below grade whereas frost penetration depth is at least 0.8 meters. Frost action result in movement of the structure and additional stresses that the structure was not designed to withstand. One visible result of excessive movement is failure (leakage) of the water bar in several expansion joints. It is therefore recommended to backfill around the primary sedimentation tanks in order to protect the footings from frost heaving.

4.2.4 Overall Assessment

In general the structures are safe and have sufficient strength to meet their intended use, however they show considerable signs of deterioration such as:

(1) weathering of all exposed surfaces,
(2) extensive cracking in walls with signs of leakage and previous repairs,
(3) inadequate cover over reinforcement, and
(4) Exposed and corroded reinforcement.

Deterioration is not yet at an advanced stage but significant effort will be required to seal leaks, repair damage and protect against further damage. The structures could be put in service without repairs but corrosion would quickly lead to irreparable damage that will significantly shorten the life of the structures.

Concrete surfaces are porous and provide inadequate cover to protect reinforcement. Corrosion of reinforcement is visible but not yet at an advanced stage. Flat concrete surfaces, prone to water ponding, are badly damaged by freeze-thaw cycles.

The leakage problem is substantial and widespread. Most of the visible leakage occurs at cracks, construction joints and expansion joints in walls and floors. Most of the previously repairs cracks seem to be holding water but several are showing signs of distress and some are beginning to leak again. All cracks and joints should be repaired from the liquid face to make them liquid tight.

4.3 ARCHITECTURAL WORK

Based on the preliminary assessment work done during the first survey of WWTP, the Study Team carried out the second assessment survey for each building facility so as to determine the rehabilitation plan for architectural work, in detail. The followings are the summary of assessment survey of architectural work.

(1) The concrete strength of super structure can be boarded by the sufficient design load.
(2) Exterior finish and interior finish are almost floated and corroded.
(3) There seems to be leakage from the roofs of all the buildings.
(4) All the fittings except the administrative building are missing.
(5) Heater and ventilation are completely broken or corroded, and lighting equipment is also missing.
(6) Fire hydrants are available for some buildings.

4.3.1 Raw Water Pumping Station And Screening Station (Facility No.1,2)

ITEM	ASSESSMENT
STRUCTURE	THE BUILDING IS STRUCTURALLY SAFE SINCE THE RESULT OF THE SCHMIDT HAMMER TEST SHOWED ACTUAL CONCRETE STRENGTH HIGHER THAN THE DESIGNED.
EXTERIOR FINISH	PEELED MORTAR CAN BE SEEN AT THE ENTIRE EXTERIOR WALL, THE BRICK ITSELF IS STRONG. BUT FINISHING IS PEELING OFF, AND THE STAIN IS AWFUL.
WATERPROOF ON ROOF	TRACES OF LEAKAGE IS VISIBLE INSIDE THE BUILDING.CORROSION OF THE COPING IS SERIOUS.
FITTINGS	OVERALL CORROSION IS SEVERE, PART OF THE FITTINGS ARE MISSING.
INTERIOR FINISH	THE STAIN IS ENTIRELY AWFUL. MORTAR IS FLOATED PARTLY.
LIGHTING EQUIPMENT	SOME OF EQUIPMENT ARE MISSING. AND REST OF EQUIPMENT ARE CORRODED..
VENTILATION EQUIPMENT	BROKEN.
HEATING EQUIPMENT	NOT EXISTING.
SANITARY EQUIPMENT	
FIRE EXTINGUISHER	NOT USEFUL,DUE TO SEVERE CORROSION.
OTHERS	CONCRETE OF THE EXTERIOR STAIRS HAS DETERIORATES,AND THE REINFORCEMENT MATERIALS ARE EXPOSED.

