4.4.1.5 Discharge of Effluent from the Treatment Plant

Effluent from the stabilization pond is discharged, as the final effluent, into a drainage/irrigation canal that flows to one of the tributaries of the Tatula River after about 5km. This tributary flows into the Tatula River after approximately 3 km.

4.4.2 Characteristics of Sewage and Plant Performance

4.4.2.1 Existing Data of the Sewage Characteristics

The Water Company conducts a water sampling and quality analysis in a manner as follows:

Frequency: once a month

Sampling points: inlet and outlet of the treatment plant

Samples are taken and analyzed at the State Company "Agro Labo" in Birzai. The result of the water quality analysis is summarized in Table 4.17 and shown in Figure4.7.

For BOD_7 of the raw water, there is one extraordinary high value (3,360 mg/l) for November 1996. Other parameters of the same date also show high values, but are not so remarkable when compared with normal values. This high BOD should be taken as a special irregular value, probably caused by either error in the analysis or by dumping of unusual wastewater into the sewer on that day.

Aside from the laboratory analysis, the Water Company keeps the records of the temperature and pH as shown below.

Table 4.16 Sewerage Temperature and pH at Treatment Plant

Month	Temperature (°C)		pH	
	Inf.	Eff.	Inf.	Eff.
Jan-97	10.5	6.0	7.9	7.8
Feb-97	7.5	5.0	7.8	7.3
Mar-97	5.0	6.0	7.8	7.1
Apr-97	9.0	9.5	7.3	7.2
May-97	11.0	17.0	7.3	7.2
Jun-97	12.0	21.0	7.5	7.6
Jun-97	12.0	20.0	7.6	7.5
Aug-97	18.0	17.0	7.7	7.5
Sep-97	15.0	14.0	7.8	7.6
Oct-97	10.0	8.0	7.8	7.1
Nov-97	12.0	5.0	7.8	7.3
Dec-97	12.0	5.0	7.7	7.4

Source: Birzai Water Company

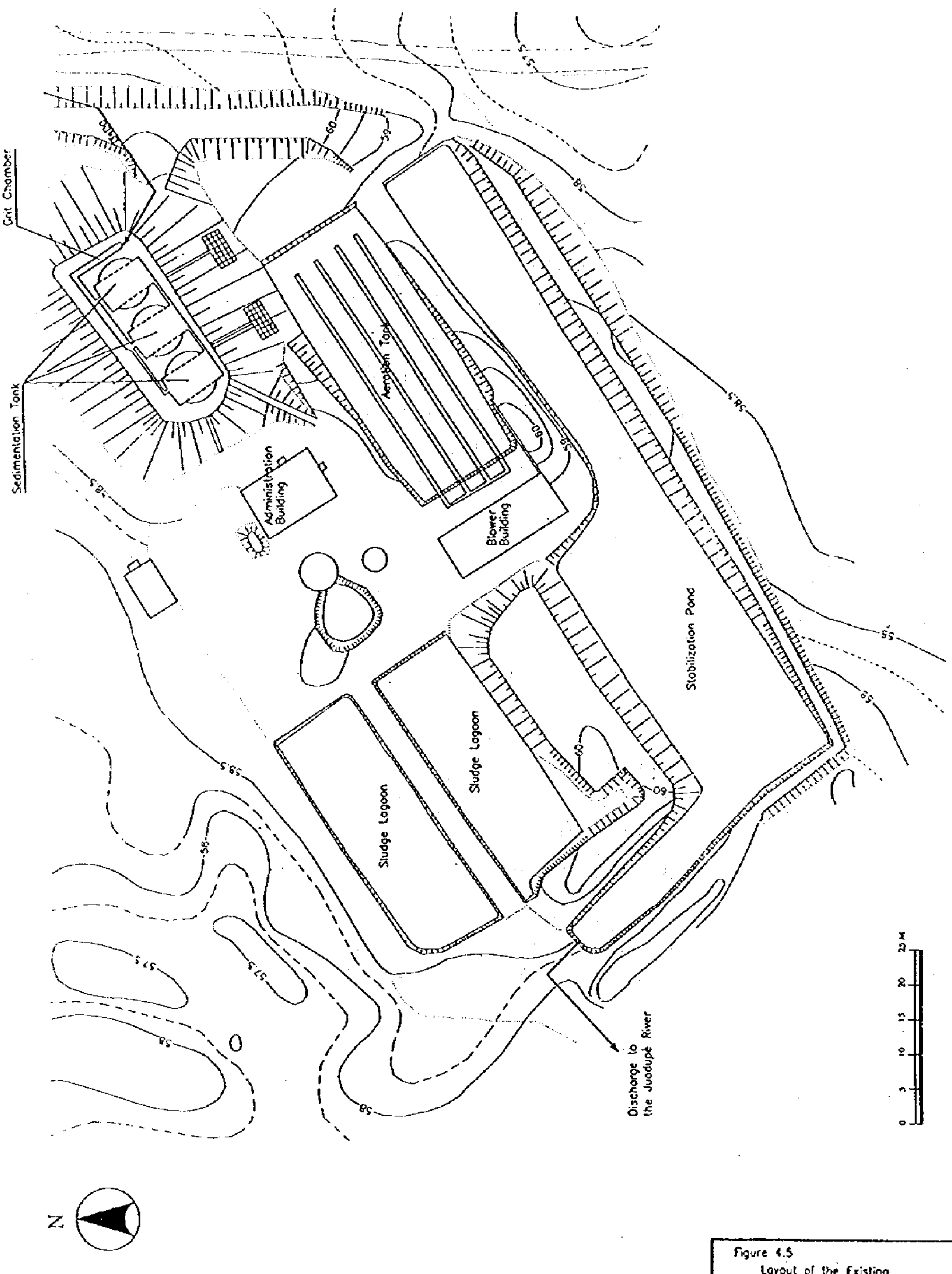


Figure 4.5
Layout of the Existing Treatment Plant

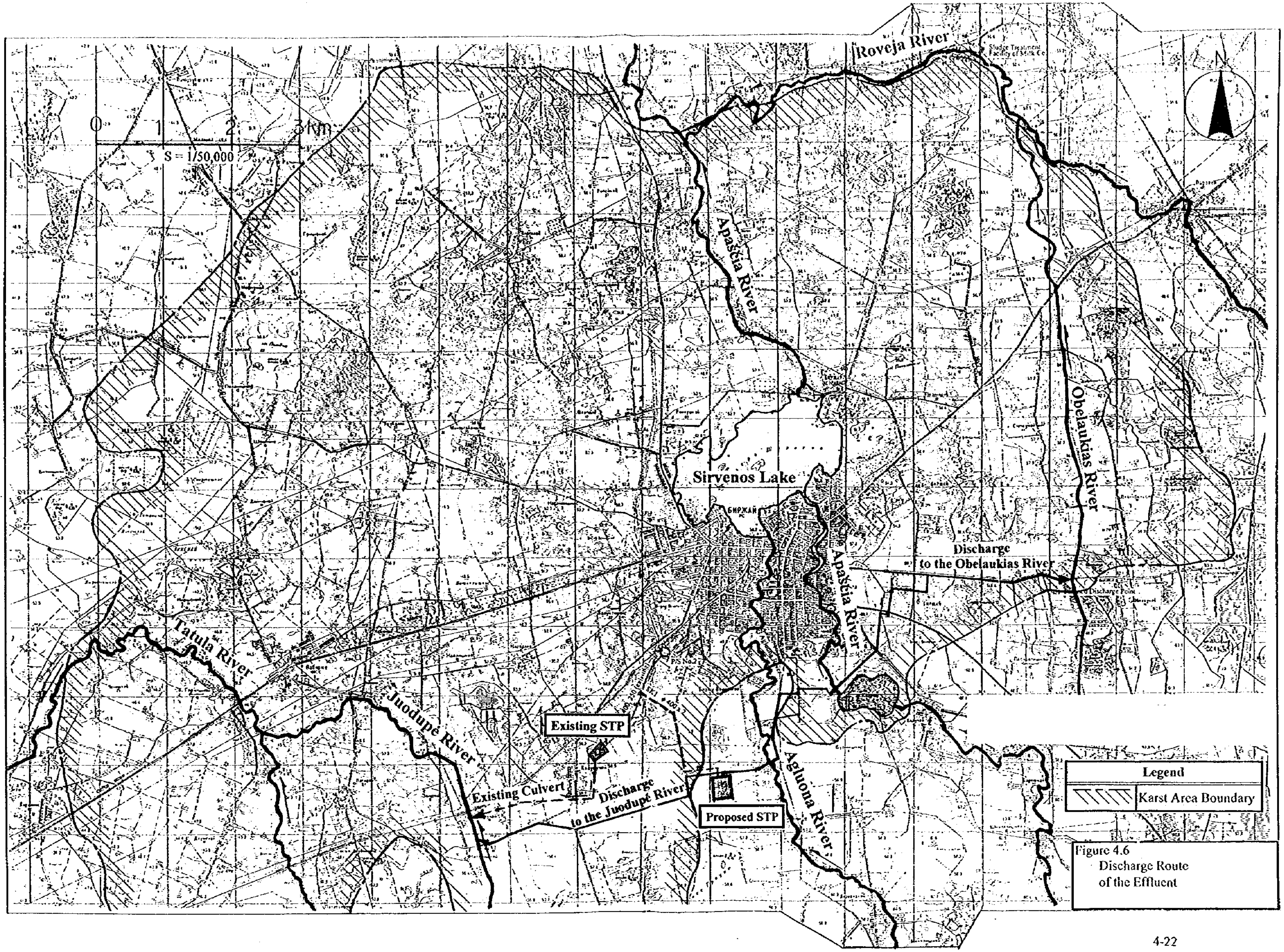


Figure 4.6
Discharge Route
of the Effluent

Table 4.17 Water Quality Data at the Existing Treatment Plant

Date	BOD_7		SS		Total-N		NH_4		NO_2		NO_3		Total-P		Cl		Oil	
	Inf.	Eff.	Inf.	Eff.	Inf.	Eff.	Inf.	Eff.	Inf.	Eff.	Inf.	Eff.	Inf.	Eff.	Inf.	Eff.	Inf.	Eff.
10 Jul. 96	228	192	69	23	12.6	34.4	11.0	24.8	-	-	-	-	0.9	2.1	115	144	-	-
08 Aug. 96	245	360	114	212	50.4	13.4	29.6	7.6	-	-	-	-	5.5	3.6	253	181	-	-
11 Sep. 96	490	285	392	58	49.2	42.5	31.0	26	-	-	4.0	3.5	4.2	6.0	325	289	-	-
09 Oct. 96	350	186	398	94	51.5	54.8	28.6	31	-	-	0.5	0.5	6.0	6.4	287	325	-	-
22 Nov. 96	3,360	348	513	66	91.8	58.2	48.0	31	-	-	10.5	4.5	7.9	5.6	402	363	-	-
16 Dec. 96	310	120	69	63	14.5	44.8	12.6	34	0.2	-	1.7	0.5	4.9	4.4	153	230	-	-
21 Jan. 97	312	177	271	68	44.5	18.9	33.0	12.4	0.2	-	2.0	1.5	5.6	1.4	249	287	0.8	0.6
19 Feb. 97	580	72	445	36	76.6	33.1	65.0	15	-	-	2.0	0.5	6.0	4.0	325	211	1.05	0.85
12 Mar. 97	293	160	214	19	42.3	33.2	38.0	28.6	0.3	-	0.5	0.5	9.2	3.8	191	191	1.7	0.9
25 Apr. 95	96	126	125	45	47.8	35.1	13.2	11	0.2	-	1.3	0.5	4.0	2.8	211	172	0.7	-
13 May 97	410	188	209	32	47.8	25.5	20.0	12	-	-	2.0	0.5	5.8	2.4	172	172	-	-
12 Jun. 97	190	190	55	29	26.6	38.9	12.0	30	0.4	-	6.0	0.5	2.4	2.8	191	197	-	0.9
16 Jul. 97	220	174	298	65	43.6	25.5	32.0	17	-	-	5.0	2.0	5.2	5.6	263	188	-	-
13 Aug. 97	1,200	186	188	35	38.2	42.5	15.0	12	-	-	1.0	3.5	9.0	4.5	263	207	-	-
22 Sep. 97	1,020	630	1,037	236	152	66.5	55.0	32	-	-	-	-	12	9.0	478	287	1.8	0.8
21 Oct. 97	150	170	78	48	14.1	21.8	5.00	14	3	-	0.5	-	1.8	3.8	249	211	1.2	0.7
25 Nov. 97	870	162	401	20	47	22	22.0	14	-	-	0.5	0.5	4.8	2.4	210	172	0.8	0.7
22 Dec. 97	480	162	121	79	22	24.6	16.0	22	0.4	-	0.5	0.5	1.8	5.0	191	153	-	-
27 Jan. 98	336	110	144	45	35	28	26.0	10	-	-	3.0	1.5	6.0	5.0	230	131	-	0.6
12 Feb. 98	210	70	161	26	21	8	16.0	6	-	-	1.0	0.5	3.0	2.9	172	172	1.3	0.8
12 Mar. 98	81	123	79	46	19	26	10.0	16	0.6	-	1.0	-	1.6	2.6	191	172	0.9	0.8
09 Apr. 98	320	186	43	38	49	29	22.0	21	-	-	1.0	2.0	4.4	3.6	134	153	1.2	1.0
05 May 98	155	130	82	49	24	26	11.0	18	0.3	-	2.0	0.5	2.4	1.2	134	115	-	-
09 Jun. 98	330	150	248	49	32	24	22.0	13		-	2.5	1.0	4.4	3.4	195	177	-	-

Inf. = Influent
Eff. = Effluent
Source: Birzai Water Company

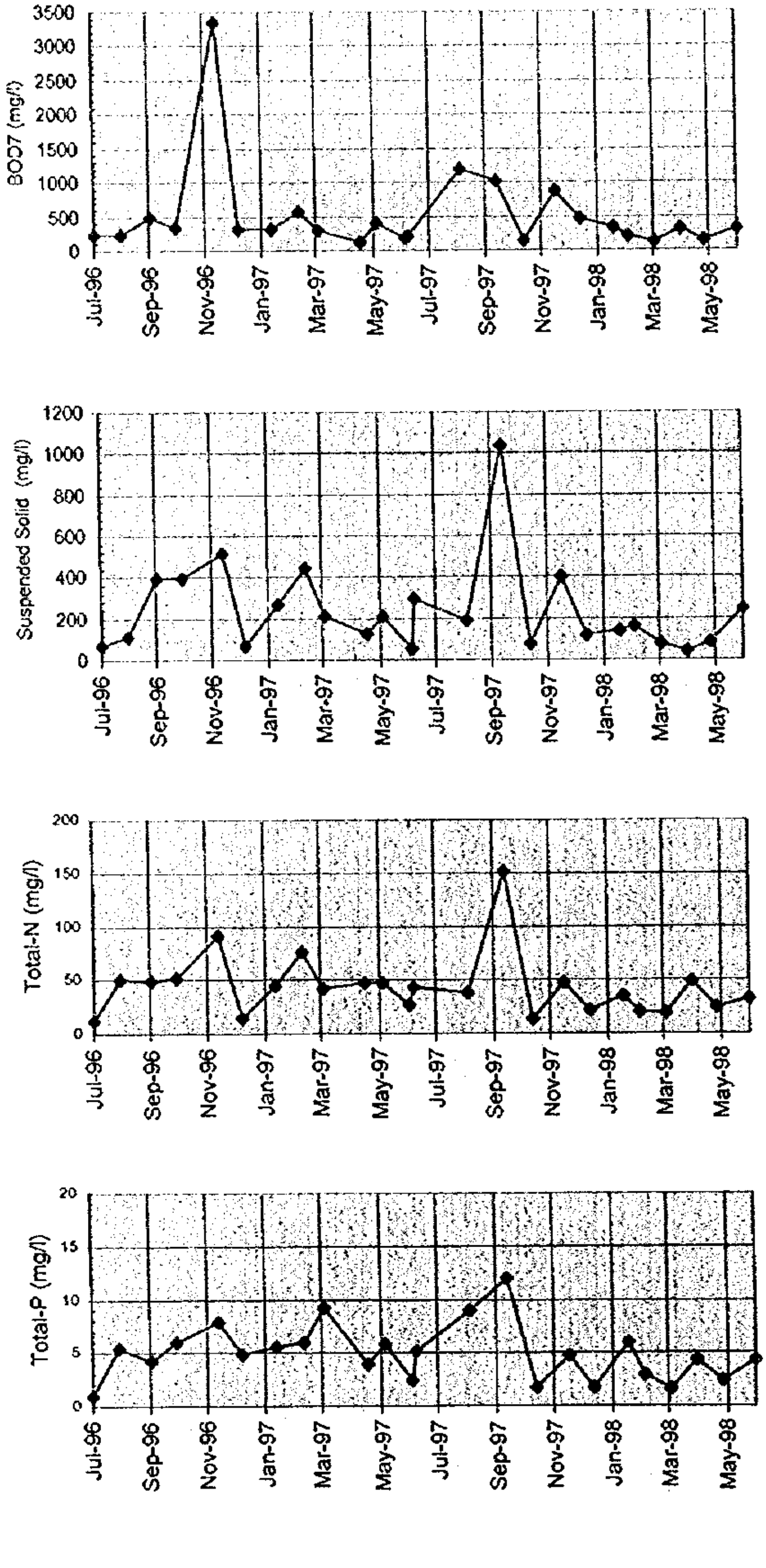
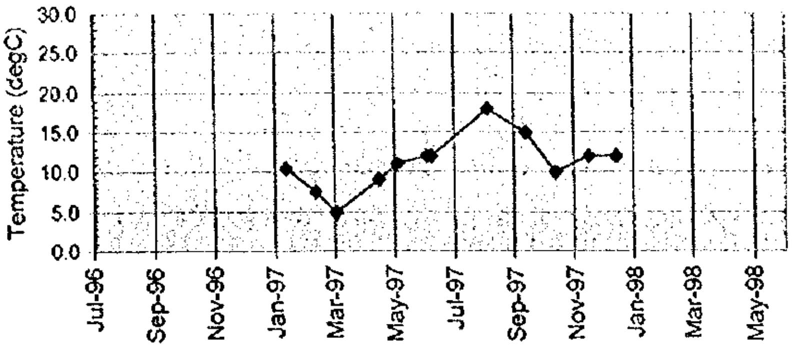


Figure4.7 Influent Quality of Treatment Plant



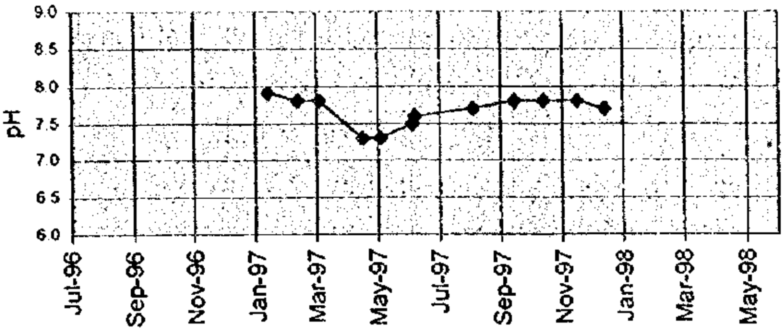


Figure 4.8 Influent Temperature and pH at Treatment Plant

4.4.2.2 Performance of the Existing Treatment Plant

As shown in the water quality data, the existing treatment plant does not satisfy the national effluent standards referred to in Section 3.5.1.1. The summary of the influent and effluent are shown below.

