Chapter 5 Preliminary Design for Renovation of Existing Facilities

5.1 Boilers and Firing Equipment

(1) Reconstruction of Boilers

Existing boilers of No.5, 7, 9 and 10 will be reconstructed to the type of firing natural gas or fuel oil.

1) Main facilities to be removed or abandoned

Following facility consisting of existing coal firing system and ash handling system will be removed.

a) Coal firing system

Coal bunkers	Coal feeders
Coal drying ducts	Coal mills
Coal burners & wind boxes	Gas/oil supporting burners

b) Ash handling system

EP ash removal system	ECO ash removal system
Pneumatic transport system	Slurry ducts

c) Boiler

Bottom membrane wall	Wet slag removal system
FDF	IDF
Controller for fans	Boiler controller
Air & flue ducts	

d) Other facility

Electrical equipment

2) Main facility for newly installed and modernization

a) Firing equipment

Low NOx gas/fuel oil burners	Wind boxes
Burner controllers	New maintenance platform

b) Boiler

Bottom membrane wall	EGR duct
EGR fan	FDF and controller
IDF and controller	Air ducts
Boiler controller	Stairs & walk ways for maintenance
R100 SH No.1	

c) Fuel supply system (common use by 150MW)

Gas reduction system	Gas flow meter
Fuel oil unloading facility	Fuel oil tanks
Fuel oil pumps	Metering system

d) Other facility

Central control room & controller
Exhaust gas measuring system
Flue duct connecting No.7 boiler & No. II chimney
C & I system

3) Reconstruction of Boilers

Side views of the existing boilers of the types 100-M and 100-R after reconstruction are shown in Figures 5.1.1 and 5.1.2, respectively. Layout of burners and EGR system is shown in Figure 5.1.3.

a) Membrane Wall at Bottom of Combustion Chamber

As the construction of 100-M and 100-R boilers are slightly different, detailed calculations were carried out to determine the size of the new chamber. This solution cuts off the original bottom of the boiler, at 10 m from the ground level, and also removes all equipment in connection with bottom-ash removal. A new membrane construction is welded air tight to the vertical parts of the remaining walls. This solution also ensures the proper location of two pieces of gas / oil burners, while providing excellent access for the operators to the burners.

Steam generation capacity after the modernization will be 100 t/h, taking capacity of the existing turbines into consideration.

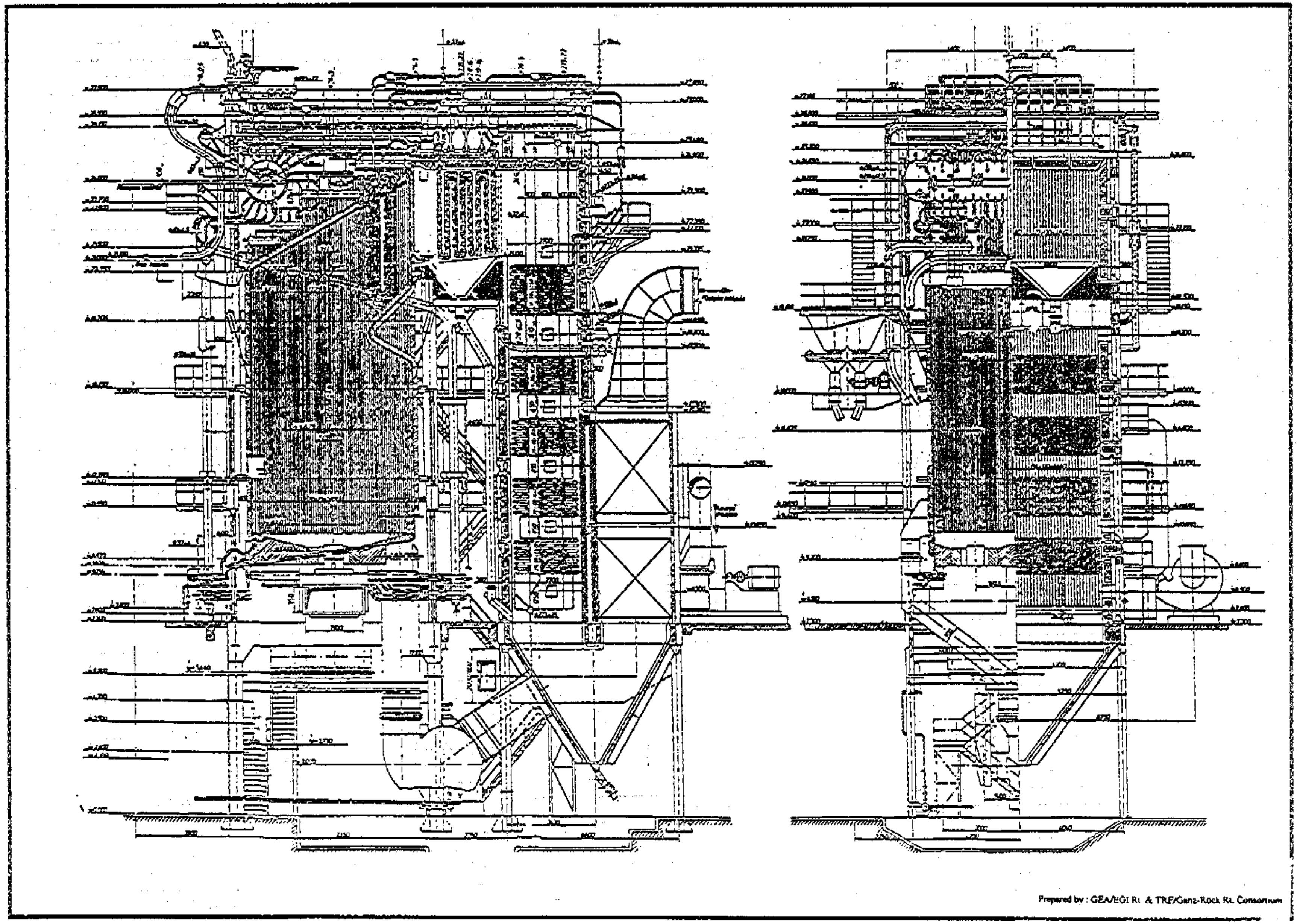
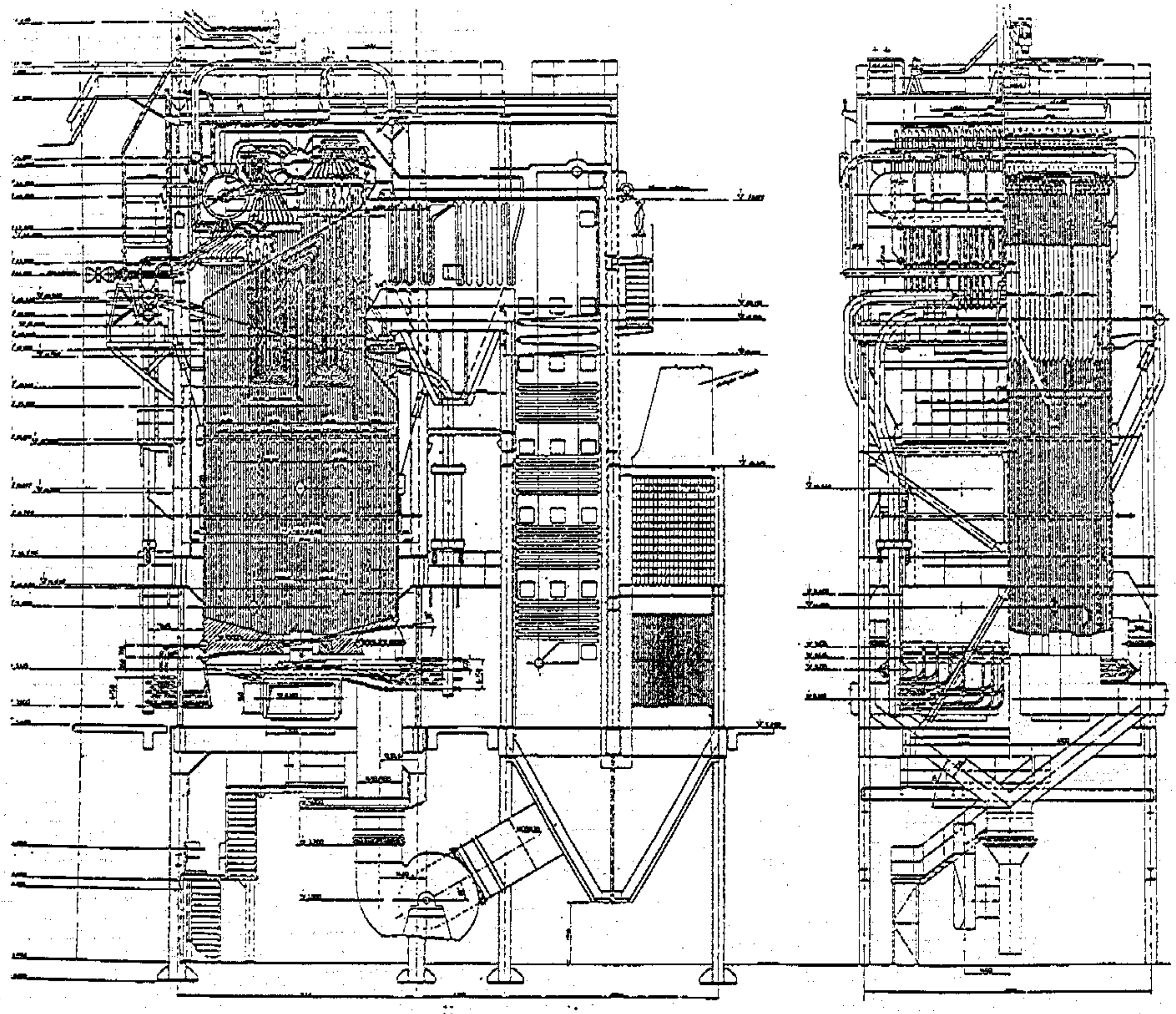