4.3.2 Recycled Sludge Pumping Station (Facility No.8)

ITEM	ASSESSMENT RESULT
STRUCTURE	THE BUILDING IS STRUCTURALLY SAFE SINCE THE RESULT OF THE SCHMIDT HAMMER TEST SHOWED ACTUAL CONCRETE STRENGTH HIGHER THAN THE DESIGNED.
EXTERIOR FINISH	PEELED MORTAR CAN BE SEEN AT THE ENTIRE EXTERIOR WALL. THE BRICK ITSELF IS STRONG. BUT FINISHING IS PEELING OFF,AND THE STAIN IS AWFUL.
WATERPROOF ON ROOF	NO TRACE OF LEAKAGE CAN BE SEEN FROM INSIDE OF THE BUILDING,BUT ITS DURABILITY LIFE(10 YEARS) HAS LAPSED. COPING IS HEAVILY CORRODED.
FITTINGS	OVERALL CORROSION IS SEVERE, PART OF THE FITTINGS ARE MISSING.
INTERIOR FINISH	THE STAIN IS ENTIRELY AWFUL.WE CAN SEE PART OF MORTAR IS FLOATED.
LIGHTING EQUIPMENT	SOME OF EQUIPMENT ARE MISSING. REST OF EQUIPMENTS ARE CORRODED..
VENTILATION EQUIPMENT	-
HEATING EQUIPMENT	NO EXISTING.
SANITARY EQUIPMENT	-
FIRE EXTINGUISHER	-
OTHERS	CONCRETE OF THE EXTERIOR STAIRS HAS DETERIORATES.AND THE REINFORCEMENT MATERIALS ARE EXPOSED.

4.3.3 Primary Sludge Pumping Station (Facility No.9)

ITEM	ASSESSMENT RESULT
STRUCTURE	THE BUILDING IS STRUCTURALLY SAFE SINCE THE RESULT OF THE SCHMIDT HAMMER TEST SHOWED ACTUAL CONCRETE STRENGTH HIGHER THAN THE DESIGNED.
EXTERIOR FINISH	FINISHING ARE PEELING OFF, AND STAIN IS AWFUL.
WATERPROOF ON ROOF	TRACES OF LEAKAGE IS VISIBLE INSIDE THE BUILDING.CORROSION OF THE COPING IS SERIOUS.
FITTINGS	OVERALL CORROSION IS SEVERE, PART OF THE FITTINGS ARE MISSING.
INTERIOR FINISH	THE STAIN IS ENTIRELY AWFUL. MORTAR IS FLOATED PARTLY.
LIGHTING EQUIPMENT	EQUIPMENTS ARE MISSING.
VENTILATION EQUIPMENT	-
HEATING EQUIPMENT	NOT EXISTING.
SANITARY EQUIPMENT	-
FIRE EXTINGUISHER	-
OTHERS	THERE ARE TRACES OF FLOOD ON WALLS

4.3.4 Thickened Sludge Pumping Station (Facility No.11)

ITEM	ASSESSMENT RESULT
STRUCTURE	THE BUILDING IS STRUCTURALLY SAFE SINCE THE RESULT OF THE SCHMIDT HAMMER TEST OF THE OTHER BUILDING SHOWED ACTUAL CONCRETE STRENGTH HIGHER THAN THE DESIGNED.
EXTERIOR FINISH	CONCRETE FINISH HAS CAUSED AWFUL STAIN ON WALLS.
WATERPROOF ON ROOF	TRACES OF LEAKAGE IS VISIBLE INSIDE THE BUILDING.CORROSION OF THE COPING IS SERIOUS.
FITTINGS	OVERAL CORROSION IS SEVERE, PART OF THE FITTINGS ARE MISSING.
INTERIOR FINISH	STAIN IS ENTIRELY AWFUL. MORTAR IS FLOATED PARTLY.
LIGHTING EQUIPMENT	NOT EXISTING.
VENTILATION EQUIPMENT	-
HEATING EQUIPMENT	NOT EXISTING.
SANITARY EQUIPMENT	-
FIRE EXTINGUISHER	HEAVILY CORRODED.
OTHERS	THERE ARE TRACES OF FLOOD ON WALLS.

4.3.5 Boiler House (Facility No.13)

ITEM	ASSESSMENT RESULT
STRUCTURE	THE BUILDING IS STRUCTURALLY SAFE SINCE THE RESULT OF THE SCHMIDT HAMMER TEST OF THE OTHER BUILDING SHOWED ACTUAL CONCRETE STRENGTH HIGHER THAN THE DESIGNED.
EXTERIOR FINISH	DAMAGE CAN BE SEEN PARTRY ON THE WALL. FINISHING IS PEELING OFF AND HAS STAINS.
WATERPROOF ON ROOF	NO TRACE OF LEAKAGE CAN BE SEEN FROM INSIDE OF THE BUILDING,BUT ITS DURABILITY LIFE(10 YEARS) HAS LAPSED. COPING IS HEAVILY CORRODED.
FITTINGS	OVERALL CORROSION IS SEVERE. PART OF THE FITTINGS ARE MISSING.
INTERIOR FINISH	STAIN IS ENTIRELY AWFUL. MORTAR IS PEELING OFF PARTLY.
LIGHTING EQUIPMENT	BROKEN
VENTILATION EQUIPMENT	-
HEETING EQUIPMENT	NOT EXISTING.
SANITARY EQUIPMENT	-
FIRE EXTINGUISHER	CORROSION IS SEVERE, IT IS NOT AVAILABLE.
OTHERS	THERE ARE TRACES OF FLOOD ON WALLS.