Table 4.18 Summary of Performance of the Treatment Plant

	BOD_7		SS		Total-N		Total-P		Oil	
	Inf.	Eff.	Inf.	Eff.	Inf.	Eff.	Inf.	Eff.	Inf.	Eff.
Maximum	3,360	630	1,037	236	152	67	12.0	9.0	1.8	1.0
Minimum	123	70	43	19	13	8	0.9	1.2	0.7	0.6
Average	513	187	240	62	44	32	5.0	3.9	1.1	0.8
Effluent Standard	20 (ave.) 30 (max.)		30 (ave.) 45 (max.)		NA		NA		1	
Average of Removal Ratio	44%		59%		18%		27%		17%	

Effluent standard: for <10,000 p.e.

BOD_7 and suspended solids far exceed the maximum values set in the standards while oil is within the acceptable range of the standards. This failure is easily explained from the design of the treatment process that does not have sufficient capacity of biological treatment.

4.4.2.3 Industrial Wastewater

In Birzai, there are several business entities, institutions, and industries that are discharging wastewater to the sewer system. Some of them have their own wells as a water source at their premises. Table 4.20 shows the list of the commercial entities, institutions, and industries in Birzai Town.

Daily average water consumption of these facilities is 596 m^3/day in total. The Water Company supplies 155 m^3/day, while the reminder is taken from the deep wells of each user. From this table, the quantity of real industrial wastewater is calculated at 498 m^3/day in average, equivalent to 25 percent of the total amount of sewage.

Only one exception is a linen factory. This factory has its own water supply and wastewater treatment plant. It is taking water from the lake and discharging treated wastewater into the Apascia River at a point immediately downstream of the lake.

As shown in the table, three major industries discharge process wastewater as follows:

Table 4.19 Major Industries and Wastewater Quality

Factory	BOD_7 (mg/l)		Suspended Solid (mg/l)	
	Average	Maximum	Average	Maximum
Beer Brewery (UAB Birzu Alus)	985	3,480	298	623
Dairy (UAB Birzu akcine pieno lenduovo)	702	1,170	163	784
Canned Food (UAB Birzu konservai)	475	960	212	603

Source: Birzai Water Company (1998)

Out of these three factories, the dairy has its own wastewater pre-treatment and sludge treatment facility. The other two factories discharge wastewater into the sewer without treatment.

Aside from the major factories above, there are three small breweries in Birzai Municipality as follows:

- Rinkuskiai: located near Pump Station No.4, using its own deep well for consumption of about 50 m^3/day.
- Ponoras: located near the canned food factory, using its own deep well for consumption of about 15 m^3/day.
- Klausuciai: located outside town boundary, using its own deep well for consumption of about 10 m^3/day, no plan to connect with the sewerage system.

Table 4.20 Commercial and Industrial Water Use and Discharge

No.		Own well		Water Use (m^3/97)		Water Source (m^3)		Water Discharged to		Wastewater Treatment	
		no.	capacity (m^3/h)	Process Water	Domestic Use	Vandenys Water	Own Source	Vandenys Sewer	Others	existing	planned
1	Birzu statyba (construction enterprise)			0	37	37	0	37		(no need)	no
2	Misku uredija (Forestry Administration)	1	28	0	38	0	38	38		(no need)	no
3	Linen factory "Siulas"	1	45	-	-	-	-	-	to lake	(no need)	no
4	Agricultural School			0	12,626	12,626	0	12,626		(no need)	no
5	Birzu akcine pieno lenduovo (Birzai dairy)	1	25	99,688		0	99,688	99,688		no	yes
6	UAB Birzu Alus (Birzai Brewery)	1	10	28,404		28,404	0	28,404		no	no
7	Panevezys Electric Power Company			0	1,426	1,426	0	1,426		(no need)	no
8	Building maintenance company			0	237	237	0	237		(no need)	no
9	UAB Birzu konservai (canned food company)	3	101	29,100	0	0	29,100	29,100		no	no
10	UAB Birzu duona (bakery)			1,102	0	1,102	0	1,102		(no need)	no
11	Public Utilities Center	1	25	0	8649	0	8,649	8,649		(no need)	no
12	Land Reclamation Construction Company	3	85	0	905	905	0	905		(no need)	nc
13	Central Hospital	1	63	0	11828	11,828	0	11,828		(no need)	no
14	Bus Garage			0	10	0	0	0		(no need)	no
15	Rinkuskiai (small brewery)	1		18,000	0	0	18,000	18,000		no	yes
16	Ponoras (small brewery)	1		5,500	0	0	5,500	5,500		no	yes
	Yearly Total Amount (m^3/year)			181,794	35,756	56,565	160,975	217,540			
	Daily Average Amount (m^3/day)			498	98	155	441	596			

Rinkuskiai (small brewery) has a plan to expand its production in the near future. Water consumption is expected to increase by 70 m^3/day.

Rinkuskiai and Ponoras will construct their own wastewater treatment plants each in their factories so that the wastewater will be treated to domestic sewage level.

4.4.2.4 *Results of the Water Sampling and Water Quality Analysis*

The JICA Study Team conducted a water sampling and water quality analysis to supplement the data for sewage and industrial wastewater. Water samples were taken at the points and with a frequency as follows:

Raw Sewage

From the inlet channel of the treatment plant

4 days x 13 samples/day (every 2 hours for 24 hours)

= 52 samples

Industrial Wastewater

From the discharge at the dairy

4 days x 5 samples/day (every 2 hours from 8:00 to 16:00 hours)

= 20 samples

From the discharge at the beer brewery

4 days x 5 samples/day (every 2 hours from 8:00 to 16:00 hours)

= 20 samples

As well as water sampling, flow rate measurements were conducted at each sampling time. Samples were analyzed at the Victa Laboratory in Vilnius. Results of the sampling are summarized in Table 4.21.

Table 4.21 Results of Water Quality Analysis

item	unit	sampling date			
		Jul 28-29	Aug 06-07	Aug 13-14	Aug 20-21
Sewage Flow	m^3/day	2,920	2,770	3,050	1,790
SS	mg/l	255	163	286	229
BOD_7	mg/l	217	229	365	335
Soluble BOD_7	mg/l	94	98	158	175
COD	mg/l	430	486	690	676
Total-N	mg/l	23	36	31	33
Total-P	mg/l	8.1	5.7	8.0	6.0

Note: Concentrations are calculated as a weighted average of the concentrations and flow-rates of the 12 samples taken every 2 hours during 24 hours. Details are presented in Appendix 4.

4.4.2.5 *Evaluation on the Characteristics of Sewage*

General

Sewage discharged into the Birzai sewerage system contains about 75 percent domestic sewage and 25 percent industrial wastewater. Most of the industrial wastewater is typical organic wastewater with high concentrations of BOD and COD.

Amount of Sewage

The Water Company has a billing record that shows the amount of sewage at 1,700 m^3/day in 1997. Amounts of sewage in the billing are based on the water consumption for the Water Company's water supply system and personal deep wells equipped with meter.

On the other hand, operation records of Pump Station No.2 show the total running time of pump as follows:

Date	Running Time	Flow
January 21, 1998:	935 minutes (average 31 minutes/hour),	3,120 m^3/day
August 14, 1998:	942 minutes (average 34 minutes/hour)	3,140 m^3/day

It is apparent that the amount of incoming sewage is much more than that discharged from the consumers. It apparently includes a substantial amount of groundwater. Considering that the water consumption is about 1,700 m^3/day, the amount of groundwater is estimated at 1,500 m^3/day.

BOD

There are three samples of high BOD in the historical record (November 96, August and September 97). These data seem to be caused by the wastewater discharged from the factories in the town. Average BOD from the data excluding these unusual figures are 320 mg/l while the sampling results show lower values.

Nitrogen

Total nitrogen ranges from 13 to 77 mg/l in the historical records with an average of 37 mg/l. Except for the sample showing high BOD (November 96, August and September 97), data is relatively consistent with the sampling result in this study.

Phosphorus

Total phosphorus level ranges from 0.9 to 12 mg/l with an average of 5.0 mg/l in the historical records. Data seems to be consistent with the sampling result in this study.

COD

There is no COD record in the Water Company data. Sampling results shows that COD is about two times the BOD concentrations.

4.5 RESIDENT AWARENESS SURVEY

4.5.1 Questionnaire Survey Conducted

The Study Team conducted a questionnaire survey to collect information for resident awareness on sewerage service and the willingness-to-pay. The survey was conducted from 13 to 18 July 1998 by the interview method with 50 people in Birzai Town.

The questionnaire included the following items:

- family income and expenditure

- water use
- water supply conditions
- sanitary conditions and facility
- willingness-to-pay for water charge
- willingness-to-pay for sewerage charge

4.5.2 Summary of the Survey Results

The major issues in the questionnaire survey are summarized in the tables below and described as follows:

- Average number of family member in Birzai is 3.38.
- Average monthly family income is 1,125 litas with a range of 500 to 1,500 litas being dominant.
- In nearly half of the households, two persons have income.
- Cost of water and sewerage is about 1.8 percent (15 litas/month) of the total family expense. It is the lowest among the utility expenses.
- Very few households connected to water and sewerage have their own well sources.
- People show more willingness to pay higher fees for water supply than for sewerage service.

Table 4.22 Number of Family Member

no. of family member	no. of sample
1	6
2	12
3	6
4	14
5	8
6	3
7	1
Total	50
Average	3.38

Table 4.23 Family Income

monthly income (litas/month)	no of member having income				
	1	2	3	4	Total
<500	4		1		5
500-1,000	8	11	1		20
1,000-1,500	4	7	2		13
1,500-2,000	2	2		2	6
2,000<	2	2	1	1	6
Grand Total	20	22	5	3	50
			average monthly income		Lt.1,125

Table 4.24 Family Expenses

income class (litas/month)	average monthly expenses (litas/month)					
	total	water & sewerage	hot water	electricity	transport-ation	commun-ication
<500	390	10	28	23	55	20
500-1,000	735	20	33	32	82	44
1,000-1,500	1,108	18	37	45	135	49
1,500-2,000	800	7	60	38	135	30
2,000<	1,084	21	147	46	213	23
average	823	15	61	37	124	33
percentage	100.0%	1.8%	7.4%	4.5%	15.1%	4.0%

Table 4.25 Connection with Water Supply and Sewerage Systems

connection with sewerage system	connection with water supply system			
	connected		not connected	total
	no other water source	with shallow well	(with shallow well)	
connected	19	2	7	28
not connected	0	0	22	22

Table 4.26 Affordability and Willingness-to-pay

water supply		sewerage		fee for sewerage new connection	
affordable amount (litas/month)	no. of sample	affordable amount (litas/month)	no. of sample	affordable amount (litas/month)	no. of sample535
<20	9	<20	2	<10	2
20-40	11	20-40	1	10-20	0
40-60	9	40-60	1	20-30	1
60-90	2	60-90	1	30-50	2
90<	1	90<	-	50-100	3
				100<	4
do not accept		do not accept		do not accept	
To be free of charge	2	to be shouldered by gov.	8	to be shouldered by gov.	1
		do not want to pay	18	do not want to pay	2

4.6 EXISTING CONSTRAINTS FOR SEWERAGE SYSTEM

4.6.1 Technical Aspects

4.6.1.1 Collection system

Infiltration

A remarkable deficiency of the sewage collection system of Birzai is a huge amount of infiltration as discussed in Section 4.4.2.5. In 1998, about half of the inflow is infiltration of the groundwater. This deficiency results in the large power consumption in pump operation. Infiltration is considered to occur from the various parts of the sewer pipes laid below the groundwater level. As the major part of small pipes is of clay, the infiltration likely occurs at cracked pipes and/or loose joints.

Detecting and reducing the infiltration will require great effort and cost, but should be worth carrying out.

Stormwater Intrusion

According to the Water Company, the sewage flow substantially increases during rainy weather. This is apparently caused by intrusion of the rain water into the sewer system. Rainwater normally flows into the sewer system from broken manholes, open connection boxes at the households, or sometimes by dumping floodwater into manholes by people or illegal connections.

Preventing stormwater intrusion is much easier than mitigation of groundwater infiltration. In many cases, points of intrusion are visible and therefore can be found by careful observation in rainy days.

4.6.1.2 Sewage treatment plant

The existing sewage treatment plant was designed to remove suspended solid and organic substances using sedimentation and biological filtration. Removal of nitrogen and phosphorous was not considered in the plant design.

The plant is hydraulically overloaded and not functioning properly. Treatment capacity of the sedimentation tank is estimated at 2,600 m^3/day from its surface area while the capacity of the biological filter is estimated at only 1,300 m^3/day.

4.6.1.3 Industrial wastewater

The national standard LAND 10-96 sets the principal norms for sewage discharged into a public sewerage system as described in Section 3.4.1. LAND 10-96 also states that:

"*the norms applied to other materials (substances) shall be established by an organization that operates the systems in making a contract with a sub-user*".

With this provision, the municipality or Water Company is given authority to set the additional requirements for wastewater discharged from the users into the public sewerage system. In Birzai at present, no additional standard has been set for this purpose. The factories therefore have no obligation to reduce their pollution as long as the wastewater meets the minimum requirements set in the LAND 10-96. The dairy, however, installed its own pre-treatment facility while the other factories have not.

From the data of water quality and water consumption, BOD_7 load of the wastewater from three major factories is estimated at about 35 percent of the total load incoming to the treatment plant. Reducing the organic load in the industrial wastewater will therefore also reduce the load at the sewage treatment plant.

Aside from the average load discharged from the industries, a very high maximum value is recorded in the data of the brewery factory (BOD_7 = 3,480 mg/l). This high value seems to have resulted from the discharge of high concentrated sludge from the factory. Such disposal must be prevented to maintain the treatment performance of the municipal plant.

4.6.2 Managerial Aspects

4.6.2.1 Collecting Incorrect Charges from Collective Housing

A controller of the company checks the meters of the enterprises and collective housing once a month, writes the bills, and delivers them to the enterprises and collective housing. The enterprises and collective housings then pay the charges to the banks, and are issued a receipt.

One person, who is in charge of checking water usage and collecting charges from each resident in a collective housing, has to pay the total charges for the housing to the company. Collective housing has a single meter but has not necessarily meters for all flats.

It has been reported that some residents tried to manipulate meter reading to reduce the consumption by use of a magnet or by releasing water in so small amount that it cannot be detected by the presently used water meters. This problem may however be more or less overcome by replacing the existing meters with ones sensitive enough to detect small flow.

Some flats do not have meters. If so, they pay charges based on a norm, which is a standard usage of volume for those who have no meters. The company has not been collecting the correct charges from residents in collective housing because residents not having meters use more water than the norm. It is estimated that the company has been losing 10 to15 percent of the correct charge.

The Water Company must install meters at all houses and flats by 2000 according to Government Decree and check all water usage from all collective housing. But installing meters is difficult because of lack of funds. Another problem is that meters in collective housing are normally installed inside of the flats in places such as the bath rooms. It will be difficult for the company to check meters when no one is home.

Another method that is suggested is to subtract the water usage from the flats with meters from the single meter reading the water usage from collective housing. The remainder would be divided by the number of flats without meters and each would pay an equal amount. In other words, change the norm that flats without meter pay.

4.6.2.2 Expansion of the Coverage Area

Since 1996, the Birzai Water Company has provided services to three sub-regions, Papilys, N.Radviliskis and Vabalninkas in addition to the Birzai region. It is possible that the company will have to provide service to additional regions in the future, although this is under debate. The number of employees was approximately 25 in 1995 and is 53 in 1998. The company provides support for three sub-region and manages three sub-region offices. This may cause management problems, such as inefficiency due to duplicated management staff members and communication gaps, lack of control due to differences of management history, policy and practices among regions and unfamiliarity with management of plural regions, etc. It is clear that these sub-regions might generate losses before they are merged and those which may be merged or built in the future may generate losses in the future because there is insufficient population to support profitable operation in the countryside. The company must manage them on a self-supporting accounting system base and lead them to healthier operation.

4.6.2.3 Possible Redundancy in Some Business Units

Business units have responsibility for operation of divisions but the number of employees in some divisions may be more than strictly necessary for management because of the expanding coverage area and other reasons.

Personnel costs to sales and to operating costs before depreciation of other companies such as large private water and sewerage companies in the U.K., a former Soviet Union company and Japanese public sewerage works are approximately 20 percent and 30 percent respectively as shown in Table 4.27. The same ratios for Birzai are 55 percent and 64 percent respectively and much higher than the others. It is difficult to compare the company with foreign companies directly, but it gives some guidelines for management and level of personnel costs.

4.6.2.4 Short of Periodic Performance Evaluations

All employees reportedly do their best in order to maintain their job stability. The Water Company has not conducted periodic performance evaluations for employees using clearly written requirements to meet and goals to perform. Employees may reduce costs and increase revenues by performing more active work to meet their goals.

4.6.2.5 Lack of Integrated Management Information System

A computerized information system is installed in a controller room to manage billing and collection of the water and sewerage fees. Computerized information systems are also installed in water and sewerage equipment rooms to monitor operations. There are no information systems for the management functions. This lack of information systems causes inefficiency in gathering correct information and inability to provide speedy action when required.

4.6.2.6 Process of a Self Supporting Management System

The Water Company manages itself on a self-supporting accounting system and also follows policies concerning tariff and costs of the municipality. Because of this dual responsibility, the company does not have autonomous management. The company should be more commercialized to cover costs because the state and municipality budgets are strictly regulated.

Table 4.27 Personnel Costs Comparison

	Turnover and Personnel costs to it	Operating Costs before Depreciation and Personnel costs to it	Personnel Costs
Severn Trent plc in the U.K. (1997) million Pounds and (%)	1,215.3 (20.9)	673.2 (37.8)	254.4
Anglian Water plc in the U.K. (1997) million Pounds and (%)	837.1 (16.1)	430.7 (31.3)	134.8
Pskov in Russia (1996) million Rubles and (%)	48,143 (22.5)	40,105 (27.0)	10,836
Public Sewerage Works in Japan (1994) million Yen and (%)	988,288 (12.0)	374,963 (31.7)	118,809
Birzai (1997) thousands litas and (%)	1,588.1 (55.3)	1,379.7 (63.7)	878.2

4.6.2.7 Unwillingness for Payment

Eighteen people out of fifty samples answered that they do not want to pay for fees of sewerage services and eight people think that fees should be shouldered by the government.

Table 4.28 Willingness to pay based on the questionnaire survey (50 samples)

	Sewerage	Fee for sewerage new connection
To be shouldered by government	8	1
Do not want to pay	18	2

4.6.3 Financial Aspects

4.6.3.1 Unclear Business Units

Financial analysis is based on the sharing of assumed indirect costs between the water and sewerage division. The cost sharing system for some business units that work for both the water and sewerage divisions, administration, and some of the other operational expenses need to be clearly defined.

4.6.3.2 Increase in Sales and Loss

Because the year 1997 was the only full accounting year since separation from the regional Water Company, exact comparison is not possible. But the sales of 1997 increased by 186 percent from the half year of 1996, mostly due to the increase of tariff and areas of service. The losses of 1997 increased by 352 percent from the half year of 1996 because the company has had to cover three sub-regions besides Birzai region, since 1996.