Figure 5.1.1 Lateral view of 100-M boiler after fuel conversion



Prepared by : GEA/EGI Rt. & TRE/Ganz-Röck Rt. Consortium

Figure 5.1.2 Lateral view of 100-R boiler after fuel conversion

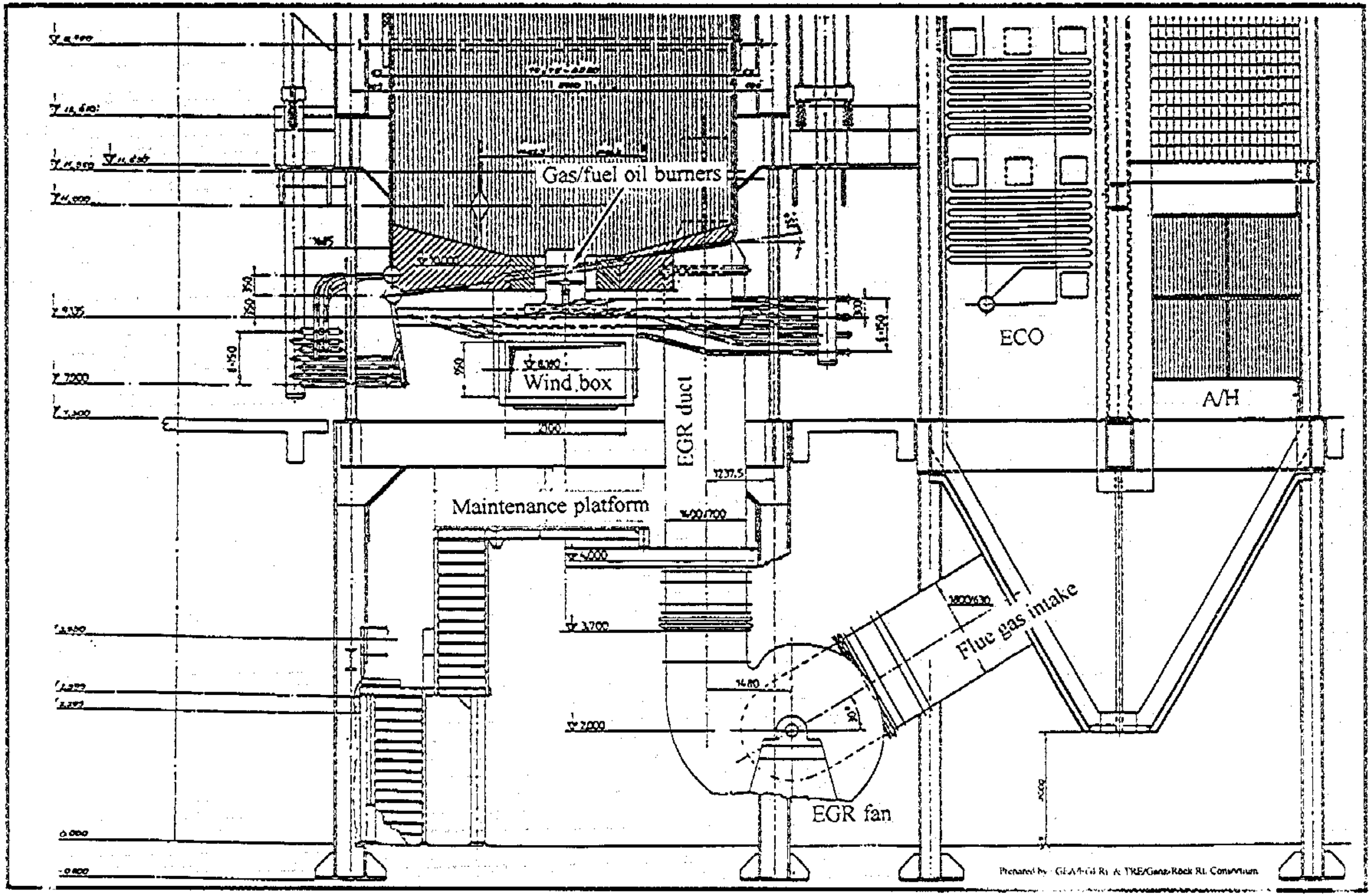


Figure 5.1.3 Layout of burners and EGR system

b) EGR Ducts

Exhaust gas recirculation (EGR) ducts will be connected to the ash discharge funnels of the existing economizers (ECO) in the second pass. The ducts running through draft EGR fans will be divided into two and connected to the both sides of each boiler bottom.

The volume of EGR gas is 50,000 Nm^3/h (310 °C)

c) Others

Careful calculations of the second and third (half) pass will ensure the proper dimensioning of ECO and AH surfaces.

(2) Firing Equipment

1) Input Heat

The heat input of gas / fuel oil burners ware calculated based on the boiler loads of 100 and 110 t/h and the results are shown below.