4.3.6 Gas Compressor Station (Facility N0.14)

ITEM	ASSESSMENT RESULT
STRUCTURE	THE BUILDING IS STRUCTURALLY SAFE SINCE THE RESULT OF THE SCHMIDT HAMMER TEST OF THE OTHER BUILDING SHOWED ACTUAL CONCRETE STRENGTH HIGHER THAN THE DESIGNED.
EXTERIOR FINISH	DAMAGE CAN BE SEEN PARTRY ON THE WALL. FINISHING IS PEELING OFF AND HAS STAINS.
WATERPROOF ON ROOF	NO TRACE OF LEAKAGE CAN BE SEEN FROM INSIDE OF THE BUILDING,BUT ITS DURABILITY LIFE(10 YEARS) HAS LAPSED. COPING IS HEAVILY CORRODED.
FITTINGS	OVERALL CORROSION IS SEVERE, PART OF THE FITTINGS ARE MISSING.
INTERIOR FINISH	STAIN IS ENTIRELY AWFUL. PART OF MORTAR IS PEELING OFF.
LIGHTING EQUIPMENT	BROKEN
VENTILATION EQUIPMENT	BROKEN
HEATING EQUIPMENT	NO EQUIPMENT IS EXISTED.
SANITARY EQUIPMENT	-
FIRE EXTINGUISHER	NOT USEFUL DUE TO SEVERE CORROSION.
OTHERS	THERE ARE TRACES OF FLOODING ON WALLS

4.3.7 Sludge Pumping Station and Sludge Dehydration (Facility No.17,18)

ITEM	ASSESSMENT RESULT
STRUCTURE	THE BUILDING IS STRUCTURALLY SAFE SINCE THE RESULT OF THE SCHMIDT HAMMER TEST OF THE OTHER BUILDING SHOWED ACTUAL CONCRETE STRENGTH HIGHER THAN THE DESIGNED.COLUMN REINFORCEMENT IS PARTLY EXPOSED.
EXTERIOR FINISH	DAMEGE CAN BE SEEN PARTLY ON WALLS. FINISHINGS ARE FLOATED, AND IT HAS STAINS.
WATERPROOF ON ROOF	ONLY PART OF THE LEAKING PORTION HAS BEEN REPAIRED AS CAN BE SEEN FROM INSIDE OF THE BUILDING.THE DURABLE YEARS OF THE WATERPROOFING MATERIAL HAS LASPED.COPING IS SEVERELY CORRODED.
FITTINGS	WINDOWS HAD BEEN REPAIRED.
INTERIOR FINISH	STAINS IS AWFUL OVERALL.IT CAN BE SEEN MORTAR WHICH IS FLOATED PARTLY.
LIGHTING EQUIPMENT	SOME EQUIPMENTS ARE MISSING,AND EXISTING EQUIPMENTS ARE BROKEN.
VENTILATION EQUIPMENT	BROKEN
HEATING EQUIPMENT	NO EQUIPMENT EXIST.
SANITARY EQUIPMENT	NO EQUIPMENT EXIST.
FIRE EXTINGUISHER	CORROSIONS ARE AWFUL AND NOT AVAILABLE.
OTHERS	THERE ARE TRACES OF FLOOD ON WALLS.

4.3.8 Air Blower Room (Facility No19)

ITEM	ASSESSMENT RESULT
STRUCTURE	THE BUILDING IS STRUCTURALLY SAFE SINCE THE RESULT OF THE SCHMIDT HAMMER TEST FOR OTHER BUILDING SHOWED ACTUAL CONCRETE STRENGTH HIGHER THAN THE DESIGNED.
EXTERIOR FINISH	SOME STAINS ARE VISIBLE.
WATERPROOF ON ROOF	THERE ARE SOME TRACES OF LEAKING WATER INSIDE THE BUILDING.
FITTINGS	CORROSIONS ARE SEVERE ENTIRELY.
INTERIOR FINISH	STAINS ARE ENTIRELY AWFUL.
LIGHTING EQUIPMENT	BROKEN
VENTILATION EQUIPMENT	BROKEN
HEATING EQUIPMENT	NO EQUIPMENT EXIST.
SANITARY EQUIPMENT	-
FIRE EXTINGUISHER	-
OTHERS	THERE ARE TRACES OF FLOOD ON WALLS