4.6.3.3 Profits of the Sewerage Division and Losses of the Water Division

In the Birzai area, some users, particularly industrial users, use a well for their supply of water. In this case, the user does not pay for the water used, but only pays for the charge for sewerage service. That is why the company had 58 percent of its sales from the sewerage division. The sewerage division made a profit on the operating basis while the water division had a large loss on the operating basis based on an assumption of sharing indirect costs between the water and sewerage division. The sewerage division has enough sales, almost 30 percent more than the breakeven point. The water division has to increase the sales by 52 percent to reach the breakeven point by the increase of the tariff.

4.7 FUTURE DEMAND FOR THE SEWERAGE SYSTEM

4.7.1 Design Year

The design year is set at the year 2010. This target is 12 years from the planning stage and considered suitable for the design horizon of the new facilities.

4.7.2 Service Area

The entire urban area is set as the service area for the proposed improvement plan of the sewerage system.

4.7.3 Planned Population and Sewage Amount

4.7.3.1 Population

Future population of the urban area of Birzai is projected using the growth ratio applied in the projection of country's population prepared by the Department of Statistics as presented in Section 2.3.3.2. Of three medium scenarios, the medium-3 scenario (medium-high) is adopted since it has a slight increase in the country's population and is on the safe side in the projection of the amount of sewage. Yearly growth rates of population are tabulated as follows:

Table 4.29 Yearly Population Growth Rate

Year	Country Total (% / year)	Urban Area (% / year)
1997-2000	-0.02%	-0.05%
2001	0.09%	0.24%
2002	0.16%	0.32%
2003	0.19%	0.34%
2004	0.21%	0.37%
2005	0.24%	0.39%
2006	0.27%	0.42%
2007	0.26%	0.39%
2008	0.24%	0.35%
2009	0.23%	0.32%
2010	0.23%	0.31%

Calculated from Population Projections of Lithuania (Medium-3), Department of Statistics, 1998

Applying the growth rates in the table above, population of Birzai town is calculated as follows:

Table 4.30 Projection of Urban Population

Year	Urban Population
1997	16,183
2000	16,176
2001	16,215
2002	16,266
2003	16,321
2004	16,381
2005	16,445
2006	16,514
2007	16,578
2008	16,637
2009	16,691
2010	16,742

4.7.3.2 Service Ratio and Population Served

As of 1997, the service ratio of water supply and sewerage expressed in population is 45.7 percent and 50.9 percent, respectively. The Water Company expects these figures to increase to 70 percent by 2010. Therefore, the population served by the water supply and sewerage would increase as calculated in table below.

Table 4.31 Projection of Population Served

Year	Water Supply		Sewerage	
	population served	service ratio	population served	service ratio
1997	7,400	45.7%	8,240	50.9%
2000	8,088	50%	8,897	55%
2005	9,867	60%	10,278	63%
2010	11,719	70%	11,719	70%

Population served = urban population x service ratio

4.7.3.3 Sewage Amount

Domestic Sewage

From the water supply data in 1996 and 1997, per capita water consumption was calculated at 197 l/cap/day (1996) and 158 l/cap/day (1997). It may be interpreted that the drop in consumption from 1996 to 1997 is because of the increase in water tariff. The Water Company anticipates that the people's attitude of saving water should continue and that the per capita consumption in 2010 will likely be lower than 1996 level.

For the projection of water consumption, increase in per capita consumption is therefore set at 160 and 180 l/cap/day for 2000 and 2010, respectively. It is assumed that 90 percent of the amount consumed is discharged into the sewers.

Water consumption at households not connected to the water supply system is considered the same as the figures above as such households have deep wells as a reliable source. Using the population served and unit water consumption, the amount of domestic sewage is calculated as follows:

Table 4.32 Projection of Domestic Sewage

Year	Population served	Per capita water consumption (l/cap/day)	Domestic Sewage (m^3/day)
1997	8,240	158	1,172
2000	8,897	160	1,281
2005	10,278	170	1,573
2010	11,719	180	1,900

domestic sewage = population served x per capita consumption x 90%

Industrial Wastewater

The present amount of industrial wastewater is 498 m^3/day as shown in Table 4.20. According to managers of the three major industries, there is no plan to expand the factory facilities at present or in the near future. Only Rinkuskiai (small brewery) has a plan for expansion of production facility and expects to increase the water consumption by 70 m^3/day.

It is therefore assumed that the amount of industrial wastewater will increase to about 565 m^3/day by 2010.

For the purpose of projection, 600 m^3/day is adopted as a rounded figure for industrial contribution of wastewater.

Infiltration

As discussed in Section 4.4.2.5, there is a substantial amount of infiltration that is estimated at approximately 1,500 to 1,700 m^3/day. Of course, the amount of infiltration should be reduced for effective use of the sewage collection and treatment facilities. How much should be invested for a leakage prevention program will need to be decided from the economical viewpoint comparing the cost of repair and reduction of the operation cost.

It is also practically impossible to determine the amount of infiltration reduction if such a mitigation program is implemented.

Considering that no measure will be taken for reducing the infiltration, 1,700 m^3/day is accounted for infiltration for projection.

Projected Amount of Sewage

From the discussion above, the amount of sewage is calculated as follows:

Table 4.33 Projection of Amount of Sewage (Daily Average Flow)

unit: m^3/day

Year	Domestic sewage	Industrial wastewater	Infiltration	Total Amount
2000	1,281	600	1,700	3,581
2005	1,573	600	1,700	3,873
2010	1,900	600	1,700	4,200

4.8 SEWERAGE SYSTEM IMPROVEMENT PLAN

4.8.1 Design Flow

The amount of sewage as a daily average basis is projected as shown in Section 4.7.3.3. The design of the sewerage facility also needs to incorporate the variation in sewage flow such as average daily flow, maximum daily flow, and peak hourly flow. These variations of sewage flow are defined as follows:

Daily average flow: The average flowrate occurring over a 24-hour period during a year.

Daily maximum flow: The maximum flowrate that occurs over a 24-hour period during a year.

Hourly peak flow: The peak sustained hourly flowrate occurring during a 24-hour period.

For determining the daily maximum flow, the variation in water consumption was analyzed for daily and seasonal pattern from the water production data that have been recorded daily. Figure 4.9 shows the historic data of water production at the filtration plant.

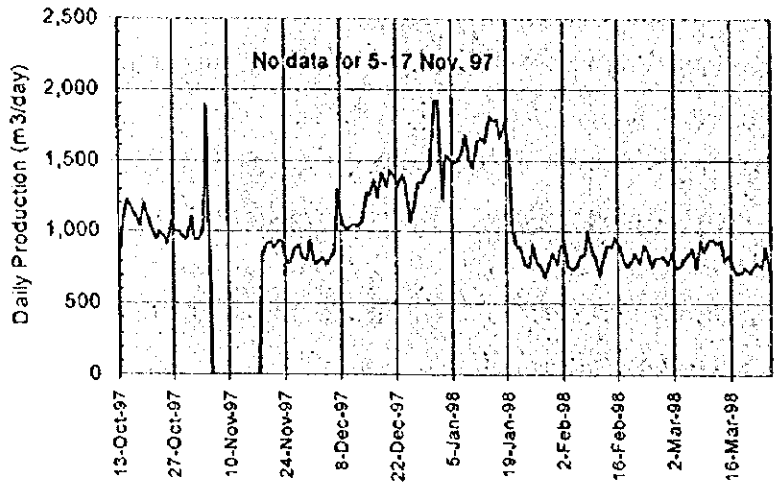


Figure 4.9 Daily Water Production Records

The drop in a total water production in January 1998 may be as a result of the increase in water tariff. The statistical analysis for each year is presented in Table 4.34.

Table 4.34 Statistical Analysis of Water Production

Item	1997	1998
Total Production (m^3/year)	72,969	158,169
Daily Average Production (m^3/day)	1,089	697
Absolutely Maximum Production (m^3/day)	1,923	1,020
Absolutely Minimum Production (m^3/day)	774	375
95 Percentile Production (m^3/day)	1,424	917
05 Percentile Production (m^3/day)	792	503
Ratio of 95 Percentile to Average	1.31	1.32
Ratio of 05 Percentile to Average	0.73	0.72

1997 data: 13 Oct. – 4 Nov., 18 Nov. – 31 Dec
1998 data: 1 Jan. –21 Jul.

As there are some unusually high and low figures in the data, 95-percentile and 5-percentile figures are calculated as shown. Ratios of the 95-percentile amount to the daily average amount range 1.31 to 1.32. The variation factor of the daily maximum flow is set at 1.35 for future planning.

Magnitude of the hourly peak flow depends on the pattern of water use in a day of the people. As a rule of thumb, a formula[1] is used as follows:

$$PF = 5/P^{1/6}$$

where,

PF: peaking factor relative to the daily average flow

P: number of the population served in thousand

Applying the formula above with the population served in Table 4.31, PF is calculated as follows:

$$PF = 5/P^{1/6} = 5 / (\approx 12)^{1/6} = 3.30$$

This factor is applied to the domestic sewage amount while the industrial wastewater and infiltration is considered stable. The hourly peak flow for 2010 is therefore calculated as follows:

$$Q_{hp} = 1{,}900/24 \times 3.30 + (500 + 360)/24 = 297 \text{ m}^3\text{/hour}$$

This flow is 2.58 and 1.85 times the daily average flow and daily maximum flow, respectively. Aside from the calculation based on the population, the flow measurement conducted in this study shows that there is no peak time in a day as presented in Section 4.4.2.5. This is because the variation of the sewage flow is absorbed in storage at the three pump stations so that the pumping amount of Pump Station No.2 to the treatment plant is almost level.

Actually, at Pump Station No.2 only one pump out of three units is running throughout a day. Running time ratio of the pump is 70 percent. The estimated amount of sewage in 1997 is also 70 percent of that in 2010. This means that the running time of one pump would simply reach about 100 percent in 2010 while absorbing the variation of sewage flow. The incoming flow at the treatment plant in 2010 is therefore expected to be steady at the discharge of one pump at Pump Station No.2 as observed in the flow measurement.

It may be possible to assume that there is no peak flow throughout the future. However, for safety of the system, a peak flow factor is defined, considering that the storage at the three pump stations cannot fully accommodate the variation. The peak factor is applied only for the domestic sewage since the peak flow of the domestic sewage and industrial wastewater unlikely occurs at same time. From the flow measurement in Skuodas, peak flow is observed around 22:00. Interviews with factory managers showed that the factories use water from 6:00 to 18:00. This means that the industrial wastewater has no influence on the peak flow at 22:00. Infiltration flow is assumed to be constant and have no peak flow.

These design flows are then summarized in Table 4.35.

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[1] Nicoll, E. "*Small Water Pollution Control Works: Design and practice*", John Wiley and Sons, 1988.

Table 4.35 Design Flow

	daily average flow Qda (m^3/day)	daily max flow Qdm (m^3/day)	hourly peak flow Qhp (m^3/day)
Domestic/Industrial sewage	2,500	3,300	5,230
Infiltration	1,700	1,700	1,700
Total	4,200	5,000	6,930
Ratio to daily average	1.00	1.20	1.65
Ratio to daily maximum	0.83	1.00	1.38

Qdm = Qda x 1.35 (for domestic sewage and industrial wastewater only)
Qhp = Qdm x 2.0 (for domestic sewage only)

4.8.2 Characteristics of Sewage and Population Equivalent

With the projected sewage amount and pollution load, characteristics of sewage is calculated using the per capita unit load (70 g-BOD_7/cap/day) as follows:

Table 4.36 Calculated BOD Load and Concentration

	Amount (m^3/day)	Population served	BOD_7 Load unit load (g/cap/day)	Total Load (kg/day)	BOD_7 (mg/l)	Population equivalent
Domestic Sewage	1,900	11,719	70	820		11,719
Industrial Wastewater						
Brewery Factory	100			70	700	1,000
Dairy Factory	300			150	500	2,143
Canned Food Factory	100			50	500	714
Other Industry	100			25	250	357
Infiltration	1,700			-	-	-
Total	4,200			1,115	260	15,933

Using the population equivalent calculated above, other pollution loads are calculated as follows:

Table 4.37 Calculated SS, Total-N and Total-P Loads and Concentrations

	SS	Total-N	Total-P
population equivalent	15,933	15,933	15,933
unit load (g/p.e./day)	70	12	2.7
total load (kg/day)	1,115	191	43
concentration (mg/l)	265	45	10.0

These calculated figures are compared with the water sampling and historical records to determine the final figures for the design. Comparison are summarized as follows:

Table 4.38 Design Loads and Concentrations

item	unit	design figures	Sampling Result				historical Record		by MOE norms
			Jul 28	Aug 6	Aug 13	Aug 20	average	95-percentile	
Sewage Flow	m^3/day	4,200	2,920	2,770	3,050	1,790	-	-	4,200
SS	mg/l	260	255	163	286	229	205	503	260
BOD7	mg/l	260	217	229	365	335	320	580	260
BOD5	mg/l	230	189	199	317	291	-	-	-
Soluble BOD7	mg/l	120	94	98	158	175	-	-	-
Soluble BOD5	mg/l	100	82	85	137	152	-	-	-
COD	mg/l	500	430	486	690	676	-	-	-
Total-N	mg/l	40	23	36	31	33	44	90	45
Total-P	mg/l	10	8.1	5.7	8.0	6.0	5	9	10

In the table above, the design figures are determined considering the following:

- Calculated concentrations of BOD_7 and suspended solids coincide with the water sampling result.
- Total-N in the water sampling results is low comparing with that calculated from the norm. This coincides with the water sampling result for the industrial wastewater, in which the nitrogen content in the industrial wastewater is relatively low comparing the BOD contents therein. Design figure is therefore set from the results of the water quality analysis.
- Historical records are based on the spot samples taken once a month and therefore they do not represent the daily average figure. These records are shown as reference.

4.8.3 Effluent Standards to be Applied

LAND 10-96 stipulates the effluent standards according to the population equivalent as discussed in Section 3.4.1.1. In this case with the population equivalent of more than 10,000 as calculated above, the effluent standard shall be as follows:

Table 4.39 Effluent Standard for Sewage Treatment

Pollutants	Permissible Concentration (mg/l)	
	Average annual concentration (Cave)	Maximum instantaneous concentration (Cmax)
BOD_7 (>10,000 PE)	15	25
COD (≥10,000 PE)	75	120
Total-P (≥10,000 PE)	1.5	2.5
Total-N (10,000 – 100,000 PE)	20	35
Suspended Solid (<100,000 PE)	30	45

In addition to these standards, a special requirement must be applied over the normal standards in Table 4.39 when the effluent is discharged into the Tatula River. This special requirement as shown in Table 4.40 was specified in the letter issued by the Ministry of Environment on July 16, 1997 addressed to the Mayor of Birzai Municipality. This special requirement was set primarily to protect the groundwater quality in the karst region.

Table 4.40 Special Standard for Effluent Discharged to the Tatula River

Pollutants	Permissible Concentration (mg/l)	
	Average annual concentration (Cave)	Maximum instantaneous concentration (Cmax)
BOD_7	4	8
Total-N	8	14
Total-P	1.0	1.5

4.8.4 Evaluation on the Existing Treatment Plant

The existing treatment system does not have sufficient capacity to treat the amount of sewage projected for 2010. Furthermore, it does not have a process to meet the required effluent standards for nutrients (N and P).

If the existing treatment plant is to be used, it will require modifications as follows (see Section 4.4.1.3):

- increase the capacity for suspended solid (SS) removal

  Sedimentation tanks will require to be doubled in area. The structure of the sedimentation tanks must be modified to achieve a smooth flow regime and to prevent turbulence.

- increase the capacity and efficiency of BOD removal

  Due to its design, the existing biological filter is expected to remove only 70 percent of the BOD_7 which would lead to an effluent quality of 20 mg/l of BOD_7. As this plant is discharging effluent to the Tatula River, the special standards (BOD_7 = 4 mg/l) would be applied if a new system is constructed.

- install a nutrient removal system (N and P)

  To meet the requirements for nitrogen and phosphorous removal, new processes must be introduced. As well as BOD removal, the special standard for the Tatula River will require a high level of treatment.

It is apparent from the discussion above, the existing treatment plant will need substantial reconstruction. It is therefore recommended that the existing treatment plant be abandoned. The decision on whether the new treatment plant be constructed at this site will be discussed in later sections.

4.8.5 Evaluation on the Design of the Partly Constructed Treatment Plant

4.8.5.1 Previous Design of the Treatment Plant

1) General

Detailed design of the new Sewage Treatment Plant of Biržai was prepared by a local company Ekoprojektas in 1994. The biological treatment system is a process so-called A2O System that is designed to remove organic substances, nitrogen and phosphorous.

For biological removal of nitrogen and phosphorus, the reaction tank is split into three zones - anaerobic (A), anoxic (A) and aerobic (O) zones. No chemical treatment process was incorporated to remove phosphorus.

2) Treatment Facilities

Primary Sedimentation Tank

Three sedimentation tanks are provided after the grit removal facility for removal of suspended solid and organic substances included in the suspended solids.

Reaction Tank

Three reaction tanks are provided after the primary sedimentation tanks. Each reaction tank has an anaerobic compartment with a separation wall immediately after the inlet. In the design, 200 percent of the design flow is recycled into this chamber from the aerobic zone. This compartment has a function of releasing phosphorous from the sludge under the anaerobic environment so that the released phosphorous can be taken up by microorganisms in the aerobic stage thereafter.

Other parts of the tank have no separation wall, but are split into two zones: namely, anoxic zone and aerobic zone. The anoxic zone is a channel equipped with a series of submergible mixers to keep solids in suspension. Denitrification occurs while the liquid is flowing through the anoxic zone.

In the aerobic zone, 684 membrane disc diffusers are installed at the bottom of the tank to provide the 4,349 m^3/h of air. The air supply system is designed with automatic control with a DO-meter installed in each aeration tank.

Final Sedimentation Tank

Three square shaped sedimentation tanks are provided after the reaction tank. Each tank is equipped with mechanical sludge scrapers.

Aerated Lagoon

Two aerated lagoons are provided to receive the effluent from the final sedimentation tanks. The lagoon is an earth dike structure with bottom lining to prevent the seepage of water into the groundwater. The lagoon is designed to have aeration pipes with blowers.

Polishing Pond

After the aerated lagoon, a polishing pond is provided to further upgrade the quality of the effluent. The structure is the same as the aerated lagoon.

The aerated lagoon and polishing pond are also designed to treat the sewage in case of emergency in which the main reaction tank is inoperable.

Disinfection

The disinfection tank is designed to inject chlorine at 3.0 mg/l into the effluent of the polishing pond. A building is provided to house the chlorination equipment of 1.3 kg/hr injection capacity.

Sludge Lagoon

Two sludge lagoons are provided to store the excess sludge and finally to reduce water contents in the sludge for easy handling in final disposal. The lagoon was proposed to reduce construction and maintenance costs compared with the mechanical dewatering devices.

The whole amount of sludge drained from the final sedimentation tanks is first collected in a sludge holding tank. The stored sludge was to be recycled by pump to the biological reaction tank as return sludge while the excess sludge is drained by gravity to the sludge lagoon.