	Heat input MWth	
Boiler load	net	gross
100 t/h	72.0	78.5
110 t/h	79.5	86.4

Based on the results, the maximum capacity of two burners to be installed will be 90 MWth.

Main parameters presented by burner manufacturers are shown in Table 5.1.1.

Table 5.1.1 Parameters of the Gas/Fuel Oil Burners

Item		A	B	C
Output		2x 45 MW	2x45 MW (82 nom.)	2x41 MW
Consumption	gas	2x5,200 m^3/h	2x4,528 m^3/h	2x4,354 m^3/h
	oil	2x4,300kg/h	2x3,860 kg/h	2x4,354 kg/h
Pressure	gas	1.0 barG	1.05 barG	1.05 barG
	oil	12.0 barG	18.0 barG	12.0 barG
Atomised by		steam	steam	steam
Emission NO_x	oil	120 mg/Nm^3	250 mg/Nm^3	250 mg/Nm^3
	gas	120 mg/Nm^3	200 mg/Nm^3	200 mg/Nm^3
Emission CO	oil	100 mg/Nm^3	100 mg/Nm^3	170 mg/Nm^3
	gas	100 mg/Nm^3	100 mg/Nm^3	100 mg/Nm^3

2) Outline of Emission Standard

Values shown in Table 5.1.12 are emission standards which KTM plans to establish. The bill concerning the emission standards was approved by the parliament in spring, 1996 and is to come into force in 2005.

Table 5.1.2 Planned Emission Standard (2005)

(mg/Nm^3)

Pollutant	Liquid fuel	Gaseous fuel
Soot & dust	50	5
CO	175	100
NOx as NO_2	350	200
SO_2	1,700	35
HCl	30	-
HF	5	-
Metals and arsenic *	2	-

note; * including Cd, CO, Cr, Ni, Pb, V and As
These values are in mg/Nm^3 for dry flue gases of 273 K temperature, 101.3 kPa pressure and 3 % O_2 content.
Liquid fuel: 15≦Pth<100MWth, Gaseous fuel: 15≦Pth

3) Emission Level of Low-NOx Burners

The renovation of the boilers to the type of gas / oil combustion will result in much better emission level, compared to that of present coal combustion.

Guaranteed emission values by burner manufactures are shown in Table 5.1.3 (at 3 % O2 content).

Table 5.1.3 Guaranteed Emission Value by Burner Manufactures

Type of burner	Fuel	NO_x (mg/Nm^3)	CO (mg/Nm^3)
A	oil	120	170
	gas	120	100
B	oil	250	100
	gas	200	100
C	oil	250	170
	gas	200	100

* Concentration of SO2 are depending on the sulfur content in fuel.

These burners apply EGR as the low-NOx technology. EGR recirculates a part of combustion air with venturi effect by the feed velocity of primary combustion air and enables to reduce a few percent of the concentration of oxygen in combustion air. Reduction of the concentration of oxygen causes incomplete combustion and flame temperature lowers. As a result, the generation of thermal NOx is controlled. In order to suppress the generation of CO and complete the combustion, secondary air is fed to the latter part of flame.

Supposing the maximum volume of exhaust gas is 102,435 Nm^3/h (with 3 % O_2), and the sulfur content of fuel oil is 1.0 %, the amount of SO_2 to be emitted is as follows:

SO_2 : 1,452 mg/Nm^3, or 149 kg/h

When two boilers connected to the same stack fire fuel oil, the category of the standard will be changed. The SO_2 emission standard for the stack is calculated as follows:

$3,650 - 90(MWth) \times 2 \times 6.5 = 2,480\ mg/m^3$

Consequently, these gas / fuel oil burners can meet the emission standards to be introduced in 2005.

(3) Combustion Air and Flue Gas System

Combustion air and exhaust gas systems after the reconstruction of the existing boilers are shown in Figure 5.1.4.

1) Combustion Air

Two combustion air fans (FDFs) at the existing boilers are in operation and are located at the elevation of 7.3 m on both sides of the boilers. Specifications of existing FDF are shown in Table 5.1.4

Table 5.1.4 Specifications of Existing FDF

Type	DMG 70/1410
Air quantity	72,000 m^3/h
Pressure head, total	57.6 mbar
Air temperature at inlet	60 °C
Drive	200 MW (380 V)