4.3.9 Power Station (Facility No.20)

ITEM	ASSESSMENT RESULT
STRUCTURE	THE BUILDING IS STRUCTURALLY SAFE SINCE THE RESULT OF THE SCHMIDT HAMMER TEST FOR OTHER BUILDING SHOWED ACTUAL CONCRETE STRENGTH HIGHER THAN THE DESIGNED. REINFORCING STEEL IS PARTLY EXPOSED.
EXTERIOR FINISH	DAMEGE CAN BE SEEN PARTLY ON WALLS. FINISHINGS ARE FLOATED, AND HAS STAINS.
WATERPROOF ON ROOF	THERE ARE NO TRACES OF LEAKING INSIDE OF BUILDING. ALTHOUGH MATERIALS FOR WATERPROOF HAD PASSED ITS GENERAL DURABLE YAERS(10 YEARS).CORROSION ON COPING IS AWFUL.
FITTINGS	CORROSIONS ARE SEVERE, AND SOME FITTINGS ARE MISSING.
INTERIOR FINISH	AWFUL STAINS AND FLOATED MORTARS ARE VISIBLE.
LIGHTING EQUIPMENT	SOME EQUIPMENTS ARE MISSING,SOME ARE BROKEN.
VENTILATION EQUIPMENT	BROKEN.
HEETING EQUIPMENT	NOT EXISTING.
SANITARY EQUIPMENT	NOT EXISTING.
FIRE EXTINGUISHER	IT IS NOT USEFUL DUE TO ITS AWFUL CORROSION.
OTHERS	THERE ARE TRACES OF FLOOD ON WALLS OF THE ELECRICAL ROOM.

4.3.10 Substation (Facility No.21)

ITEM	ASSESSMENT RESULT
STRUCTURE	THE BUILDING IS STRUCTURALLY SAFE SINCE THE RESULT OF THE SCHDMIT HAMMER TEST FOR OTHER BUILDING SHOWED ACTUAL CONCRETE STRENGTH HIGHER THAN THE DESIGNED.
EXTERIOR FINISH	THERE ARE SOME FLOATINGS AND STAINS ON FINISHING.
WATERPROOF ON ROOF	THERE ARE TRACES OF LEAKING WATER INSIDE THE BUILDING.
FITTINGS	CORROSIONS IS ENTIRELY SEVERE. SOME FITTINGS ARE MISSING.
INTERIOR FINISH	AWFUL STAINS ARE VISIBLE ENTIRELY.
LIGHTING EQUIPMENT	BROKEN.
VENTILATION EQUIPMENT	-
HEATING EQUIPMENT	-
SANITARY EQUIPMENT	-
FIRE EXTINGUISHER	-
OTHERS	THERE ARE TRACES OF FLOOD ON WALLS

4.3.11 Reception (Facility No22)

ITEM	ASSESSMENT RESULT
STRUCTURE	THE BUILDING IS STRUCTURALLY SAFE SINCE THE RESULT OF THE SCHDMIT HAMMER TEST FOR OTHER BUILDING SHOWED ACTUAL CONCRETE STRENGTH HIGHER THAN THE DESIGNED.
EXTERIOR FINISH	IT HAS BEEN REPAIRED.
WATERPROOF ON ROOF	IT HAS BEEN REPAIRED.
FITTINGS	IT HAS BEEN REPAIRED.
INTERIOR FINISH	IT HAS BEEN REPAIRED.
LIGHTING EQUIPMENT	IT HAS BEEN REPAIRED.
VENTILATION EQUIPMENT	-
HEATING EQUIPMENT	NOT EXISTING.
SANITARY EQUIPMENT	IT HAS BEEN REPAIRED.
FIRE EXTINGUISHER	IT HAS BEEN REPAIRED.
OTHERS	-

4.3.12 Administration Building A-Block (Facility No23A)

ITEM	ASSESSMENT RESULT
STRUCTURE	THE BUILDING IS STRUCTURALLY SAFE SINCE THE RESULT OF THE SCHDMIT HAMMER TEST FOR OTHER BUILDING SHOWED ACTUAL CONCRETE STRENGTH HIGHER THAN THE DESIGNED.
EXTERIOR FINISH	FLOATED MORTARS ARE VISIBLE AT ENTIRE WALLS,BUT BRICK ITSELF IS HEALTHY.FLOATING AND STAINS ON FINISHIG ARE VISIBLE.
WATERPROOF ON ROOF	IT HAD BEEN REPAIRED ALREADY.
FITTINGS	IT HAD BEEN REPAIRED ALMOST.
INTERIOR FINISH	IT HAD BEEN REPAIRED ALMOST.
LIGHTING EQUIPMENT	IT HAD BEEN REPAIRED ALMOST.
VENTILATION EQUIPMENT	THERE IS NO VENTILATION FAN FOR EXAMINING WATER.
HEATING EQUIPMENT	NO EQUIPMENT EXISTS.
SANITARY EQUIPMENT	SOME OF EQUIPMENTS ARE NOT REPAIRED.
FIRE EXTINGUISHER	SOME ARE REPAIRED,BUT MOST OF THOSE HAD NOT BEEN REPAIRED.
OTHERS	-