Drainage

Wastewater discharged from the administration building or the supernatant from the sludge lagoon and sand lagoon is collected into the internal pumping station and then returned to the inlet.

Pipe Materials

The detailed design specifies the pipe materials for in-plant piping as cast iron, PVC and steel.

Building

An administration building is provided to house the central control room, transformer room, sludge dewatering room, blower room and office.

Construction materials

Pre-cast concrete sheets named KVK-LI-77 were proposed for the structural walls. This is the standard practice in Lithuania.

3) Design Flow and Quality of Sewage and Effluent

Design flow and quality of sewage and effluent employed in the detailed design are summarized as follows:

Table 4.41 Design Flow

Item	First Stage	Total Capacity
Daily Average	5,000 m^3/day	10,000 m^3/day
Hourly Maximum	420 m^3/hr	750 m^3/hr
Hourly Average	208 m^3/hr	416 m^3/hr
Secondly Maximum	0.117 m^3/sec	0.208 m^3/sec

Table 4.42 Quality of Sewage and Effluent

Item	Influent	Total Lord (kg/day)		Effluent (mg/l)
		First Stage	Total Capacity	
BOD_5	380 mg/l	1,900	3,800	6
Suspended Solid	282 mg/l	1,410	2,820	10
Total-N	45.0 mg/l	225	450	12 (yearly ave.)
Total-P	6.3 mg/l	31.5	63.0	1.5 (yearly ave.)
Temperature	12–15°C	NA	NA	NA

Table 4.43 Removal Ratio of Pollutants

Process	BOD_5	SS	T-N	T-P
Pre-treatment	380 → 266mg/l	282 → 141mg/l	45.0mg/l	6.3mg/l
A2O Reaction Tank	266 → 15mg/l 30 - 50 %	141 → 12mg/l 50%	not specified	not specified
Aerated Lagoon/ Facultative Lagoon	15 → 6mg/l	12 → 10mg/l	-	-

4) Block Flow Diagram

Flow diagram of the treatment plant is shown as follows:

5) Dimension and Specification of Major Facilities

Major treatment facilities in the detailed design have dimension and specifications as shown in Table 4.44.

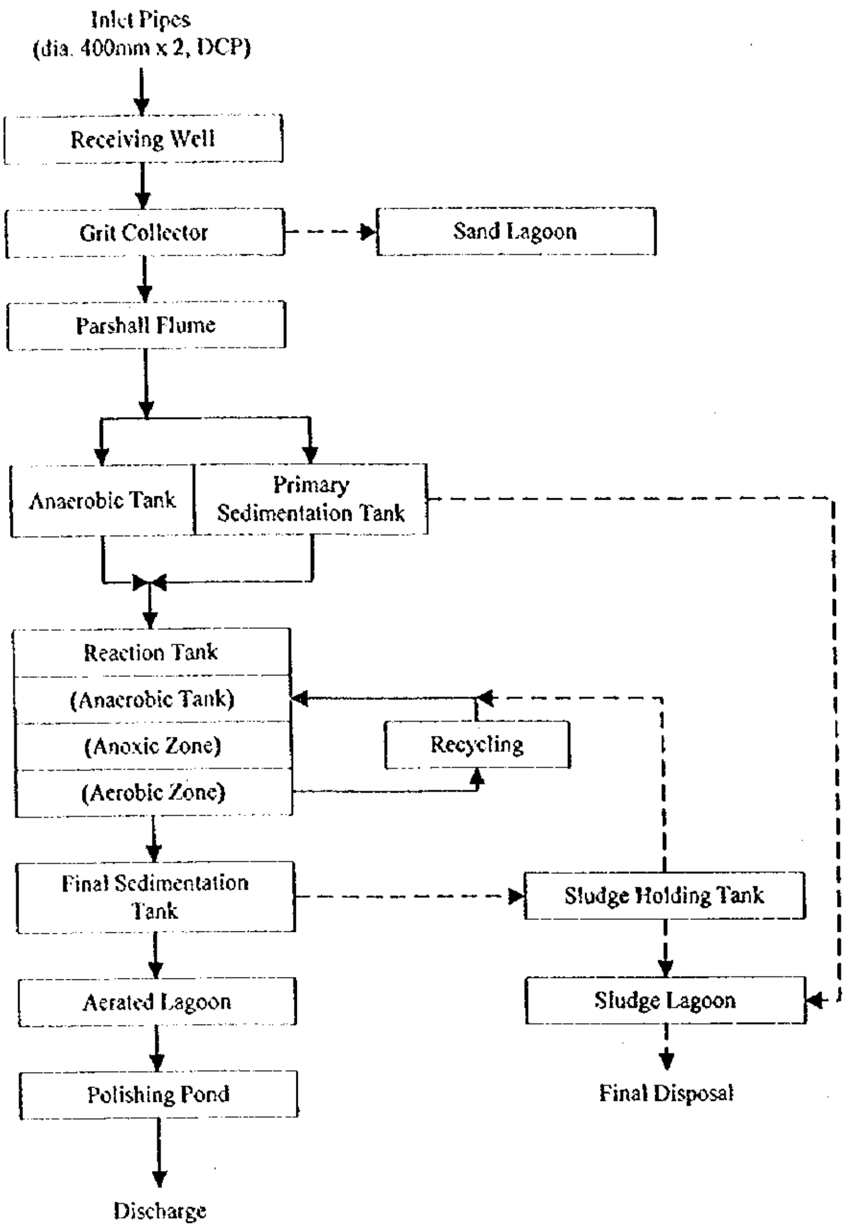


Figure 4.10 Flow Diagram of the Treatment System

Table 4.44 Dimension and Specification of Major Facilities

Equipment		No.	Dimension/Specification	Notes
Receiving Well		1	L5.5 m×W2.5 m×H1.8 m, v = 5.5 m^3	
Sand Collector		2	dia. 4.0m × D3.45 m Water content = 60%	(1) tank for 5,000 m^3/d, 48.8 m^3/unit
Incoming Sewage Measuring Flume		2	L2.6 m×W0.6 m×H0.9m	
Anaerobic Reactor	Primary Sedimentation Tank	3	L8.8 m×W8.8 m×H9.63 m v = 351 m^3/unit Water content = 95% Retention time = 2.6 hour	In case of high load, either system can be utilized.
	Anaerobic Tank	1	L8.8 m×W8.8 m×H9.63 m v = 351 m^3/unit Concentrated sludge rate is 15-20g/l Retention time 2.6 hour	
Reaction Tank	Anaerobic Tank	3	L4.8 m×W5.8 m×H5.77 m v = 139 m^3/unit	Receiving return sludge
	Anoxic Tank	3	L54.7 m×W5.8 m×H5.77 m v = 1,583 m^3/unit	Submerged mixers: (2.5 kw×6)×3
	Aerobic Tank	3	L29.8 m×W5.8 m×H5.77 m Circulating pump: 140 m^3/h×H2.65 m×2.8 kw×1 Membrane disc diffusers(228/each) ×3, 864 m^3/uit	
Final Sedimentation Tank		6	L8.8 m×W8.8 m×H9.75 m Surface load 1.08m^3/m^2/hr v = 601m^3/unit	
Aerated Lagoon		2	L(100-110.8) m×W(40-45.5) m×H3.6m ×1 unit, v = 12,291.3 m^3/unit L(100-110.8) m×W40 m×H3.6 m×1 unit v = 11,670.4 m^3/unit	Aeration through perforated PVC pipes
Polishing Pond		1	L(100-110.8) m×W(40-45.5) m×H3.6m v = 6,308.9m^3 Discharge pump: 208 m^3/hr×H22 m×22 kw×2 (1 stand-by)	
Activated Sludge Holding Tank		1	W6.0 m×L6.0 m×H3.65 m, v = 104.4m^3 Sludge pump: 115m^3/hr×H6.6 m×4.2 kw×2 (1 stand-by)	Excess sludge (4.4m^3/hr) Return sludge (110m^3/hr)
Internal Pumping Station		1	dia. 3.0 m×H4.65 m Transfer pump: 20m^3/hr×H10.8 m×2.15 kw×2 (1 stand-by)	
Sand Lagoon		2	L(24-30) m×W(12-15) m×H2.0 m v = 518m^3/unit	
Sludge Lagoon		8	L34.8 m×W25.0 m×H2.0 m×4 units v = 5,230.4m^3/unit L34.8 m×W25.0 m×H2.5 m×4 units v = 6,799.6m^3/unit	
Administration Building		1	Single story building Floor area = 1,055 m^2 Blower: 1,125-2,500m^3/hr ×1,563bar×55kw×3 (1stand-by)	
Disinfection Equipment		1	Chlorinator 1.3kg/hr Use 1.5kg/hr capacity mobile cars	
Deep Well for Utility Water		1	Well pump: 10m^3/hr.×H10 m×2.8kw×1 W 2.1m^3 of elevated tank	

4.8.5.2 Construction Cost Estimates

Cost estimates prepared in 1994 by Ekoprojektas show that the total construction cost is 9.76 million litas broken down as below:

Table 4.45 Cost Estimates of the Treatment Plant Construction

No.	Name of Facility	Estimation Cost (Litas)		Total
		Civil Work	Equipment	
1	Receiving Tank	22,243	0	22,243
2	Grit Chamber	57,865	0	57,865
3	Flow Measurement Flume	15,153	57,226	72,379
4	Primary Sedimentation Tank/Anaerobic Tank	625,015	0	625,015
5	Biological Reaction Tank/Final Sedimentation Tank	3,073,159	366,659	3,439,818
6	Aerated Lagoon/Polishing Pond	1,358,989	69,460	1,428,449
7	Sludge Holding Tank	69,190	18,004	87,194
8	Sand Lagoon	104,776	0	104,776
9	Sludge Lagoon	1,280,745	0	1,280,745
10	Internal Pumping Station	67,126	12,974	80,100
11	Air Blower	949,849	1,575,637	2,525,486
13	Main Building	30,914	5,700	36,614
Total		7,655,024	2,105,660	9,760,684

Source: Ekoprojektas Cost Estimates
Cost is based on the 1994 price.

The civil contract for the treatment plant construction was awarded to a local contractor in Panevėžys while the tendering for the mechanical and electrical equipment was not carried out. Parts of the biological reaction tank and final sedimentation tank have been constructed by the civil work contractor. Completed works include the foundation work, construction of the base slab, and installation of pre-cast concrete panels for walls.

Cost of the civil work for the biological reaction tank was estimated at about 3 million Litas in the table above. The portion constructed is estimated at about 70 to 80 percent of the total cost. Therefore, the constructed portion is accounted of 2.1 to 2.4 million Litas value.

4.8.5.3 Evaluation of the Previous Detailed Design

The previously prepared detailed design was carefully reviewed since the construction was carried out partly for the reaction tanks which is the main structure. Economic value of the treatment plant is also taken into consideration. The results of evaluation is summarized as follows:

Design Basis and Treatment Process

- Design flow of the previous design (5,000 m^3/day) coincides the daily maximum flow of 2010 projected in this study.
- It is reasonable that the previous detailed design incorporated the removal process of nitrogen and phosphorous. This concept meets the requirement of the latest effluent standards in Lithuania.
- Sludge lagoon is not recommended. Phosphorous will be released from the settled sludge into the supernatant under anaerobic condition. The supernatant with high phosphorous content will then be returned to the sewage treatment process and it will adversely affect the efficiency of phosphorous removal in the entire treatment system.
- Aerated lagoon and polishing pond may not be required if the reaction tank and recycling of liquid and sludge is properly designed to remove organic substances (BOD) as well as nutrients.
- It is recommended that primary sedimentation tanks not be provided since the influent pollution load is not high and the biological reaction tanks will be able to handle the organic load.

Design of Structure

- The reaction tanks that have been partly constructed have sufficient volume to remove BOD, nitrogen and phosphorous. This structure could be used as a reaction tank with minimum modification.
- The final sedimentation tanks are rectangular (8.9 m square) with 45 degree hopper at its bottom. No sludge scraper or sludge extraction pump is provided in the original design. Sludge settled is to be removed by gravity. The shape and sludge removal system is not appropriate since it would make it difficult to extract sludge constantly and evenly from each of the six tanks.

  It is therefore recommended to construct two new circular sedimentation tanks with sludge scrapers and sludge pumps. It is further proposed that the existing structure of the sedimentation tanks be converted to an equipment room that will accommodate the following equipment:

  - Blowers
  - Return sludge pumps and excess sludge pumps
  - Chemical feeding equipment

  With this arrangement, the existing structure will be fully used for the new treatment system.

Basically, the invested cost of more than 2 million litas should not be disregarded by abandoning the constructed facilities unless it fails to meet the treatment requirements. As evaluated above, the previous design can be used with some modifications as detailed above.

4.8.6 Improvement Plan for the Sewage Collection System

As the capacity of each pump station is sufficient for pumping the amount of sewage, no major improvement will be required. Only improvements needed are as follows:

- To expand the existing monitoring system (for Pump Stations No.2 and No.4) to cover Pump Stations No.1 and No.3. The Water Company wishes to have this system so that the entire pumping system could be monitored at the head office building.
- To repair the leaks in the walls of each Pump Station. Fine cracks in the wall should be chipped and filled with a suitable sealing material.

4.8.7 Improvement Plan for the Treatment System

4.8.7.1 Discharge Point Alternatives

As discussed in Section 4.8.1, two options must be considered for effluent standards depending on where the effluent is finally discharged. For the site of a proposed treatment plant, there are two alternatives: namely, using the existing old treatment plant site (hereinafter called site No.1) or using the site for the incompleted new treatment plant (hereinafter called site No.2).

Effluent may be discharged to the following surface waters:

- Tatula River (through the Juodupe River)
- Obelaukias River
- Agluona River
- Apascia River

The Obelaukias River is a small tributary of the Roveja River. It flows bypassing the Birzai Town to the east. The Roveja River then flows into the Apascia River about 5 km downstream of the Sirvenos Lake. The Obelaukias River flows in the eastern end of the karst area. The course of the Roveja River coincides with the boundary line of the karst area along the east side of the Birzai Town. The 1994 design of Ekoprojektas is based on the discharge into the Obelaukias River. A 7km long transmission pipeline was proposed to discharge the effluent into the Obelaukias River by pumping. This option seems to have been selected as a reasonable option with the least impact on the karst area.

Both the Agluona River and Apascia River flow down through the Birzai Town into the Sirvenos Lake that is located less than 4 km from the treatment plant site No.2. Discharge of the effluent into these two rivers will therefore mean the discharge of effluent into the lake. The environmental impact will be serious if the effluent is discharged into these rivers since the downstream lake is a sensitive area and must be free from risk of eutrophication. A high level of treatment will likely be required if the effluent flows into the lake.

Considering the combination of the treatment plant sites and discharge points, the possible alternatives and their comparison are summarized in the table below.

Table 4.46 Comparison of Discharge Alternatives

Alternative	Surface water	Treatment plant site	Discharge pipe length (m)	Discharge pumping	Remark
1	Tatula River (via Juodupe River)	No.1	less than 50 m	no	STP has an impact on karst area
2		No.2	2.0 km	no	less impact on karst area
3	Obelaukias River	No.2	7.0 km	yes	
4	Agluona River	No.2	less than 50 m	no	heavy impact on the lake
5	Apascia River	No.2	2.5 km	no	

Treatment plant site No.1: near the existing treatment plant
Treatment plant site No.2: site for the new treatment plant

For the options above, important points are discussed as follows:

Site for Alternative 1

In the preparation of the previous design for the new treatment plant, the area around the existing treatment plant (Site No.1) had been considered as an alternative. Objection to the use of this location was made by the Geological Service of Lithuania because the area is located in the karst area.

It should be noted that selection of this site leads to abandoning the previously constructed facilities for the new treatment plant. Such facilities to be abandoned are the dual 400 mm transmission pipes (ductile iron, dia. 400 mm, total length 4,000 m), biological reaction tanks, and sedimentation tanks. The total cost invested for construction of these facilities is approximately 8 million litas. Disregarding such investment should be considered inappropriate in terms of financial, economic and political aspects.

Alternative 1 above is therefore not recommended.

Treatment for Discharge to the Tatula River

In Alternatives 1 and 2 above, a tertiary treatment will be required to further reduce BOD and Total-N to meet the requirements in Table 4.40.

Discharge to the Sirvenos Lake

Alternatives 4 and 5 will have a heavy impact on the Sirvenos Lake water in terms of risk of eutrophication. Currently, water quality in the lake shows signs of pollution as follows:

Table 4.47 Water Quality of Sirvenos Lake

unit: mg/l

Location	BOD_7	Total-N	Total-P
Southern side (upstream)	5.90 6.95	5.58 5.19	0.85 0.15
Northern side (downstream)	1.07 0.91	2.02 1.15	0.19 0.032

Source: water sampling and analysis by the JICA Study Team
figures (up): sampled on July 27, 1998
figures (down): sampled on August 20, 1998

Water upstream is apparently polluted by incoming water of the Rivers of Apascia and Agluona. Water downstream shows low levels of pollution that may be brought about by dispersion and natural purification process in the lake water.

Although the extent of the environmental impact caused by discharge of the effluent from the sewage treatment plant could not be immediately examined, it will definitely add a pollution load over the present level. From the viewpoint of protection of the lake water, discharge of the effluent from the sewage treatment plant into the lake should be discouraged. Alternatives 4 and 5 will therefore be excluded from the detailed comparison for the combination of discharge point and treatment method.

Conclusion for Alternatives

Considering the discussion above, the possible combinations of the discharge point and treatment method are limited only for alternatives 2 and 3. These two alternatives are acceptable in terms of technical aspects, and are proposed as Options 1 and 2 as follows:

Option 1: Effluent to be discharged to the Juodupe River after treatment by a tertiary treatment process.

Option 2: Effluent to be discharged to the Obelaukias River after treatment by secondary treatment process.

Detailed comparison between these options is discussed in Section 4.8.8.

4.8.7.2 Discharge Pipe Routing for Options 1 and 2

For Option 1, a new discharge pipe is proposed to be laid from the new treatment plant to the Juodupe River. The existing discharge pipe is defective and needs to be reconstructed. Proposed routing of the discharge pipe is shown in Figure 4.11. The route of the pipeline was chosen along the existing road except for a river crossing and about 400 m that passes through agricultural land.

For Option 2, a detailed design was prepared in 1994 for a 7 km discharge pipeline.

Figure 4.11

Discharge Pipeline Routing for Option 1

4.8.7.3 Sewage Treatment Method

Secondary Treatment

As discussed previously in Section 4.8.5.3, the existing structures at the new treatment plant site can be used with some modifications and operated in an anaerobic-anoxic-aerobic operation mode (referred to as A2O).

For comparison of treatment method, an oxidation ditch process is proposed as the most feasible and economical alternative. Comparison between the alternatives is summarized as follows:

Alternative 1: To complete the existing structures and use them for the originally designed system with necessary modifications.

Alternative 2: To construct new biological reaction tanks for the oxidation ditch.

The cost comparison based on a preliminary design is summarized as follows.

Facility	Alternative 1(A2O) (litas '000)	Alternative 2 (OD) (litas '000)
Inlet Works	28	28
Reaction Tank	139	2,476
Final Sedimentation Tank	561	561
Equipment/pump room	127	102
Sludge Treatment	320	320
Sludge storage yard	483	483
Administration building	588	588
M-E Equipment (70% of civil)	4,550	4,182
Others (road, site development etc.)	862	814
Total	7,658	9,553

The difference in the total construction cost is apparently derived from the cost for the reaction tanks. Considering that the originally designed system is appropriate and completion of the structures is more economical than constructing the new system, Alternative 1 is recommended.