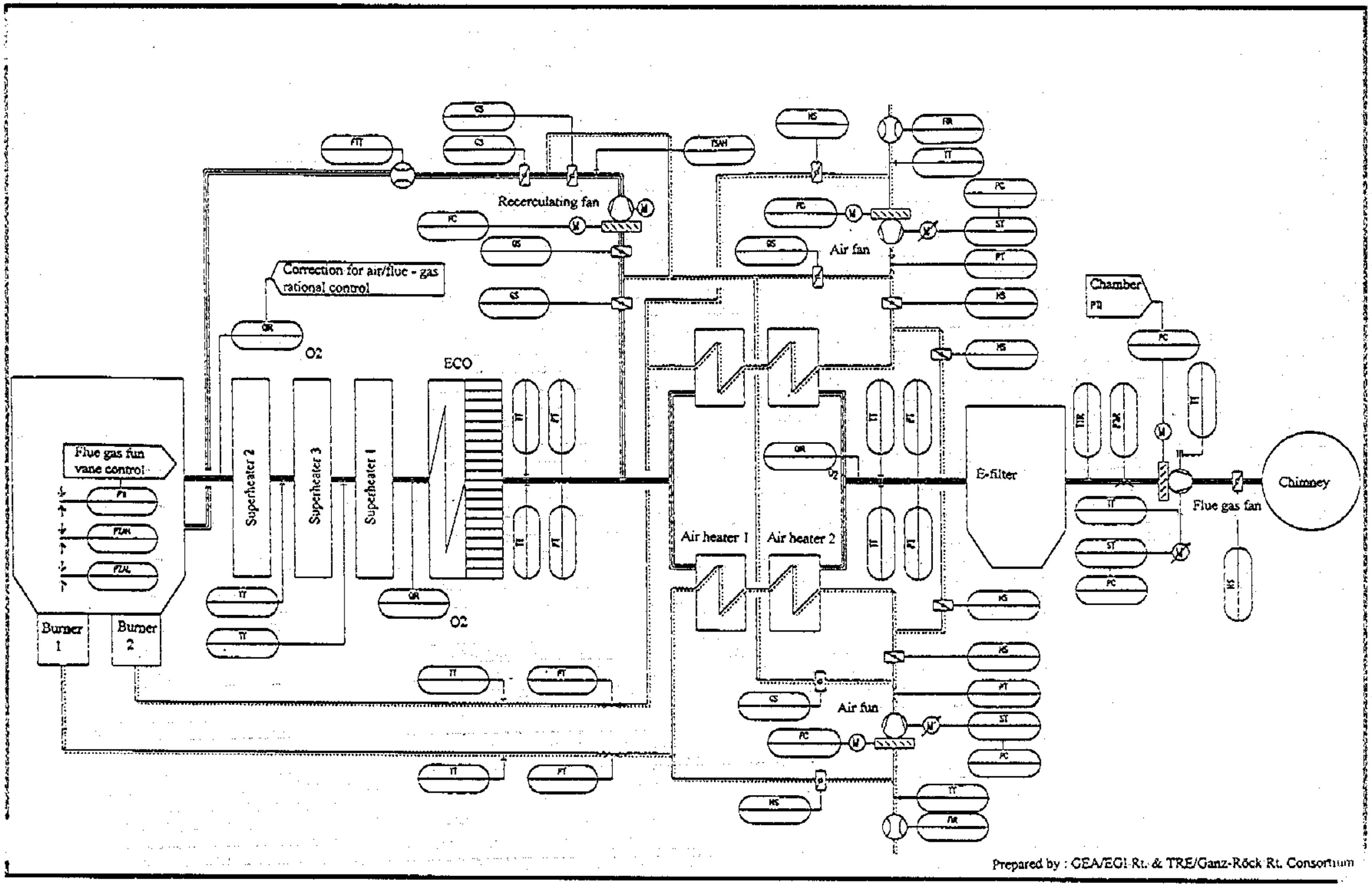


Figure 5.1.4 Combustion air and flue gas system after fuel conversion

After the reconstruction, the maximum air demand with 60 °C air temperature is 35 m^3/s (17.5 m^3/s for each fans). The needed air pressure before the burners (fully open dampers) 25-35 mbar according to specifications of the burner suppliers. Taking into account the total loss of the duct-work as 15-20 mbar, the necessary pressure head is 40-55 mbar. Based on the Δp-Q curves of the fans, air volume of 17.5 m^3/s can be delivered with a 55.6 mbar static pressure head.

The control of the fans will be done by the new frequency- converters and vane control system. The driving motors are also replaced.

2) Flue Gas System

One flue gas fan (IDF) at the existing boilers is in operation.

Table 5.1.5 Specifications of Existing IDF

Type	KVPD-212/212	
Flue gas volume	315,000	m^3/h
Total pressure head	32.06	mbar
Nominal flue-gas temperature	180	°C
Driving motor	420	kW

After the reconstruction, the design point of operation will be 165 °C temperature and 60 m^3/s flue gas volume with 30 mbar static pressure difference. This point results in very low (70-72%) efficiency, and the motor output should be increased by 35 - 39 kW. Therefore, new gears and frequency converters are needed. This fans operates with 81-82 % efficiency.

3) EGR System

Due to the lower specific flue gas volume (compared to that of PCF) a new flue gas recirculation fan and its system are newly installed.

Design requirements for EGR fan.

EGR gas flow	29.5	m^3/s
Static pressure	8	mbar
Gas temp.	310	°C

As the EGR volume depends on the boiler load, it's controlled by vain control.

Flue gas recirculation fan: 1 piece.

q	=	29.15	m^3/s	(49,998 Nm^3/h)
p_{st}	=	800	Pa	
ρ	=	0.587	kg/m^3	
t	=	300	°C	
q_{min}	=	10	m^3/s	(17,150 Nm^3/h)

Flue gas is taken from the hopper under the ECO and connected to the bottom of side walls

4) Connection of Stacks and Boilers

Exhaust gas ducts of the existing boilers are connected to three stacks of 101 m as follows:

Boiler: Nos.1-2-3	Chimney: No. I.
Boiler: Nos.4-5-6	Chimney: No. II.
Boiler: Nos.7-8-9 -10	Chimney: No. III.

After the reconstruction, the stacks will be connected as follows.

Boiler: Nos.5-7	Chimney: No. II.
Boiler: Nos.9-10	Chimney: No. III.

Regulations in Hungary do not permit connecting coal and gas fired boilers to the same stack. Therefore, it is necessary to connect boiler No. 7 to stack No. II in order to continue the operation of the boilers No. 5, 7, 9 and 10 in the future. Namely, the boilers No. 9 and 10 will continue firing pulverized coal until the start of reconstruction work.

This work determines the sequence of reconstruction as follows:

1) Reconstruction of boiler No.5
2) Connection of boiler No.7 to stack No. II, through the flue duct of boiler No.6
3) Sorting out of boiler No.4 and 6
4) Reconstruction of boiler No.7
5) Reconstruction of boiler No.9

6) Reconstruction of boiler No.10

On the other hand, the National Building Code prohibits discharging the exhaust gases of gas combustion and fuel-oil combustion through the same duct. Accordingly, it is necessary to consult with the competent government office (National Fire Service Headquarters) in advance, concerning the operation plan if the fuel in boilers No. 5 and 7 and that used in boilers No. 9 and 10 are different.

An outlined layout of boiler facilities in the boiler house after the renovation is shown in Figure 5.1.5.

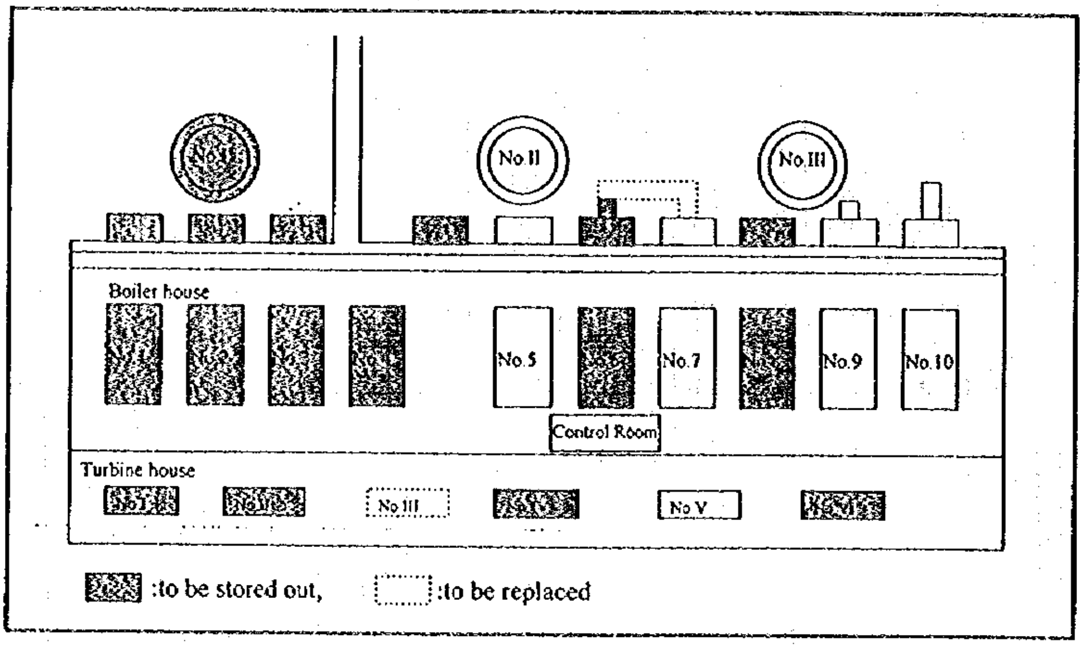
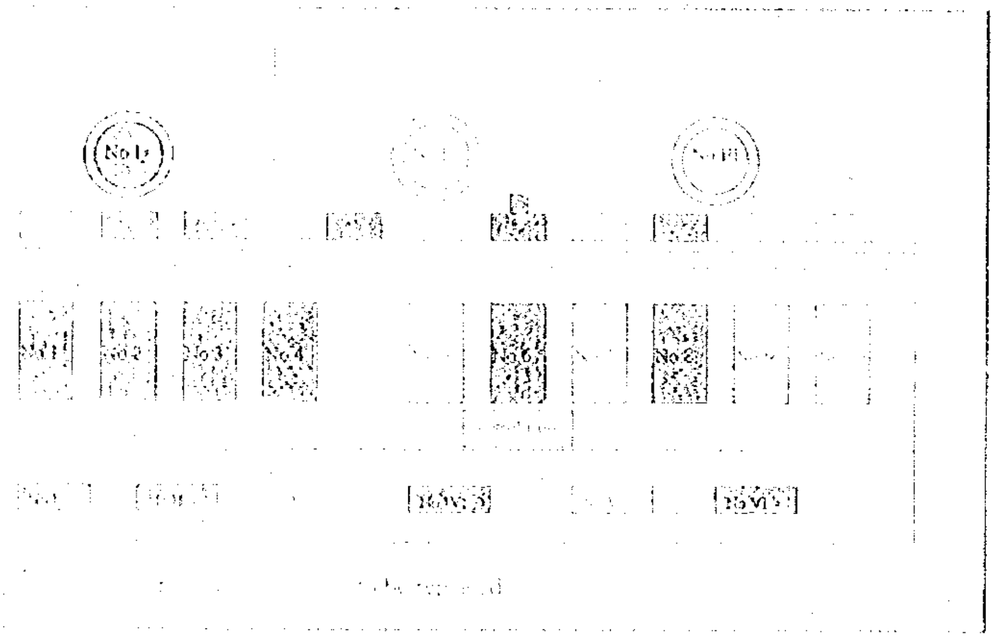