4.3.13 Administration Building B-Block (Facility No23B)

ITEM	ASSESSMENT RESULT
STRUCTURE	THE BUILDING IS STRUCTURALLY SAFE SINCE THE RESULT OF THE SCHDMIT HAMMER TEST FOR OTHER BUILDING SHOWED ACTUAL CONCRETE STRENGTH HIGHER THAN THE DESIGNED.
EXTERIOR FINISH	FLOATED MORTARS ARE VISIBLE AT ENTIRE WALLS. BRICK ITSELF IS HEALTHY.FLOATING AND STAINS ON FINISHIG ARE VISIBLE.
WATERPROOF ON ROOF	IT HAD BEEN REPAIRED ALREADY.
FITTINGS	IT HAD BEEN REPAIRED ALMOST.
INTERIOR FINISH	SOME ROOMS ARE NOT REPAIRED.
LIGHTING EQUIPMENT	SOME ROOMS ARE NOT REPAIRED.
VENTILATION EQUIPMENT	-
HEATING EQUIPMENT	NOT EXISTING.
SANITARY EQUIPMENT	SOME OF EQUIPENTS ARE NOT REPAIRED.
FIRE EXTINGUISHER	SOME ARE REPAIRED,BUT MOST OF THOSE ARE NOT REPAIRED.
OTHERS	-

4.3.14 Administration Building C-Block (Facility No23C)

ITEM	ASSESSMENT RESULT
STRUCTURE	THE BUILDING IS STRUCTURALLY SAFE SINCE THE RESULT OF THE SCHDMIT HAMMER TEST FOR OTHER BUILDING SHOWED ACTUAL CONCRETE STRENGTH HIGHER THAN THE DESIGNED.
EXTERIOR FINISH	FLOATED MORTARS ARE VISIBLE AT ENTIRE WALLS. BRICK ITSELF IS HEALTHY.FLOATING AND STAINS ON FINISHIG ARE VISIBLE.
WATERPROOF ON ROOF	IT HAD BEEN REPAIRED ALREADY.
FITTINGS	LARGE DOOR AT THE ENTRANCE IS NOT REPAIRED.
INTERIOR FINISH	IT IS NOT REPAIRED.
LIGHTING EQUIPMENT	IT IS NOT REPAIRED.
VENTILATION EQUIPMENT	-
HEATING EQUIPMENT	NOT EXISTING.
SANITARY EQUIPMENT	-
FIRE EXTINGUISHER	SOME ARE REPAIRED,BUT MOST OF THOSE ARE NOT REPAIRED.
OTHERS	-

4.3.15 Service Water Pumping Station (Facility No24)

ITEM	ASSESSMENT RESULT
STRUCTURE	THE BUILDING IS STRUCTURALLY SAFE SINCE THE RESULT OF THE SCHDMIT HAMMER TEST FOR OTHER BUILDING SHOWED ACTUAL CONCRETE STRENGTH HIGHER THAN THE DESIGNED.
EXTERIOR FINISH	FLOATINGS AND STAINS ON FINISHING ARE VISIBLE.
WATERPROOF ON ROOF	THERE ARE NO TRACES OF LEAKING INSIDE OF BUILDING. ALTHOUGH MATERIALS FOR WATERPROOF HAD ALREADY PASSED ITS GENERAL DURABLE YAERS(10YEARS).CORROSION ON COPING IS AWFUL.
FITTINGS	CORROSIONS ARE ENTIRELY SEVERE.IT IS NOT USEFUL.
INTERIOR FINISH	STAINS ARE ENTIRELY AWFUL.SOME MORTARS ARE FLOATING.
LIGHTING EQUIPMENT	BROKEN.
VENTILATION EQUIPMENT	-
HEATING EQUIPMENT	NOT EXISTING.
SANITARY EQUIPMENT	-
FIRE EXTINGUISHER	-
OTHERS	-