Tertiary Treatment

The effluent standard set for the Tatula River requires a high level of BOD removal. A sand filter and a biological membrane filter are the two possible options that are commonly applied for the tertiary treatment for the effluent of the secondary biological treatment.

The sand filter is similar to that used in the drinking water treatment. The biological membrane filter consists of a filter media and aeration system. There are several types of material for the filter media such as small plastic pieces in various shape, anthracite, etc. Microorganisms develop on the surface of the filter media.

Comparison of treatment performance of these two methods is presented in Table 4.48. The sand filter is normally used for removal of suspended solid while the biological membrane filter is used where higher removal is required for BOD. Nitrogen removal by the biological membrane filter is said to be relatively better than that by the sand filter.

To meet the requirement of the BOD level, the biological membrane filter is recommended.

Table 4.48 Treatment Performance of Tertiary Treatment Methods

Item	Sand Filter (mg/l)	Biological Membrane Filter (mg/l)
BOD_5	4 – 5	3 - 5
BOD_7	5 – 6	3 - 6
SS	6 – 8	6 - 8
Total-N	5 – 10	4 - 9
Total-P	<1.0*	<1.0*

* Total-P removed by chemical coagulation
$BOD_7 = BOD_5 \times 1.15$

4.8.7.4 Sludge Treatment and Disposal

In Lithuania, sludge disposal is restricted as stipulated in the Ministry Order LAND 20-96 as described in Section 3.5.1.2. In that, use of sludge produced from the sewage treatment plant is strictly restricted in the karst region. Only the sludge meeting Category I requirement is allowed to be used for fertilizing the intensive karst area in which Birzai is situated. In the existing treatment plant, sludge is extracted from the sedimentation tanks and stabilization pond and is just stored in a pond in the site. When the pond becomes full, another pond will be excavated to store the excess sludge. Because of the absence of a dewatering device, sludge has a high water content and is difficult to transport.

The Water Company intended to process the sludge by a composting method using a composting machine purchased by a private company in Birzai. In such a case, it is speculated that the sludge could be transferred after composting, to outside the karst area for fertilizing the agricultural area. The composting machine has a treatment capacity of 14 m^3/day that is sufficient to treat the sludge produced in the proposed treatment plant.

In the new treatment plant, it is proposed that a mechanical dewatering machine be provided to reduce the water content in sludge below 85 percent so that transportation will be easier. A decanter (centrifuge) type dewatering is selected as a suitable method due to its high efficiency and ease of operation. Prior to dewatering, a gravity thickening process will be provided to reduce the water contents from about 99.4 percent to 98 percent.

4.8.8 Comparison of Options

As discussed in Section 4.8.7.1, Options 1 and 2 are compared in detail taking into account the construction and operation costs. Layout and profiles for the two options are shown in Figure 4.12 to Figure 4.14. Results of the comparison are summarized in the table below:

Table 4.49 Summary of Detailed Comparison

OPTION	1 (Tatula via Juodupe)		2 (Obelaukias)	
Receiving Water	Tatula (via Juodupe)		Obelaukias	
Location of Treatment Plant	No.2 (at the New Treatment Plant Site)			
Effluent Standard as Annual Average (mg/l)				
BOD_7	4		15	
SS	30		30	
COD	75		75	
Total-N	8		20	
Total-P	1.0		1.5	
Treatment Facility				
Secondary treatment	A2O		A2O	
Tertiary treatment	Biological Membrane Filter		N/A	
Sludge Treatment	thickening, dewatering, storage			
Expected Effluent Quality at the Best Operation Practice				
BOD7	3 – 6		7 - 10	
Total-N	4 – 9		5 - 10	
Total-P	< 1.0*		< 1.0*	
Discharge pipe				
pipe material	reinforced concrete		ductile iron	
length (m)	3,250		7,000	
dia. (mm)	400		300	
Discharge pump	no		yes	
Economic Comparison				
Construction Cost ('000 litas)	9,964		15,111	
secondary treatment		7,689		7,689
tertiary treatment		1,300		-
influent transmission pipe		-		-
discharge pipe		975		7,325
discharge pump		-		97
Operation Cost ('000 litas/year)	178		212	
secondary treatment		156		156
tertiary treatment		22		-
discharge pumping		-		56
Total Cost in NPV** ('000 litas)	11,215		16,303	

* Phosphorous removal is achieved by chemical coagulation.
** NPV: Net Present Value for 25 years operation, discount rate = 5 %/year

Option 1 is more economical than Option 2 in terms of both the construction and operation costs as shown above. Option 1 however needs careful operation of the tertiary treatment process to meet the special requirement for the Tatula River. In terms of operation of the treatment plant, Option 2 will be less sensitive because of its simplicity of treatment process and less strict effluent standard.

Option 1 is recommended for its economical advantage provided that the Water Company is confident to operate the tertiary treatment system. Option 2 is still considered as a possible option due to ease of operation in case that the financial disadvantage can be overcome. These two schemes are proposed as possible options so that the Water Company and Ministry of Environment will make a final decision including the review of the special effluent standard for the Tatula River.

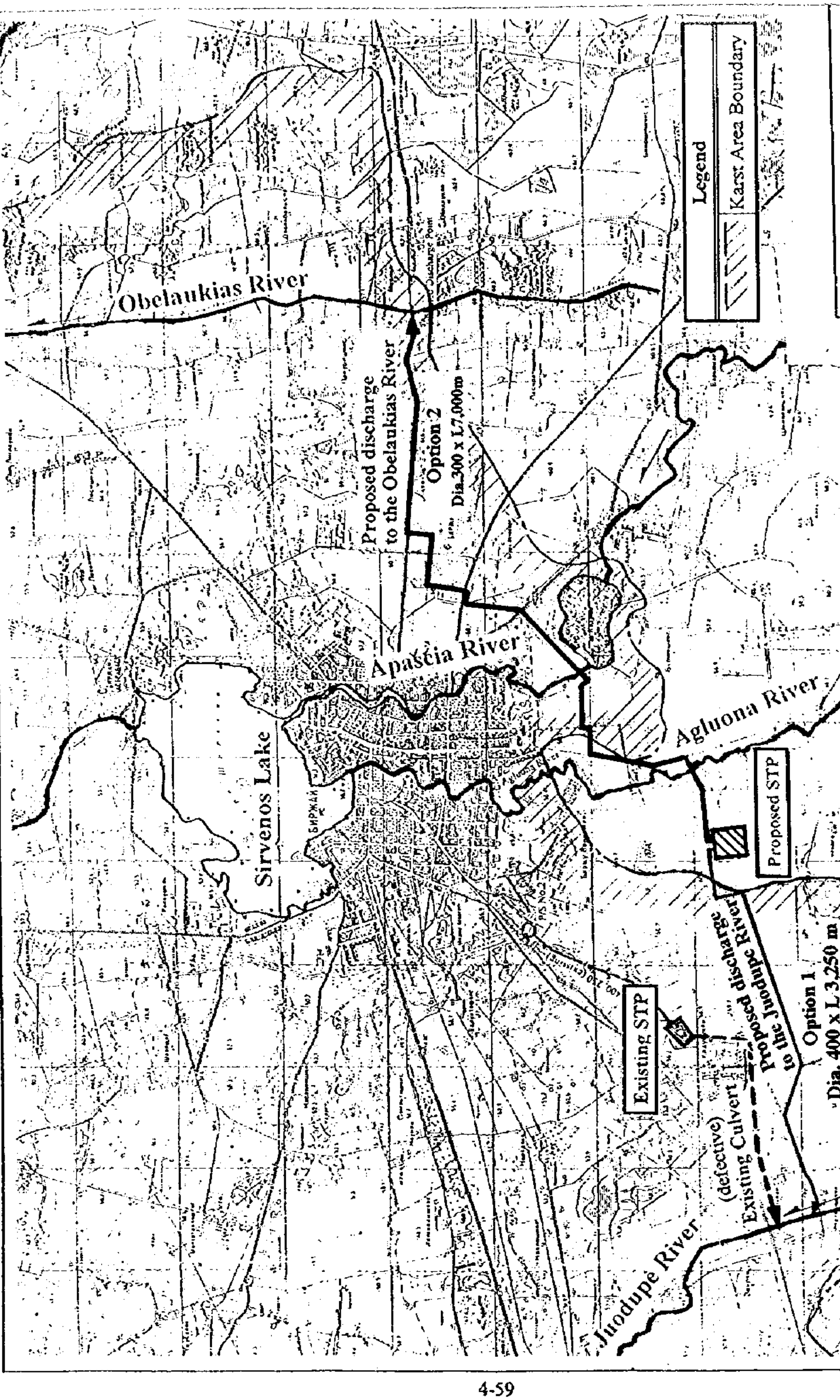


Figure 4.12
Layout of Two Options

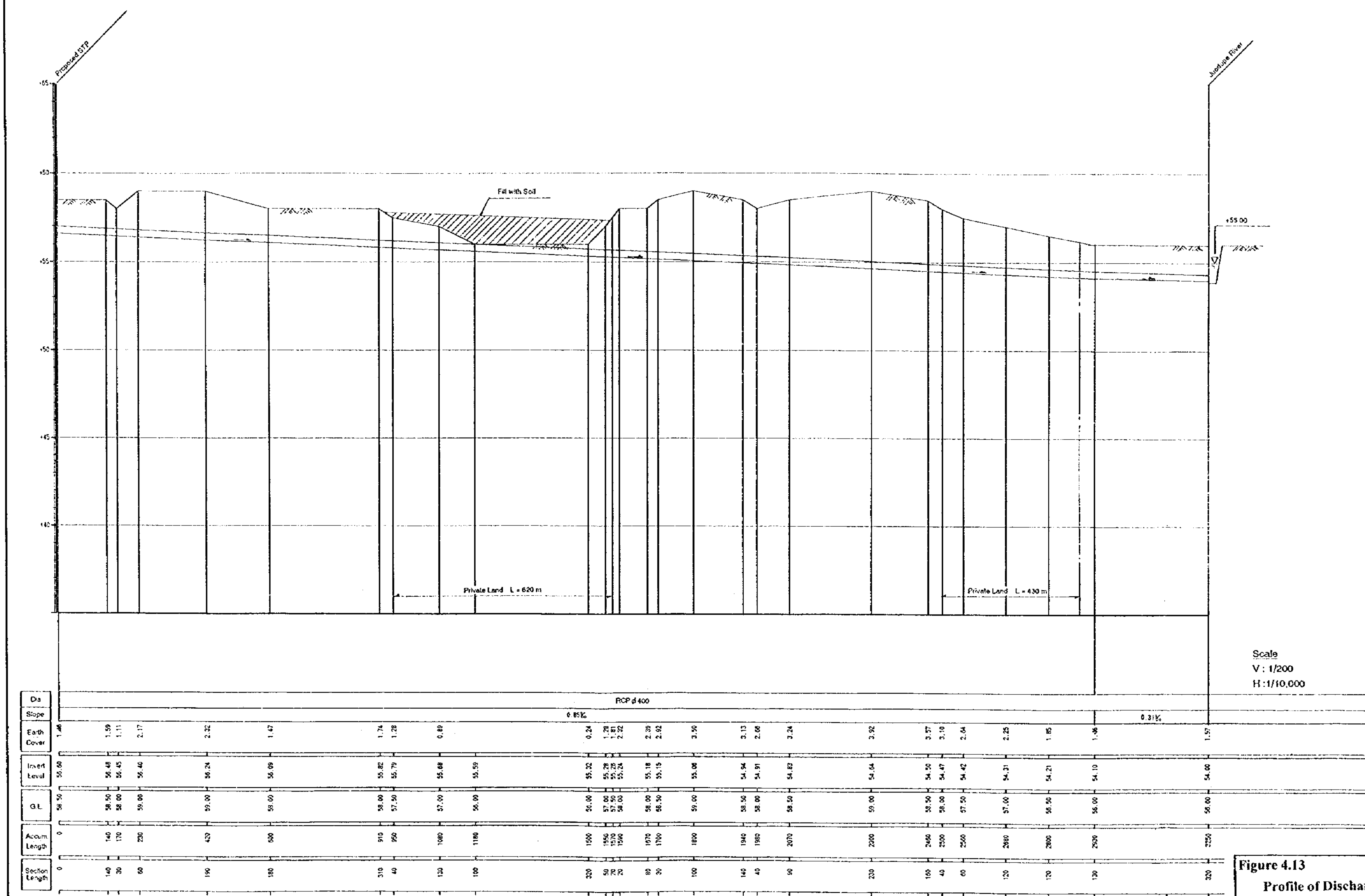
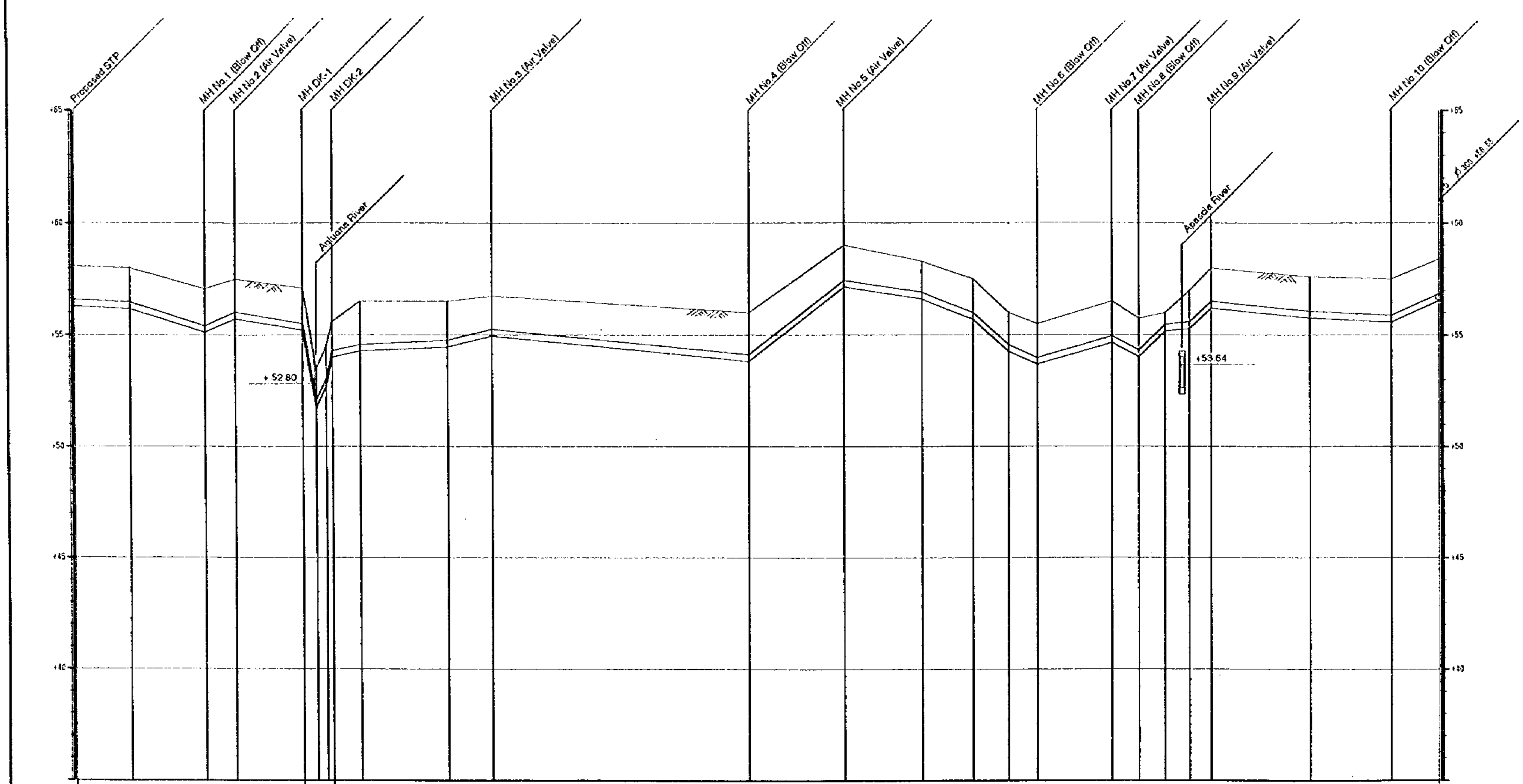


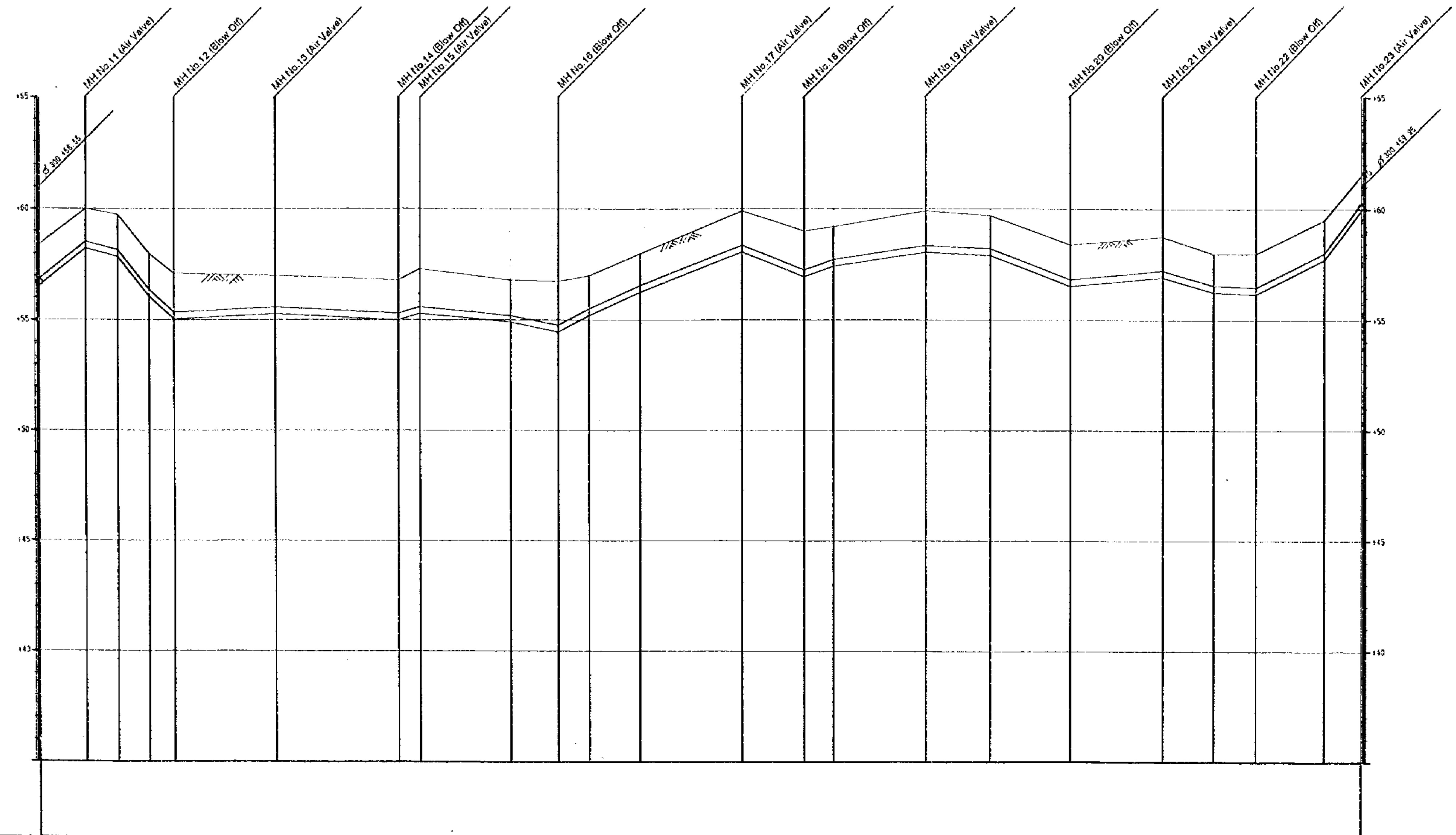
Figure 4.13
Profile of Discharge Pipe for Options 1