Figure 5.1.5 Outlined Layout of Existing Boiler Facilities after Renovation

[illegible] Reconstruction of boiler No.10

[illegible] Article [illegible] of the National Building Code prohibits discharging the exhaust [illegible] of gas combustion and fuel oil combustion through the same duct. Accordingly, it is necessary to consult with the competent government office (National Gas Service Headquarters) in advance, concerning the operation plan if the fuel in boilers No. 5 and 7 and that used in boilers No. 9 and 10 are different.

An outlined layout of boiler facilities in the boiler house after the renovation is shown in Figure 5.1.8.



[illegible] Outlined Layout of Existing Boiler Facilities after Renovation

5.2 Fuel Supply System

(1) Natural Gas Supply

At present the gas is supplied from the Miskolc-Ózd, so called Northern pipe line. Beyond the Plant site there is a high pressure gas reduction station run by the Gas Supply Company, which gives the gas at 6 barG pressure, led to the Plant on a pipe bridge through a 150 mm pipe. The low pressure reduction station is already within the Plant. The capacity of the station is maximum 15,000 m^3/h. At the second side the controlled pressure of the gas is about 2.3 barG. From this station the gas is led into the boiler house via a 200 mm pipe, where the metering devices are also located.

North Hungary Gas Pipeline system are shown in Figure 5.2.1.

The natural gas supply facility is used commonly by the renovated boilers and the new CFB boiler. Table 5.2.1 shows the consumption of the Plant during the modernization, taking into account the possible time schedule of the renovation and the gas consumption of coal fired units as well:

Table 5.2.1 Natural Gas Consumption of the Boilers During Reconstruction

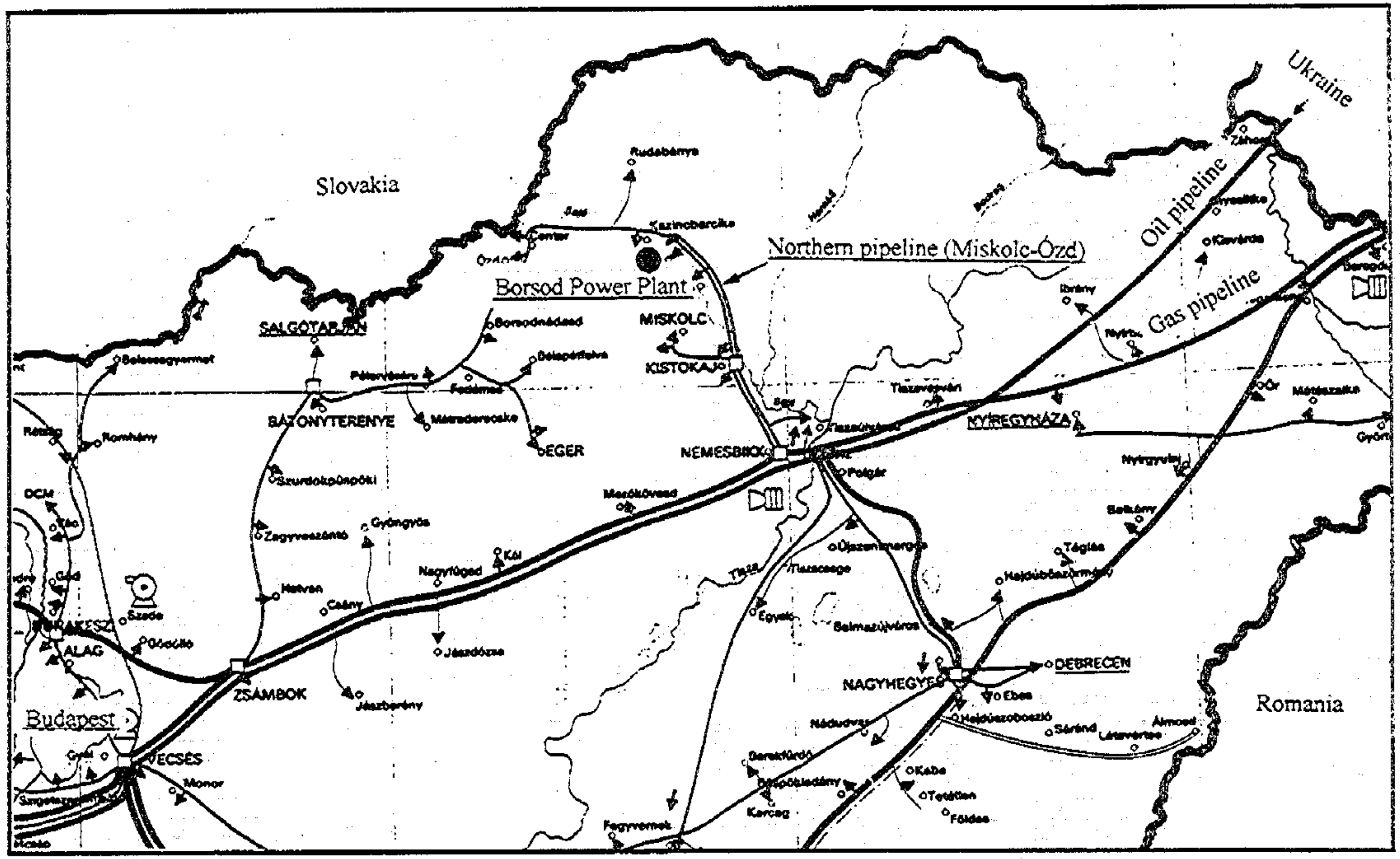
	Reconstructed boilers & fuel consumption		PCF boilers & fuel consumption		Total consumption
I.	1	9,154 Nm^3/h	5	7,000 Nm^3/h	16,154 Nm^3/h
II.	2	18,308 Nm^3/h	4	5,600 Nm^3/h	23,905 Nm^3/h
III.	3	27,443 Nm^3/h	3	4,200 Nm^3/h	31,643 Nm^3/h
IV.	4	27,443 Nm^3/h	-	-	27,443 Nm^3/h

Figure 5.2.2 shows the gas supply system in the boiler house. The gas consumption by three boilers in operation after the modernization is 27,443 Nm^3/h. Gas supply system in the boiler house is shown in Figure 5.2.3.