Dia.	Earth Cover	Invert Level	G.L.	Accum Length	Section Length
DCIP φ300	1.48	56.29	58.08	0.0	0.0
	1.52	56.17	58.00	124.0	124.0
	1.64	55.12	57.07	291.0	167.0
	1.46	55.73	57.50	359.0	68.0
DCIP φ325 x 2	1.57	55.22	57.10	512.5	153.5
	1.54	51.76	53.50	542.5	30.0
	1.40	52.71	54.50	564.5	22.0
	1.45 1.26 1.29	54.00	55.60	577.5	13.0
DCIP φ300	1.92	54.27	56.50	640.5	63.0
	1.73	54.48	56.50	834.5	194.0
	1.48	54.96	56.75	933.5	99.0
	1.87	53.82	56.00	1503.5	570.0
	1.55	57.14	59.00	1717.5	214.0
	1.37	56.62	58.30	1890.5	173.0
	1.49	55.70	57.50	2005.5	115.0
	1.43	54.28	56.00	2085.5	80.0
	1.51	53.68	55.50	2149.5	64.0
	1.53	54.60	56.50	2313.5	164.0
	1.42	54.02	55.75	2371.5	58.0
	0.51	55.18	56.00	2430.5	59.0
	1.40	55.29	57.00	2485.5	55.0
	1.49	56.20	58.00	2533.5	48.0
	1.53	55.76	57.60	2754.5	221.0
	1.61	55.58	57.50	2933.5	179.0
	1.54	56.55	58.40	3041.5	108.0

Scale
H : 1/200
V : 1/10,000

Figure 4.14
Profile of Discharge Pipe for Options 2 (1of 3)



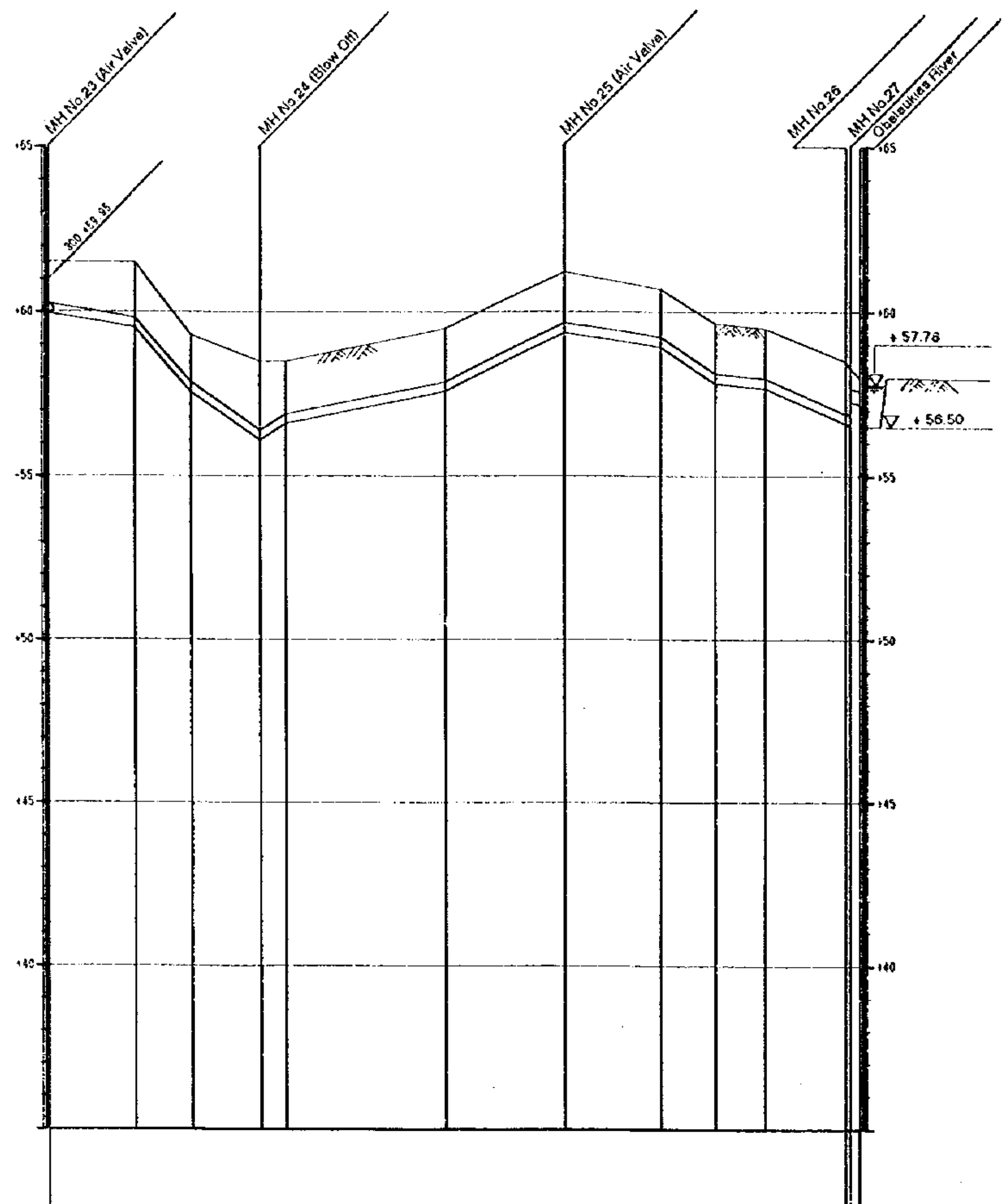
Dia.	DCIP ø300							
Earth Cover	1.54	1.46	1.57	1.62	1.75	1.42	1.50	1.69
Invert Level	56.55	58.23	57.87	56.07	55.04	55.27	54.99	55.30
GL	58.40	60.00	59.75	58.00	57.10	57.00	56.80	57.30
Accum. Length	3041.5	3146.5	3218.5	3290.5	3347.5	3574.5	3854.5	3902.5
Section Length	0.0	105.0	72.0	72.0	57.0	227.0	280.0	48.0

Dia.								
Earth Cover	1.59	1.97	1.48	1.44	1.53	1.74	1.46	1.54
Invert Level	54.90	54.47	55.21	56.25	58.06	56.95	57.42	58.05
GL	56.90	56.75	57.00	58.00	59.90	59.00	59.19	59.99
Accum. Length	4102.5	4210.5	4280.5	4395.5	4621.5	4760.5	4824.5	5033.5
Section Length	200.0	108.0	70.0	115.0	226.0	139.0	64.0	209.0

Dia.							
Earth Cover	1.48	1.57	1.51	1.43	1.52	1.47	1.24
Invert Level	57.91	56.52	56.93	56.26	56.17	57.72	59.95
GL	59.70	58.40	58.75	58.00	58.00	59.50	61.50
Accum. Length	5176.5	5357.5	5563.5	5675.5	5769.5	5924.5	6008.5
Section Length	143.0	181.0	206.0	112.0	94.0	155.0	84.0

Scale
H : 1/200
V : 1/10,000

Figure 4.14
Profile of Discharge Pipe for Options 2 (2 of 3)



Dia.	DCIP ϕ300											DCIP ϕ400 / DCIP ϕ325
Earth Cover	1.24	1.67	1.43	2.09	1.59	1.61	1.52	1.45	1.52	1.52		1.59 1.56 1.42 0.63 0.39
Invert Level	59.95	59.52	57.56	56.10	56.60	57.58	59.37	58.94	57.82	57.67		56.60 56.54 57.26 57.20
G.L.	61.50	61.50	59.30	58.50	58.50	59.50	61.20	60.70	59.65	59.50		58.50 58.30 58.00
Accum Length	6008.5	6141.5	6226.5	6330.5	6369.5	6614.5	6793.5	6937.5	7023.5	7100.5		7220.5 7226.5 7241.5
Section Length	0.0	133.0	85.0	104.0	39.0	245.0	179.0	144.0	86.0	77.0		120.0 6.0 15.0

Scale
H: 1/200
V: 1/10,000

Figure 4.14

Profile of Discharge Pipe for Options 2 (3 of 3)

4.8.9 Conclusion and Recommendation

As discussed in the Sections above, the recommended improvement plan for the Birzai Sewerage System is summarized as follows:

1. Sewage Collection System Improvement
   - Water Company must make an effort to prevent stormwater from intruding in the sewers;
   - Investigation of the infiltration of groundwater into the sewers is recommended. Budget may need to be allotted for this purpose.
2. Sewage Treatment System

   <u>Common to Options 1 and 2</u>
   - Construct a new treatment plant at the formerly proposed site outside the town boundary;
   - Abandon the existing treatment plant upon completion of the new treatment plant;
   - New treatment plant will be designed to treat 5,000 m^3/day sewage as a daily maximum flow. The plant will employ the previously designed treatment method that is a so called anaerobic-anoxic-aeration (A2O) method for secondary treatment;
   - Excess sludge will be treated by gravity thickening and mechanical dewatering using a centrifuge;
   - For emergency case if the dewatering machine breaks down, a sludge lagoon having one month storage will be provided; and
   - Dewatered sludge will be transported outside the plant for composing.

   <u>For Option 1</u>
   - Treated effluent will be discharged to the Juodupe River that flows to the Tatula River by gravity through a 3.2 km long discharge pipe made of reinforced concrete;
   - A tertiary treatment process using a biological membrane filter will be used for the secondary effluent to meet the special requirement for the effluent discharged to the Tatula River.
   - It is recommended that construction of the tertiary treatment process be subject to evaluation of the effluent quality of the secondary treatment process and reconsideration by the Ministry of Environment of the special effluent standard for the Tatula River.

   <u>For Option 2</u>
   - Treated effluent will be discharged to the Obelaukias River by pumping through a 7 km long discharge pipe made of ductile iron;

- No tertiary treatment process is required.
- For discharging the effluent to the Obelaukias River, pumps will be provided at the treatment plant.

4.9 PRELIMINARY DESIGN OF THE PROPOSED FACILITIES

4.9.1 General

A preliminary design of the proposed facilities for a sewage treatment plant and a discharge pipeline is presented based on the recommendation described in the previous section. Detailed preliminary drawings are presented in the volume of Drawing in the Supporting Report. This section presents the engineering details of each facility of the sewage treatment plant.

4.9.2 Required Land Area of the Sewage Treatment Plant

For the proposed treatment facility, the required land area is estimated at 2.7 ha as shown in the plant layout in Figure 4.15. This land area is smaller than the previously proposed scheme that required a land area of approximately 5 ha.

4.9.3 Design Basis

Design basis of the treatment plant is summarized in Table 4.50.

Table 4.50 Design Basis of the Treatment Plant

Item	Value		Remark
Design Flow			
Daily Average Flow	4,200 m^3/day		used for computing sludge amount and operation cost
Daily Maximum Flow	5,000 m^3/day		used for design of biological reaction tank and sludge treatment
Hourly Peak Flow	6,930 m^3/day		used for design of pipelines, inlet works and sedimentation tank
Influent Quality			
BOD_7	260 mg/l		BOD_5 is used for design of the biological treatment system.
BOD_5	230 mg/l		
COD	500 mg/l		
Total-N	40 mg/l		
Total-P	10 mg/l		
Suspended solid	260 mg/l		
Design Effluent Quality (Secondary Treatment)	Cave.	Cmax.	LAND 10-96
BOD_7	15 mg/l	25 mg/l	
BOD_5	13 mg/l	22 mg/l	
COD	75 mg/l	120 mg/l	
Total-N	20 mg/l	35 mg/l	
Total-P	1.5 mg/l	2.5 mg/l	
Suspended solid	30 mg/l	45 mg/l	

Table 4.50 Design Basis of the Treatment Plant (continued)

Item	Value		Remark
Design Effluent Quality (Tertiary Treatment)	Cave.	Cmax.	Special requirement for the Tatula River (to be applied for Option 1)
BOD_7	4 mg/l	8 mg/l	
BOD_5	3.5 mg/l	7 mg/l	
Total-N	8 mg/l	14 mg/l	
Total-P	1.0 mg/l	1.5 mg/l	
Minimum temperature	7°C		

4.9.4 Sewage Treatment Plant

4.9.4.1 Sewage Reception and Grit Removal

Incoming sewage will be received in a receiving box that has been partly constructed according to the previous design. This facility will be completed and used as a receiving box. Incoming sewage will flow from the receiving box to a grit chamber. A gravity type grit chamber is proposed due to its simple structure and ease of operation and maintenance. There will be a pit at the bottom of the chamber to store the settled grit.

A main channel and a bypass channel will be constructed. A mechanical bar screen will be installed in the main channel while a manual bar screen will be installed in the bypass channel.

Dimensions and design parameters of the grit chamber are as follows:

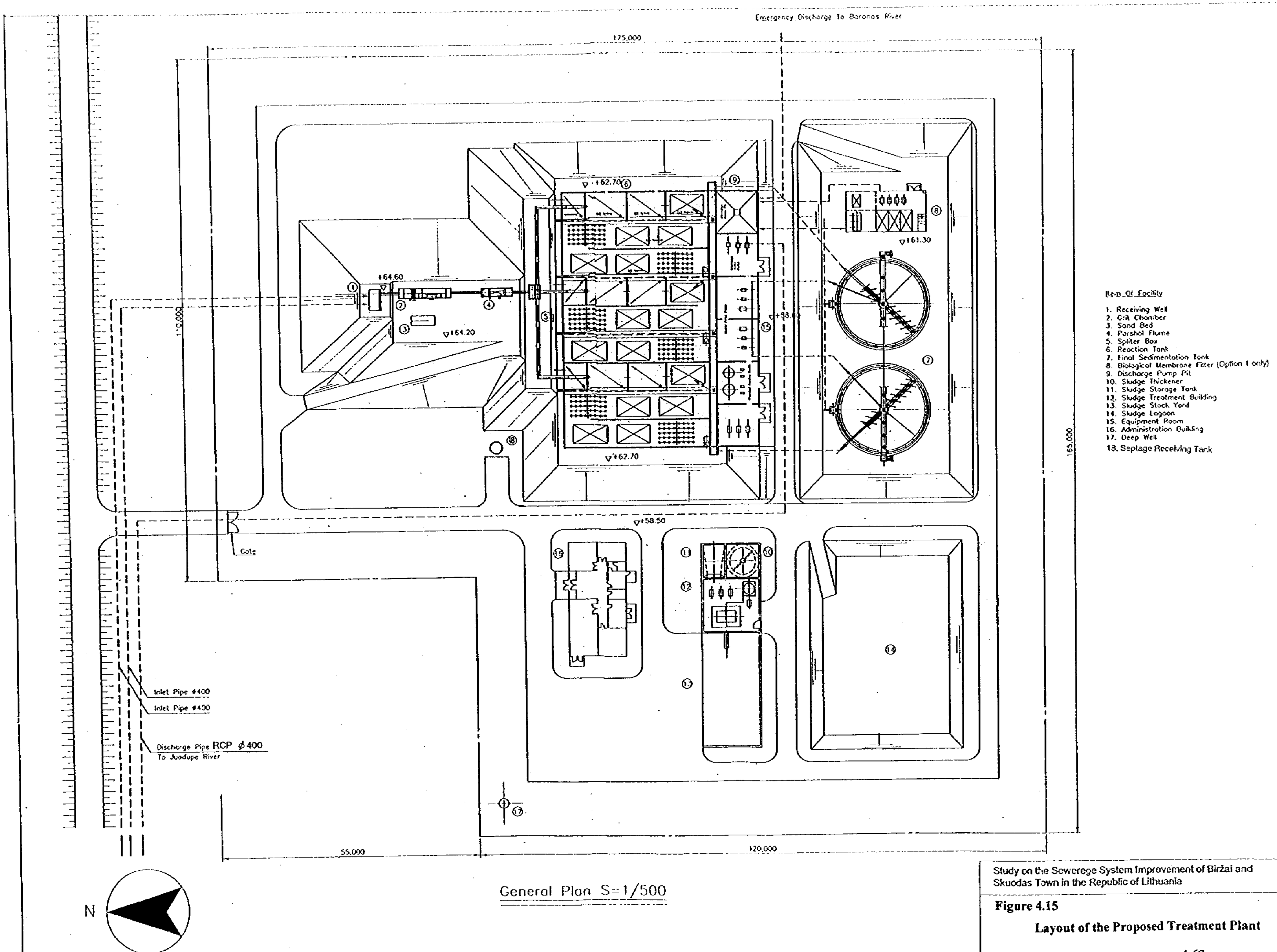
- Surface load = 1,800 m^3/m^2/day
- Maximum velocity in the channel = 0.3 m/sec
- Shape = Rectangular
- Sand removal = by sand pump
- W 1.0 m x L 4.0 m x D 0.4 m x 1 unit (D = depth of water)
- Structure
  foundation = direct foundation
  super structure = reinforced concrete

Dimensions of the screen are as follows:

- Mechanical screen: W 1.0 m x H 1.0 m x Bar spacing 5 mm x 1 unit x 0.4 kW
- Manual screen: W 1.0 m x H 1.0 m x Bar spacing 20 mm x 1 unit

Other Provision:

A bypass of storm water should be provided to prevent the excessive amount caused by accidental inflow of stormwater from flowing into the treatment system.



General Plan S=1/500

Study on the Sewerege System Improvement of Biržai and Skuodas Town in the Republic of Lithuania

Figure 4.15

Layout of the Proposed Treatment Plant

4.9.4.2 *Flow Measurement*

Flow measurement will be carried out by a Parshall flume channel constructed after the grit chamber. A Parshall flume is recommended because it is one of the most common practices for flow measurement at a sewage treatment plant. Water depth measured in the channel is converted to the flow rate using a formula particularly set for the design of the Parshall flume.

Dimensions and design parameters of the Parshall flume are as follows:

- Range of measurement = min. 24.3 - max 697 l/sec = (min.2,100 -max.60,220 m^3/day)
- Shape = Rectangular
- W 0.457 m (W: width at a throttle)
- Structure
  foundation = direct foundation
  super structure = reinforced concrete

4.9.4.3 *Biological Reaction Tank*

The biological treatment process is designed as an anaerobic-anoxic-aerobic (A2O) method that will effectively remove nitrogen and phosphorus. In the preliminary design of the facility, provision for an optional operation under the three-stage Bardenpho method is incorporated. This optional mode consists of four steps as anoxic-anaerobic-anoxic-aerobic in which higher removal of phosphorus is expected. Two operation modes are explained in detail in Section 4.10.