The pressure demand before the burners is 1 barG.

In case a decision is made on the early renewal of the existing units, it is practical to take into consideration the later demand of the modernization as well. In order to ensure safe operation of the new burners, only small modifications will be needed.

The optimum capacity should be 15,000 Nm^3/h and the second side pressure would be 2.3 barG.



Source MOL Rt.

Figure 5.2.1 Gas pipelines in North Hungary

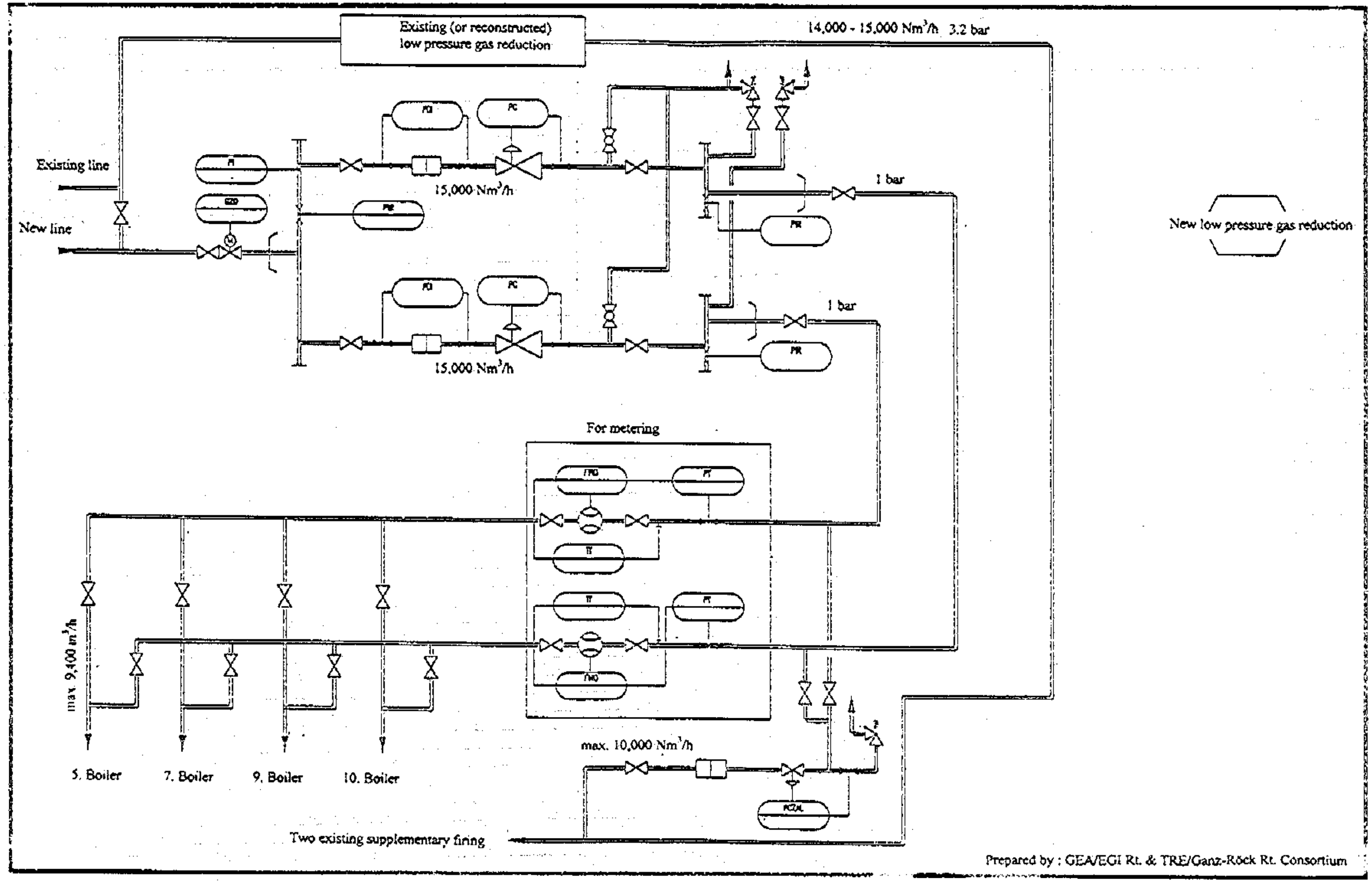


Figure 5.2.2 Gas supply system for existing boilers

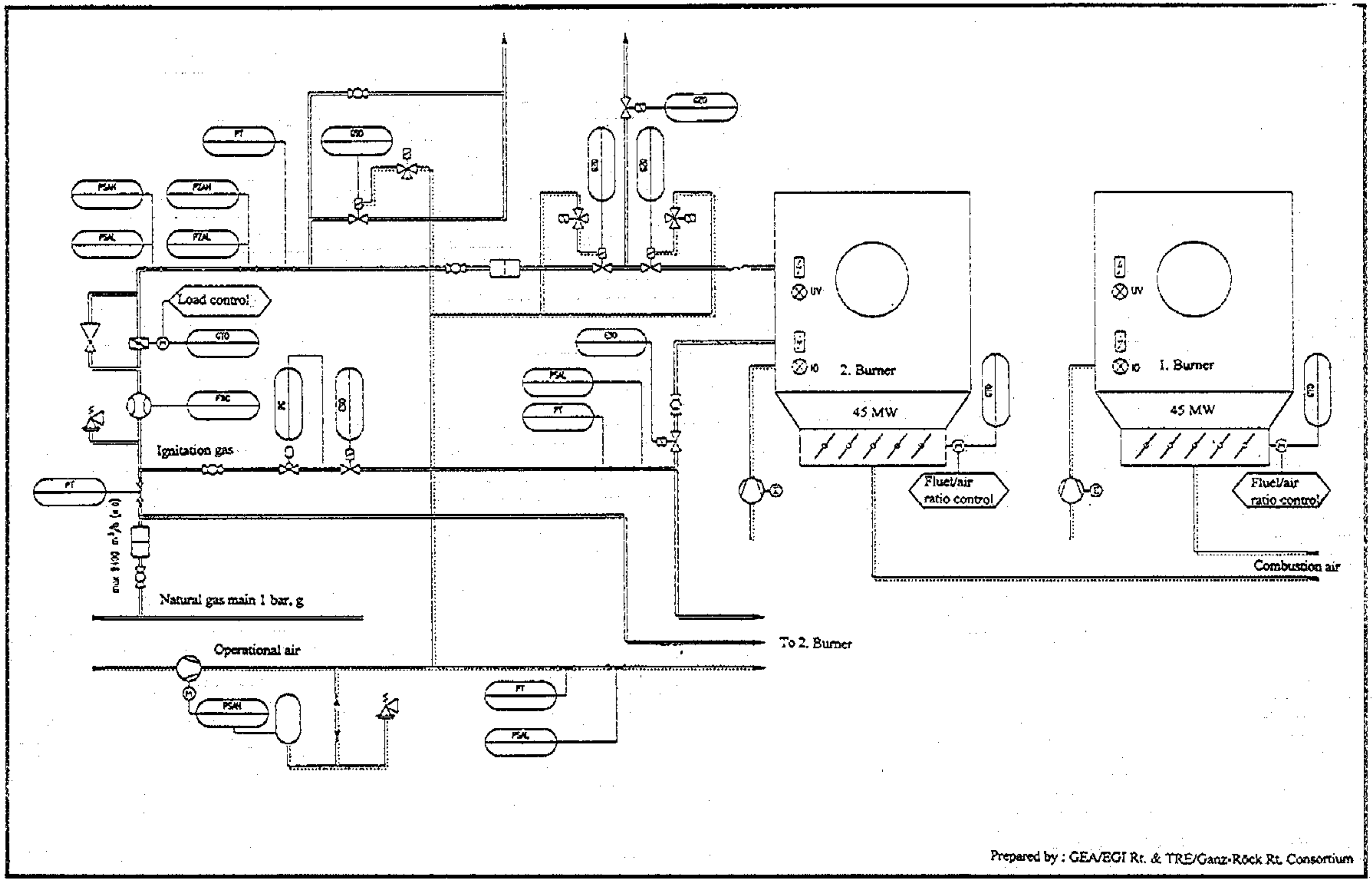


Figure 5.2.3 Gas supply system of boiler house

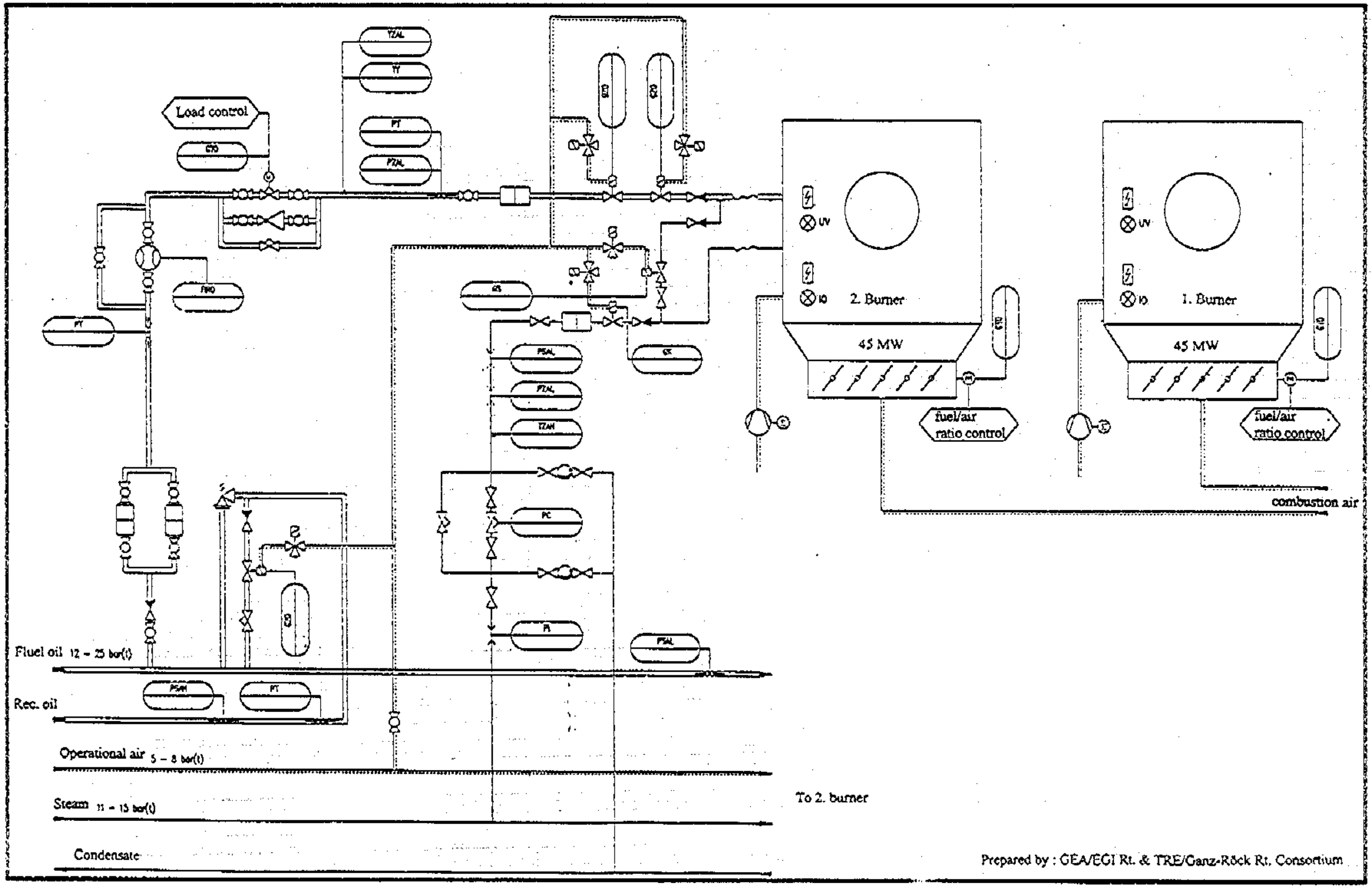


Figure 5.2.4 Fuel oil supply system of boiler house

Parts to be shared with new unit are described in the section of 4.3.

It is necessary to install two highly accurate measuring systems for controlling fuels. Necessary measuring devices will be installed so as to enable exact measurement of fuel consumption by each of the burners or by each of the boilers, depending on the boiler control system.

As the result of the early negotiations, the MOL Rt. is ready to sign a contract for fuel supply with Borsod Power Plant. It has to be stressed that in case of gas shortage Borsod Power Plant should be able to switch over to fuel oil.

(2) Fuel Oil Supply

Oil is only fired upon a sudden shortage of gas, or planned outage of the gas supply for start up or as supporting fuel. The existing oil system serves as auxiliary system of the coal fired boilers. It can not be used as the supply of the modernized boilers. Fuel oil supply system will be newly installed but shared with that of new 150 MW unit.