When the average concentration of phosphorus is 6.0 mg/l or lower, the proposed treatment system is said to be able to reduce phosphorus below 1.5 mg/l. For higher concentrations of phosphorus, chemical coagulation will likely be required to meet the effluent standard. In the preliminary design, this chemical treatment is recommended as back-up for the biological treatment process.

Aeration and mixing will be carried out separately using membrane diffusers and a submersible propeller mixer to easily adjust the aerobic and anoxic operation.

Dimensions and design parameters of the reactor are as follows:

- MLSS = 3,000 mg/l
- BOD-SS Ratio (F/M ratio) = 0.06 kg-BOD/kg-SS z
- Hydraulic retention time (HRT):

	anaerobic zone	2.0 hours
	anoxic zone	6.7 hours
	aerobic zone	28.6 hours
	Total =	37.3 hours

- Aeration system
  Blower = roots type, 18 m^3/min x 37 kW x 3 units (incl. 1 stand-by)
  Diffuser = membrane diffuser
- Mixing system

Submersible propeller type mixer =
dia. 0.22 m x 1.1 kW x 3 units (for block no.1)
dia. 0.22 m x 2.4 kW x 9 units (for blocks no.2 to 4)

- W 5.8 m x L 89.4 m x D 5.0 m x 3 units (D = depth of water)

  Each tank will be separated in 6 zones as follows:

Block no.	Length of channel (m) in each tank	Operation	
		Mode 1	Mode 2
1	4.8 m	anaerobic	anoxic (1)
2	8.0 m	anoxic (1)	anaerobic
3	8.0 m	anoxic (2)	anoxic (2)
4	9.0 m	aerobic (1)	aerobic (1)
5	29.8 m	aerobic (2)	aerobic (2)
6	29.8 m	aerobic (3)	aerobic (3)
Mode 1: anaerobic-anoxic-aerobic (A2O) Mode 2: anoxic-anaerobic-anoxic-aerobic (3-stage Bardenpho)			

- Structure (as constructed)
  foundation = direct foundation
  bottom slab = reinforced concrete
  wall = pre-cast reinforced concrete panel

The reaction tanks will be equipped with internal recycle pumps that will recycle flow for denitrification in the anoxic zone. Specifications of recycling pumps are as follows:

- Maximum recycling ratio = 150 % of the daily maximum flow
- Type of pump = submersible non-clogging pump
- Number of pump = 3 units
- Capacity of pump = 1.8 m^3/min x 5 m head x 3.7 kW

4.9.4.4 Final Sedimentation Tank

Two final sedimentation tanks will be provided to clarify the effluent from biological treatment. Dimensions and design parameters of the sedimentation tanks are as follows:

- Surface load = 8 m^3/m^2/day (taking into account the low settling velocity under low temperature)
- Shape = Circular
- Bottom slope = 10/100
- Mechanical sludge collector = center post type, center driven sludge collector with picket fence
- Sludge extraction = by pumping
- dia. 20.0 m x D 3.5 m x 2 units (D = effective depth of water)
- Structure
  foundation = direct foundation
  bottom slab = reinforced concrete
  wall = pre-cast reinforced concrete panel

4.9.4.5 Sludge Recycling

Settled sludge extracted from the final sedimentation tanks will be returned to the reaction tank to keep MLSS at the required level. Recycling will be carried out by sludge return pumps that will operate continuously.

Specifications of the sludge return pumps are as follows:

- Maximum recycling ratio = 100 % of the daily maximum flow
- Type of pump = non-clogging centrifugal screw pump
- Number of pump = 4 units
- Capacity of pump = 0.9 m^3/min x 5 m head x 2.2 kW

4.9.4.6 Disinfection

In Lithuania, disinfection of effluent is required only when the effluent is discharged into bathing water. In this case, there is no bathing area immediately downstream of the treatment plant. Therefore, disinfection facility will not be provided.

4.9.4.7 Effluent Discharge Pump (For Option 2)

For Option 2, effluent will be discharged into the Obelaukias River by pumping through a 7,000 m long discharge pipe. A discharge pump well will be provided making use of one of the originally designed final sedimentation tanks. The pump units will be installed in the equipment room.

Specifications of the effluent discharge pumps are as follows:

- Maximum discharge = 100 % of the peak hour flow
- Type of pump = horizontal shaft, single suction, centrifugal pump
- Number of pump = 2 units (including 1 stand-by)
- Capacity of pump = 4.8 m^3/min x 45 m head x 50 kW

Discharge pump well will be provided in the existing structure constructed for a sedimentation tank as follows:

- Shape = Rectangular
- W 8.8 m x L 8.8 m x max. D 7.8 m x 1 unit (D = effective depth of water)
- Structure
  foundation = direct foundation (as existing)
  bottom slab = reinforced concrete (as existing)
  wall = pre-cast reinforced concrete panel (as existing)

For Option 1, the discharge pump well above is provided as an effluent holding tank to maintain the water level at +61.20 m.

4.9.4.8 Sludge Treatment

Excess sludge in the final sedimentation tanks will be withdrawn from each tank using sludge pump. Sludge extraction pumps will operate by pre-set timer to maintain the sludge surface level in each tank. Sludge extracted from each sedimentation tank will be pumped to a sludge thickener provided in the sludge treatment building. The sludge thickener is provided to reduce the water contents in the sludge. Thickened sludge will be discharged to a sludge storage tank before it is transferred to a sludge dewatering machine.

Dewatered sludge will be transferred to a sludge storage yard by a screw conveyor. In the sludge storage yard, sludge will be stored for one month. Sludge will then be transferred to the private company that has a composting machine.

In these processes, water contents of the sludge is set as follows:

Excess (secondary) sludge:	99.4%
Thickened sludge:	98.5%
Dewatered sludge:	85.0%

Design criteria and parameters of each sludge treatment process are described below:

Sludge Extraction Pumps

- Type of pump = progressive cavity pump
- Number of pump = 2 units
- Capacity of pump = 6.5 m^3/hour x 10 m head x 2.2 kW

Sludge Thickener

- Dry solid surface load = 30 kg-DS/m^2/day
- Solid yield = 80%
- Shape = Circular
- Bottom slope = 10/100
- Mechanical sludge collector = hanging type, center driven sludge collector with picket fence
- Sludge extraction = by pumping
- dia. 7.0 m x D 4.0 m x 1 unit (D = effective depth of water)
- Structure
  foundation = direct foundation
  bottom slab = reinforced concrete
  wall = pre-cast reinforced concrete panel

Sludge Storage Tank

- Retention time = 2 days
- Shape = Rectangular
- Bottom slope = 10/100
- Mixing = by blower
- Sludge extraction = by pumping
- W 4.5 m x L 7.0 m x D 4.0 m x 1 unit (D = effective depth of water)

- Structure
  foundation = direct foundation
  bottom slab = reinforced concrete
  wall = pre-cast reinforced concrete panel

Sludge Dewatering Machine

- Type of machine = centrifugal dewatering machine (decanter)
- Solid yield = 95%
- Number of unit = 1 unit
- Capacity = 12.0 m^3/hour x 44.5 kW

Sludge Storage Yard

- Storage period = 1 month
- Stockpiling yard = W 12.0 m x L 24.0 m x 1 line
- Structure
  foundation = direct foundation
  bottom slab = pre-cast reinforced concrete panel
  wall = pre-cast reinforced concrete panel (1 m high around each stockpiling yard)
  roofing and support = metal roofing with steel columns and steel frame trusses
  (roofing only on the stockpiling yards)

4.9.4.9 Sludge Lagoon

For emergency, in case the sludge dewatering machine breaks down, a sludge lagoon will be provided to receive the thickened sludge.

Dimensions and design parameters of the sludge lagoon are as follows:

- Storage volume = one month volume of sludge for daily average production
- W (top) 32 m-(bottom) 26 m x L (top) 44 m-(bottom) 38 m x D 1.5 m
  x 1 unit (D = depth of water)
- Structure: open cut

4.9.4.10 Chemical Feeding Facility

Chemical feeding facilities used in the proposed treatment system are as follows:

For Phosphorous Removal

- Type of chemical = aluminum oxychloride
- Dosage ratio = average 2.4 mg/l – maximum 7.0 mg/l as Al_2O_3
- Chemical mixing tank = FRP made, 13.0 m^3 equipped with a mixer x 1 unit
- Chemical feeding pump = diaphragm pump, 0.3 l/min x 2 units

For pH Control in Sewage Treatment

- Type of chemical = Caustic soda
- Dosage ratio = average 27 mg/l – maximum 80 mg/l as 20% liquid
- Chemical mixing tank = FRP made, 8.0 m^3 equipped with a mixer x 1 unit

- Chemical feeding pump = diaphragm pump, 0.2 l/min x 1 unit

For Sludge Dewatering

- Type of chemical = polymer
- Dosage ratio = average 1.2 % – maximum 1.5 % of dry solid
- Chemical mixing tank = FRP made, 8.0 m^3 equipped with a mixer x 1 unit
- Chemical feeding pump = progressive cavity pump, 1.3 m^3/hour x 1 unit

4.9.4.11 Septage Receiving Tank

The sewage treatment plant will receive some kinds of wastewater or sludge taken out of septic tanks at households or factories that are not connected with the sewerage network. Such wastewater will be transferred by tanker trucks and dumped into the treatment process. Such wastewater should be defined as "septage" that is normally named for waste from a septic tank.

Septage dumped from the tanker trucks will be either transferred to the sludge thickener or to the biological process depending on its characteristics and load condition of the treatment plant.

Septage receiving and transfer system consists of the following facilities:

- Septage receiving tank with screen
- Septage transfer pump

Specification of the septage receiving tank is as follows:

- Storage volume = 4 m^3 (same as the volume of a tanker truck)
- Shape = Circular
- Manual screen: W 1.0 m x L 1.0 m x Bar spacing 15 mm x 1 unit
- Dia. 2.0 m x depth 2.5 m 1 unit
- Structure
  foundation = direct foundation
  bottom slab = reinforced concrete
  wall = pre-cast circular barrel

Pump equipment will be provided in the septage receiving tank as follows:

- Type of pump = submersible non-clog pump
- Number of pump = 1 unit
- Capacity of pump = 0.3 m^3/hour x 10 m head x 1.5 kW

4.9.4.12 Tertiary Treatment Facility

A biological membrane filter will be provided for tertiary treatment to meet the effluent requirement for the Tatula River. Pollutants to be removed by this process are BOD and Total-N.

Discharge pump well is provided in the existing structure constructed for a sedimentation tank as follows:

- Filtration rate = 200 m/day
- Aeration rate = 0.15 m^3/m^2/min

- Air scouring rate = 1.0 $m^3/m^2/min$
- Backwash rate = 0.9 $m^3/m^2/min$
- Shape = Rectangular
- Filter media thickness = 1.0 m (effective thickness)
- Flow type = gravity flow
- W 2.5 m x L 3.5 m x Area 8.75 m^2/filterx 3 units
- Structure
  foundation = direct foundation
  bottom slab = reinforced concrete
  wall = reinforced concrete

Equipment provided for the biological membrane filter are as follows:

- Feed pump = 2.4 m^3/min x 7.5 kW x 3 units (including 1 stand-by)
- Blower for aeration = 4.0 m^3/min x 7.5 kW x 2 units (including 1 stand-by)
- Blower for air scouring = 9.0 m^3/min x 15 kW x 2 units (including 1 stand-by)
- Backwash pump = 4.0 m^3/min x 15 kW x 3 units (including 1 stand-by)
- Drain pump = 0.25 m^3/min x 0.75 kW x 2 units (including 1 stand-by)

4.9.4.13 Instrumentation

For Birzai, a central monitoring system using computers will be provided to reduce manpower and cost. Basically, the control of equipment will be carried out at the equipment site. Aeration volume, sludge volume and flow rates will be monitored by operators at site. Operation control of each equipment will be carried out by setting timers and manual control.

The instrumentation systems for monitoring and operating the treatment plant are summarized as follows:

Table 4.51 Instrumentation of the Treatment Plant

Treatment Facility	Item to monitor	Place of monitoring	Item to control	Place of control
Parshall flume	inlet flow	monitoring room	-	-
Chemical tank	liquid level	monitoring room	operation of feed pump	equipment side
Discharge pump well	water level	monitoring room	operation of discharge pump and backwash pump	equipment side
Sludge holding tank	liquid level	monitoring room	operation of thickened sludge pump and sludge feed pump	equipment side
Feed pump pit for Tertiary treatment	water level	monitoring room	operation of feed pump	equipment side
Tertiary treatment drain tank	water level	monitoring room	operation of drain pump	equipment side
Biological membrane filter	water level	monitoring room	back wash	equipment side

4.9.4.14 Power Supply

Power supply will be provided from the Power Company's power line. The Power Company will install an extension line and a transformer of a capacity required for the treatment plant. A 300 KVA transformer will be required for the operation of the proposed treatment plant including the tertiary treatment plant.

In Birzai, the entire volume of sewage will be transferred from the sewer network to the treatment plant by pumping. The last pumping station No.2 does not have a stand-by power supply unit but has an emergency sewage storage pond to store 12hours volume of sewage. This means that no sewage will reach the treatment plant in case of power interruption. Stand-by generator will therefore not be provided at the treatment plant.

4.9.4.15 Auxiliary Facilities

Administration Building

An administration building will be constructed as follows:

- Rooms included = workers room, laboratory room, office, store room, warehouse, drying room, toilet, electric, electric room, garage
- Single story, W 12.0 m x L 18.0 m x Total floor area 216 m^2
- Structure
  foundation = footing foundation
  floor slab = pre-cast reinforced concrete panel
  wall = brick wall
  roofing and support = metal roofing with ceiling

Sludge Building

A sludge building will be constructed to accommodate the sludge dewatering machine and chemical feeding system as follows:

- Rooms included = sludge dewatering machine and chemical feeding room
- Single story, W 12.0 m x L 11.0 m x Total floor area 132 m^2
- Structure
  foundation = footing foundation
  floor slab = pre-cast reinforced concrete panel
  wall = brick wall
  roofing and support = metal roofing with ceiling

Equipment Room

The structure of the final sedimentation tanks that has been previously constructed will be converted to a equipment room to accommodate blowers, sludge pumps, chemical feeding equipment, effluent discharge pumps, and a discharge pump well.

Dimensions and design parameters of the equipment room are as follows:

- Single story, W 9.0 m x L 48 m x 1 unit x Total floor area 432 m^2
- Structure
  foundation = direct foundation (as constructed)
  bottom slab = reinforced concrete (as constructed)
  wall = pre-cast reinforced concrete panel (as constructed)
  roofing = pre-cast reinforced concrete panel with asphalt lining (new construction)

4.9.5 Effluent Discharge Pipeline

For Option 1, as discussed in Section 4.8.7.2, 400 mm diameter RC pipe is recommended. Flow conditions for the proposed pipeline are calculated s follows:

Total length:	3,250 m
Diameter of pipe:	400 mm
Material of pipe:	Reinforced concrete
Hourly peak flow:	6,930 m^3/day = 80 l/sec
Velocity in pipe:	0.64 m/sec
Friction loss in pipe:	4.6 m (by Hazen-Williams formula, C=110)

For Option 2, a 7,000 m long pipeline will be constructed. The pipe design for this case is as follows:

Total length:	7,000 m
Diameter of pipe:	300 mm
Material of pipe:	Ductile iron
Hourly peak flow:	6,930 m^3/day = 80 l/sec
Velocity in pipe:	1.13 m/sec
Friction loss in pipe:	42 m (by Hazen-Williams formula, C=110)

4.10 OPERATION AND MAINTENANCE PROGRAM

4.10.1 Maintenance of Sewage Collection System

4.10.1.1 Sewer Facility

(1) Inspection

Objectives of operation and maintenance of the sewer facility includes:

maintenance of flow capacity
prevention of damage
prevention of infiltration and rainwater intrusion
extension of life

- Raw sewage contains various materials such as human wastes, garbage, and solids that may settle in the pipe and cause problems. Possible troubles caused by such settlement are clogging, reduction in dissolved oxygen, emission of hydrogen sulfide, etc. Deterioration of sewage, in particular, excessive anaerobic conditions also results in poor treatment performance at the treatment plant. Maintenance of sewers is therefore of importance to prevent deterioration in the sewerage system and treatment.

- It is recommended that the Water Company prepare a schedule for inspection and repair of the sewer system. Frequency of inspection and repair will be dependent on the age of pipes and local conditions.
- Major inspection items are summarized below.

Table 4.52 Major Inspection Items for Sewage Collection System

Item	Point of Inspection
Pipe & Culvert	flow conditions, sediments land or pavement settlement any physical damage to structures infiltration of groundwater intrusion of rain and surface run-off existence of hydrogen sulfide offensive/illegal activity on the sewers
Manhole	safety of manhole cover erosion and corrosion on inside walls any physical damage to structures
House connection	any physical damage to structures sediment in connection boxes intrusion of rain and surface run-off

(2) Cleaning and Maintenance

Cleaning the sewers will be required to maintain the sewage collection system in good condition. Frequency of cleaning may be once in a few years depending on the actual condition of sediment in the sewers. An effective method of sewer cleaning is to use a high pressure flushing machine. Sewer cleaning, using such a machine, can be carried out under a sub-contract with a firm that provides this service.

As the size of the sewage transmission pipeline (dia. 400 mm) is larger than the optimum size of 300 mm, the pipe is expected to have solids at the bottom over the long distance to the treatment plant. To remove this sediment, it is recommended that all three pumps at Pump Station No.2 be operated at the same time occasionally so that the high flow will flush out sediments in the pipe.

(3) Recording of Maintenance

Recording the activities of inspection and maintenance and information obtained through such activities is important and useful for future operation and management of the Water Company.

Data and information to be collected and compiled must include the following items:

- date and activities performed
- costs of repair or maintenance
- as-built drawings if there is any construction or modification work on the existing facilities
- cause of the problem

4.10.1.2 Pump Stations

(1) Normal Operation

All existing pump stations are operated by an automatic on-off system linked with a water level detector installed in the pump wet well. As this operation will continue in the future, the Water Company will need to properly maintain the automatic operation system.

Aside from maintenance of the instrumentation equipment, physical conditions at each pump station should be inspected periodically. An inspection checklist is presented in Volume III Supporting Report, together with the inspection check lists for the treatment plant.

Data from the pump operation will be useful to evaluate the sewage flow, variations in sewage discharge, power cost, estimates of infiltration etc. Operational data to be recorded must include running time of each pump, electric consumption each day and when lubrication is performed, and repairs performed.

(2) Inflow of Stormwater

As discussed in Section 4.6.1.1, the existing pump system has a sufficient pumping capacity for the projected sewage flow. The most serious problem for the sewerage system is intrusion of stormwater into the sewers. This problem will result in an excessive amount of flow from the pump stations to the sewage treatment plant.

By-pass facility should be provided to avoid the hydraulic overloading in the treatment plant. Particularly, overloading in the reaction tank will result in the washout of the MLSS and cause malfunction of the biological reaction in the tank. Although a bypass will be provided at the treatment plant, operation at Pump Station No.2 should be limited to only one or two pumps at same time.