After the renovation, the oil demand for one boiler with the capacity of 110 t/h will be max. 7,439 kg/h, which means max. 22,242 kg/h with 3 boilers in operation. That is to say, the maximum daily consumption is approximately 510 t (it is about 600 m^3). Fuel oil consumption of the boilers during reconstruction is shown in Table 5.2.2.

Figure 5.2.4 shows fuel oil supply system of boiler house.

Table 5.2.2 Fuel Oil Consumption of the Boilers During Reconstruction

	Reconstructed boilers & fuel consumption		PCF boilers & fuel consumption		Total consumption
I.	1	7,439 kg/h	5	4,000 kg/h	11,430 kg/h
II.	2	14,860 kg/h	4	3,200 kg/h	18,060 kg/h
III.	3	22,242 kg/h	3	2,400 kg/h	24,642 kg/h
IV.	4	22,242 kg/h	-	-	22,242 kg/h

5.3 Turbines and Electrical Facilities

5.3.1 Existing State

Tables 5.3.1 through 5.3.5 shows the technical data of the existing turbines, generators, and transformers.

At present 9 units of steam turbines are installed, but turbine No. VIII is out of operation. These include both the condensing type and the back pressure type (Table 5.3.1).

The generators of the condensing turbines are original of GANZ manufactures, with nominal output of 44 MVA and the voltage of 10.5 kV (Table 5.3.2). Three of these for the operational turbines are connected to the 35 kV switch-gear.

The generators of the back-pressure steam turbines are working on the 120 kV switch-gear system (excluding No. VII which is connected to 35 kV).