When the stormwater flows in, and only one or two pump units will be run, excessive rainwater, if occurring, will flow into the emergency reservoir at the Pump Station No.2. When the emergency reservoir is full, it will overflow.

4.10.1.3 Organization for Operation

(1) Required Staff

It is recommended that operators of the treatment plant also circulate the pump stations for operation and maintenance.

If additional manpower is required which exceeds the Water Company's staff available for special work such as cleaning operations, employing of temporary workers is recommended as an èconomical measure.

(2) Emergency and Security

The most probable emergency may be an interruption of the pump operation caused by a power failure. This occasion will cause serious problems at the pump stations. Only Pump Station No.2 has an emergency reservoir with a 12-hour storage capacity. No pump station is equipped with a stand-by generator. In Birzai, power failure occurs about once a month, the duration of which varies from 30 minutes to 12 hours based on the past record. To accommodate power failures, it is recommended that the Water Company purchase a mobile generator with a capacity to support any one of the pump units at the four pump stations.

For the sewer system, the possibility of accidents or damage is rare. If an accident does occur and the pipe needs repair, the Water Company must respond as soon as possible to prevent raw sewage spills. Normally, preparing for an accident will require a stock of construction vehicles, spare parts, pipe materials, special equipment for repair work, etc. Since storing these equipment and materials at the Water Company is not economical, it is recommended that the Water Company make an arrangement with the Municipality, other agencies or private sectors for lease or rent of the equipment on an as needed basis.

4.10.2 Sewage Treatment Operation

4.10.2.1 Operation and Maintenance of the Proposed Sewage Treatment Plant

(1) Principle of Secondary Biological Treatment

Two Operation Modes

The proposed treatment plant will employ the Anaerobic-Anoxic-Aerobic (A2) treatment method. This treatment method is designed for effective removal of nitrogen and phosphorus as well as organic substances through biological treatment. Each of the three existing reaction tanks will have separation walls to create five compartments (zones) as detailed in Section 4.9.

The proposed preliminary design also makes it possible to operate the reaction tanks under the three-stage Bardenpho System (anoxic-anaerobic-anoxic-aerobic mode) which may have even higher efficiency for removal of nitrogen and phosphorus. Conversion between the two operations, the anaerobic-anoxic-aerobic mode and the three-stage Bardenpho mode, can be easily made by only operating valves on the inlet and internal recycling pipe in each reaction tank.

A schematic diagram for operation under the two modes is shown in Figure 4.16. As to which of the two methods is best, there is no clear criteria in the operating parameters. Treatment performance is also affected by various factors such as the characteristics of sewage, temperature, conditions of microorganisms in the tank, etc. As there is no difference in the operational cost of the two modes, it is recommended that the reaction tank be operated alternately under both modes each for several months. Data accumulated during such operations will be useful in deciding which operation mode under variable conditions in the incoming sewage is the best for Birzai.

Phosphorous Removal and Chemical Coagulant Dosage

A chemical coagulant system is provided to supplement phosphorus removal in the biological treatment process. Phosphorus will likely be reduced to 1.5 mg/l by biological treatment when phosphorus in the influent is not higher than 6 mg/l (daily average). The chemical coagulant system can be used only when the biological treatment cannot reduce the phosphorus to the required level of 1.5 mg/l. As the chemical coagulant is an additional operation cost, the dosage amount must be minimized. To reduce the chemical dosage, biological reaction for phosphorus removal should be carefully monitored and should be set to the most appropriate condition as much as possible.

If the pH in the effluent decreases to a low value because of the addition of the alum coagulant, a caustic soda feeding system is provided for pH adjustment.

(2) Tertiary Treatment Process (Biological Membrane Filter)

The proposed treatment plant will be provided with a tertiary treatment process after the final sedimentation tanks to further reduce BOD, Total-N and Total-P to meet the special effluent requirement for discharging to the Tatula River. The proposed tertiary process is a biological membrane filter that looks similar to the existing sand filtration system of the plant for water supply in Birzai. Differences between the biological membrane filter and the sand filtration are as follows:

- the biological membrane filter uses a special filter media to attach aerobic micro-organisms. Various types and materials of filter media have been developed and used by a number of manufacturers;
- the biological membrane filter requires aeration during the filtering operation to supply oxygen to the aerobic micro-organisms; and
- the biological membrane filter removes pollutants through a biological reaction that occurs when influent flows through the filter media.

The biological membrane filter requires backwashing just as in sand filtration. Structures and components of the biological membrane filter are also similar to these used in sand filtration.

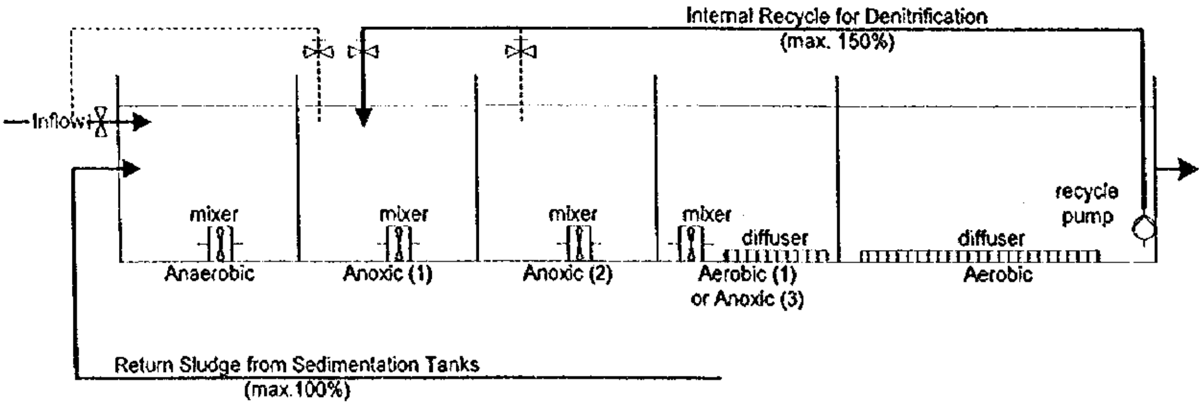
(3) Operation of the Secondary Treatment Plant System

This section describes the operation procedure for each component of the proposed secondary treatment system.

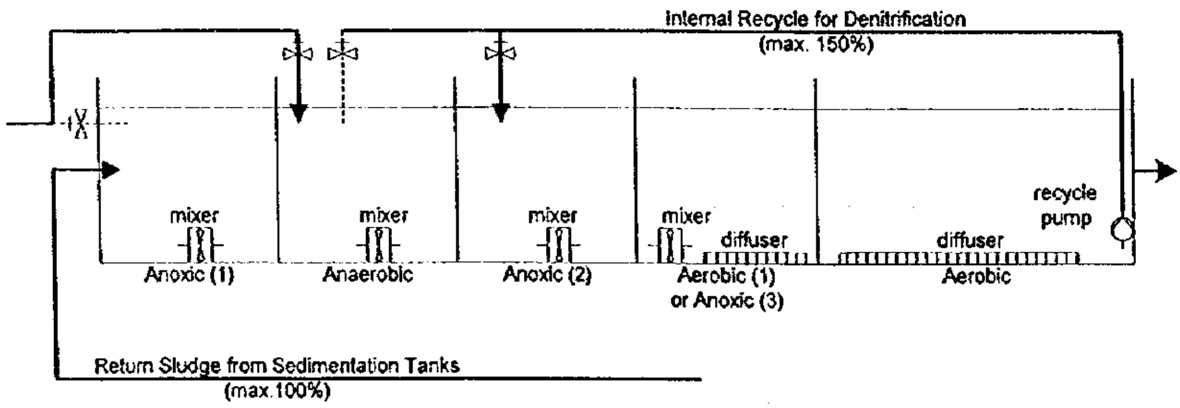
Grit Chamber

At the grit chamber, large floating materials will be removed by the mechanical screen while relatively heavy particles will settle in the hopper provided in the channel. Materials trapped at the bar screen will be automatically removed as screenings and dropped into a container. Screenings stored in the container should be disposed of every few days either to the Municipality garbage disposal facility or be buried on site.

Settled grit in the hopper will be removed by a sand pump that will pump a grit solution to the sand bed for separation of solids and water. Dry grit should be removed for disposal every few weeks.



Anaerobic-Anoxic-Aerobic (A2O) Operation Mode



3 - Stage Bardenpho Operation Mode

Figure 4.16 Two Operation Modes for Reaction Tank

Parshall Flume

At the Parshall flume, the water level in the flume is measured, indicated and recorded for conversion to a flow rate for the incoming sewage. There is no activity or operation for the Parshall flume.

Biological Reaction Tank

As mentioned above, the reaction tank has several zones each equipped with mixers and/or diffusers. In the anaerobic and anoxic zones, only mixing will be provided while aeration through fine bubble diffusers will occur in the aerobic zone. There is an internal liquid recycle system for nitrogen removal and for recycle of sludge from the final sedimentation tank. Control of the flow from these recycle systems is the main operation parameter. The intensity of aeration is also an important operation that will affect the aerobic reactions in the tank. These operations will be controlled as follows:

Mixing: Mixing the liquid in the anaerobic and anoxic zones will be performed by the submersible mixers installed at the bottom of each reaction tank. All mixers will operate 24 hours a day.

Internal Recycle: An amount of about 100 percent to a maximum 150 percent of the incoming sewage flow should be returned to the anoxic zone by a recycle pump at the end of the aerobic zone. Recycled liquid has been nitrified in the aerobic zone and denitrified in the anoxic zone mixed with the influent as a carbonatious energy source. Internal recycle will normally be operated 24 hours a day.

Sludge Recycle: Settled sludge from the final sedimentation tank in the amount of about 60 to 100 percent of the incoming sewage flow is to be returned by a return sludge pump to the inlet of the reaction tank. The amount of return sludge is determined to keep the MLSS level in the reaction tank at a proper level (normally 3,000 mg/l).

Aeration: Aeration is to be operated 24 hours a day for removal of organic substances and for nitrification. Intensity of aeration will be established so that the DO level in the end of the reaction tank is kept at about 2.0 mg/l. Insufficient aeration results in less removal of BOD, less nitrification; and the discharge standards will not be met. Excessive aeration affects the reaction in the anaerobic zone that receives the internal recycle flow, and also affects the discharge quality.

It should be noted that electricity consumption due to the blowers supplying air will be the largest portion of the operating cost of the treatment plant. Setting the blower operation at the optimum level while adjusting to the incoming pollutant load will therefore contribute substantially to saving cost for operations.

Operation parameters for the reaction tank are summarized as follows:

Design BOD-SS load = 0.06 kg-BOD/kg-SS

MLSS = 3,000 mg/l

ORP (oxidation-reduction potential) in the anaerobic zone = -200 to -250 mv

Final Sedimentation Tanks

The final sedimentation tanks will separate suspended solids from the effluent of the reaction tanks. Each tank is circular in shape and equipped with a mechanical sludge collector. Settled sludge is collected at the center of the tank by the mechanical sludge collector and removed by sludge pumps for return to the reaction tank and for removal as excess sludge. Operation of the sedimentation tanks will be as follows:

- Extraction of the return sludge must be made by pumping basically in a continuous mode over 24 hours;
- The amount of return sludge will be dependent on the MLSS in the reaction tanks and suspended solid concentration in the return sludge. A rule to follow is to maintain the MLSS in the reaction tanks at about 3,000 mg/l;
- Extraction of excess sludge will be carried out to maintain the sludge surface in the sedimentation tank at a certain proper level;
- Proper extraction of excess sludge is to be given high importance since the accumulation of excess sludge in the system will cause problems such as anaerobic conditions, deterioration of biological treatment, and degrading the settlement in the sedimentation tanks. Extraction of sludge must therefore be carefully controlled observing the incoming pollution load and accumulation of sludge.
- Scum will also be automatically removed by a scum skimmer rotating with the mechanical sludge collector. When scum is not properly removed by the scum skimmer, it should be manually removed.

(4) Operation of the Sludge Treatment System

This section describes the operation procedures for the proposed sludge treatment system. The most important issue in sludge treatment is to remove excessive sludge from the system immediately. This operation is important to prevent release of phosphorus from the sludge under anaerobic conditions. Phosphorus released from the sludge is returned to the network through removal of supernatant from the sludge thickener and increases the phosphorus concentration in the effluent. If chemical coagulant is used, release of phosphorus can be controlled.

Sludge Thickener

A gravity sludge thickener will be provided for reducing the water content in the sludge extracted from the sedimentation tanks. The thickener is rectangular in shape and equipped with a mechanical picket fence that rotates in the tank to accelerate sludge settlement. Settled sludge is automatically collected by hydraulic means from a pit at the bottom and transferred using sludge pumps to a sludge storage tank located adjacent to the thickener. Operation of the sludge thickener is to be carried out as follows:

- Excess sludge pumping from the sedimentation tank needs to be regulated at a constant rate as much as possible to avoid a peaking load at the thickener;
- Extraction of the thickened sludge from the storage tank must be made every day by pumping set by a timer;
- The sludge surface in the thickener should be maintained at a level not higher than 1 m from the water surface;
- Design retention time of the sludge should be limited to 19 hours, at a maximum.

Sludge Dewatering Centrifuge (Decanter)

A mechanical centrifuge will be provided to further dewater the thickened sludge up to about 85 percent water content. Polymer needs to be added to the thickened sludge prior to the centrifuge operation. Operation of the centrifuge is to be carried out as follows:

- The centrifuge is designed to operate every day for 6 hours each day;
- Operating parameters such as dosage rate of the polymer, rotating speed, differential speed, etc. will need to be determined by trial operation by the supplier, before delivering the plant to the Water Company;
- Loading the thickened sludge into the centrifuge should be at a constant rate as much as possible to achieve a high degree of dewatering;
- Characteristics of the supernatant discharged from the centrifuge should be monitored.

Sludge Storage Yard

In Birzai, the Water Company will make an arrangement with a private firm which has a composting machine to treat the sludge for final use as low-level fertilizer and soil conditioner for agriculture. A sludge storage yard for one month volume of the dewatered sludge will be provided. Dewatered sludge will be transferred from the centrifuge by a screw conveyor to the storage yard.

Sludge Lagoon

For emergency conditions, if the centrifuge ceases to operate for more than a few days or for repair or maintenance, a sludge lagoon will be provided for storing the sludge to be extracted from the thickener. The sludge lagoon also has a volume for one-month storage of the thickened sludge. No daily operation will be required for the sludge lagoon.

(5) Operation of the Tertiary Treatment System (Biological Membrane Filter)

This facility will be provided for Option 1 only.

Operation of the biological membrane filter is basically the same as that for the sand filter system at the water treatment plant operated by the Water Company. Operation of the biological membrane filter is as follows:

- It will be operated observing the filter head loss, and will be backwashed periodically as the media clogs;
- The filtering rate will be set at about 200 m/day. The number of filters to be operated will therefore be determined so that the filtering rate does not vary far from this rate;
- Backwashing will need to be performed properly until the backwash water becomes clear;
- Aeration will need to be maintained at proper levels as defined by the manufacturer.

(6) Septage Receiving Facility

Septage receiving system will be operated to receive septage transferred from the households or factories that are not connected with the sewerage system.

Receiving tank will be provided with a manual screen to remove objects included in septage. Septage received in the receiving tank will be pumped either to the sludge thickener or to the biological reaction tank. Selection of these two routes will be made by manually operating valves.

(7) Inspection and Maintenance

There are various points to be inspected and maintained in the sewage treatment facilities. Major activities are defined in categories as follows:

Daily Inspection: This will be carried out by the operators every day at each of the treatment process units and at each piece of equipment. Activities include operation of equipment, observation of conditions of the running equipment, treatment performance (i.e. conditions of effluent and sludge), data acquisition from instrumentation and meters, etc.

Periodic Maintenance : This will be carried out about once a year, normally by shutting off each piece of equipment. Activities include detailed inspection and maintenance for lubrication, adjustment, calibration, etc.

Special Maintenance : This should be normally performed by a sub-contractor, usually a manufacturer of the equipment. Frequency will depend on the condition of equipment. This activity is required only for equipment that needs special knowledge, skills, or spare parts for maintenance.

(8) Data Acquisition and Compilation

Equipment

Data and information acquired for the operation of the treatment plant needs to be compiled for management of the treatment system. Such data will be useful for evaluating the treatment performance and for financial evaluation of maintenance and operation. Data to be acquired and compiled are as follows:

Equipment inventory: Upon completion of the treatment plant, an inventory listing all the details of equipment should be provided by the contractor/manufacturer.

Operational data: Operator will need to record operational data for the equipment at the treatment plant. Data must also include records of trouble and repair.

Water Quality

Water quality must be monitored at various points in the treatment process. Recommended sampling and analysis is suggested as follows:

Location	Daily	Once a week	Once a month
Raw sewage	odor, temperature, transparency, pH	SS, COD	BOD, NH_4-N, Total-N, Total-P
Reaction tank	odor, temperature, transparency, pH ORP, DO, MLSS	MLSS, ORP	MLSS
Final sedimentation tank effluent	transparency, pH	SS, COD, NH_4-N, NO_3-N	BOD, NH_4-N, Total-N, Total-P
Final Effluent	transparency, pH	SS, COD, DO	BOD, NH_4-N, Total-N, Total-P

For the anaerobic-anoxic-aerobic reaction tank, the following monitoring schedule is recommended:

Location	DO	NH_4-N	Org-N	NO_X-N	PO_4-P	ORP	pH
Influent	-	A	A	A	A	-	B
Anaerobic zone	-	-	-	-	A	A	-
Anoxic zone	-	-	-	A	A	B	-
Aerobic zone	A	A	B	B	B	-	A

A: high priority, recommended to monitor frequently
B: medium priority, recommended to monitor less frequently
- : low priority, recommend to monitor as necessary

Characteristics of Sludge

It is recommended that characteristics of sludge be tested and monitored as follows:

Location		Daily	Once a Week
Sludge thickener	Thickened sludge	examine visually	temperature, pH, solids, sludge surface level *heavy metal (*as required)
	Supernatant	TSS, SS	BOD, Total-N, Total-P
Dewatering	Dewatered sludge	examine visually	water content
	Supernatant	SS	BOD, Total-N, Total-P
Sludge storage	Storage	examine visually	water content, *bacteria *heavy metal (*as required)

4.10.2.2 Organization for Operation

(1) Required Staff

It is recommended that the treatment plant will be manned 24 hours a day with two operators during day time and one operator at night. The total number of operators will be four. The additional operator rotates when the others are off duty. Suitable procedures must be adopted to safeguard the single night operator from accidents.

(2) Emergency

Emergency and Security

The most probable emergency that could occur at the treatment plant is an interruption of the power supply. Power failure will result in stoppage of all equipment in the plant. Sewage will however continue to flow through the plant by gravity as long as Pump Station No.2 is operating and transferring sewage to the treatment plant. The tertiary treatment process will however, not operate for very long after a power failure as it need electric power for pumping and aeration. A bypass line is provided for the tertiary treatment process to release effluent to the discharge pump well. From the discharge pump well, a bypass line will be provided to release effluent to the adjacent Agluona River if the discharge pumps cannot work.

4.10.3 Sludge Disposal

As mentioned previously, the Water Company is to transfer sludge after dewatering to a private firm for composting. The estimated amount of sludge is 4.6 wet-ton/day or 1,686 wet-ton/year. This process should be monitored by the Ministry of Environment.