5 of the above 6 generators (3 units of condensing turbines and two of back pressure turbines) can also be switched to the 10 kV collectors.

The 120 kV switch-gear is connected to the national grid via 3 lines, and the 35 kV switch-gear is directly connected to the industrial consumers.

The 120 kV and the 35 kV switch-gears are operated as a substation of ÉMÁSZ Rt, and this ensures the power supply directly from 120 kV to 35 kV station, too.

Each of the generators in the Plant is connected to one main transformer (Table 5.3.3). There is no existing bus-system in operation. Moreover each of the turbines, except No. X, has an auxiliary transformer (Table 5.3.4). For ensuring the safe supply of the self-consumption, two units of 35/3 kV auxiliary transformer are also in the system. The connection between the 120 kV and 35 kV systems is given by 4 units of coupling "K" transformers (Table 5.3.5).

5.3.2 Turbines

With reconstruction of the 4 boilers, turbines will be operated as follows:

1) Until the renovation works of boilers are completed, the existing turbines will be used with necessary maintenance works.

Table 5.3.1 Turbines

Turbine No.		I - IV	V	VI	VII	X
Manufacturer		Láng - BBC	Láng - BBC	Láng - BBC	Láng - BBC	Láng - BBC
Type		condensing	changing back pressure	extraction, back pressure	extraction, back pressure	extraction, back pressure
Output	MW	32	25	12.5	4.3	10
Revolution	rpm	3000	3000	3000	3000	3000
Steam inlet						
- quantity	t/h	130	112	200	90	90
- pressure	bar	71	71	71	71	71
- temperature	°C	485	485	485	485	485
Steam outlet						
- quantity	t/h	96.0	62.7	120 80	60 30	50 40
- pressure	bar	0.08	1.52	29.5_{-1}^{+2} 15_{-1}^{+2}	29.5_{-1}^{+2} 15_{-1}^{+2}	15_{-1}^{+1} 7_{-1}^{+2}
- temperature	°C	38	110	400 330/340	400 330/340	330/340 250
Extraction(s)		4	3			
Control		oil hydraulic	oil hydraulic	oil hydraulic	oil hydraulic	oil hydraulic
License of operation until		Dec. 31, 2001	Dec. 31, 2014	Dec. 31, 2014	Dec. 31, 2009	Dec. 31, 2014

Table 5.3.2 Generators

Coupled to Turbine		I, VI	II, IV, V	VII	X
Manufacturer		GANZ	GANZ	GANZ	GANZ
Type of generator		OG 930x3500/2	OG 930x3500/2	OF 760x1600/2	OF 760x1600/2
Nominal capacity	(MW)	32	30.8	6.6	6.6/12.8
Output	(MVA)	40	44	8.2	8.2/16
Voltage	(kV)	11	10.5	10.5	10.5/10.5
Cooling		air	air	air	air
Pressure of cooling water	(bar, g)	0.5	0.5	0.5	0.5
Excitation		rotational	rotational	rotational	rotational
Voltage of excitation	(kV)	0.12 - 0.145	0.12 - 0.145	0.12 - 0.145	0.12 - 0.145
Cooling of excitation		air	air	air	air

Table 5.3.3 Main Transformers

Location	I	II	III	IV	V	VI	VII	VIII	X
Manufacturer	GANZ	GANZ	GANZ	GANZ	GANZ	GANZ	GANZ	GANZ	GANZ
Type	KNTFV 40000/31	KNTFV 40000/31	DRFV 40001/120	KNTFV 40000/31	DRFV 40001/120	DRFV 40001/120	DRFV 8000/30	DRFV 8000/30	DRFV 40001/120
Output (MVA)	40	40	40	40	40	40	8.5	8.5	40
Voltage range (kV)	38.5/10.5	38.5/10.5	132/10.5	38.5/10.5	132/10.5	132/10.5	38.5/10.5	38.5/10.5	132/10.5
Cooling	oil / air	oil / air	oil / air	oil / air	oil / air	oil / air	oil / air	oil / air	oil / air

Table 5.3.4 Auxiliary transformers

Location	I	II	III	IV	V	VI	VII	VIII
Manufacturer	GANZ	GANZ	GANZ	GANZ	GANZ	GANZ	GANZ	GANZ
Type	KNFV 8000/30	KNFV 8000/30	KNFV 8000/30	KNFV 8000/30	KNFV 8000/30	KNFV 8000/30	ANT 1600/35	NALO 1600/10
Output (MVA)	8	8	8	8	8	8	1.6	1.6
Voltage range (kV)	10.5/3.15	10.5/3.15	10.5/3.15	10.5/3.15	10.5/3.1	10.5/3.1	10.4/0.4	10.5/0.4
Cooling	oil / air	oil / air	oil / air	oil / air	oil / air	oil / air	oil / air	oil / air

Table 5.3.5 35/3 kV and Coupling "K" Transformers

Location & Kind	I, 35/3	II, 35/3	I, "K"	II, "K"	III, "K"	IV, "K"
Manufacturer	GANZ	GANZ	GANZ	GANZ	GANZ	GANZ
Type	RNST 10000/35	RNST 10000/35	DHSV 40001/120	DHSV 40001/120	DHSV 40001/120	DHSV 40001/120
Output (MVA)	10	10	40	40	40	40
Voltage range (kV)	35/3.15	35/3.15	120/36.75	120/36.75	120/36.75	120/36.75
Cooling	oil / air	oil / air	oil / air	oil / air	oil / air	oil / air

2) By the end of 2003, turbines No. I, II, III, IV, VI, and X will be abolished, and a new 32 MW double extraction (29 bars and 15 bars) condensing type turbine will be installed in the place of No. III turbine. The new turbine will supply steam and, when necessary, generate power with the existing 40 MVA generator.

3) Turbines No. V and VII will be used for the district heating.

The main characteristics of the new turbine are shown in Table 5.3.6.

Table 5.3.6 Main Characteristics of the New Turbine

Installed capacity		MW	32	32
Outdoor air temperature		°C	0	25
Live steam	Pressure	bar	74.50	74.50
	Superheating	°C	500.00	500.00
	Mass flow	kg/s	70.35	33.00
Extraction 1	Pressure	bar	30.00	30.00
	Temperature	°C	387.89	437.39
	Mass flow	kg/s	30.55	7.20
Extraction 2	Pressure	bar	15.00	15.00
	Temperature	°C	310.08	355.32
	Mass flow	kg/s	12.00	3.80
Condenser	Pressure	bar	31.66	105.45
	Temperature	°C	25.00	46.88
	Mass flow	kg/s	8.32	13.42
	Steam flow, volume	m^3	308.28	170.46
	Cooling zone	K	3.00	5.05
	Temperature gradient	K	10.00	16.82
Cooling water	Mass flow	kg/s	1,383.24	1,383.24
	Temperature(cold)	°C	12.00	25.00
	Temperature (warm)	°C	15.00	30.05
Feed water tank	Pressure	bar	13.50	100.00
	Temperature	°C	193.35	202.49
	Mass flow	kg/s	70.35	33.00
	Pressure	bar	100.00	100.00
	Temperature	°C	195.44	202.49
	Mass flow	kg/s	70.35	33.00
Power output		MW	31.99	19.82
Steam output		MW	132.50	35.33
Heat input		MW	180.77	83.76
Efficiency		%	90.99	65.85

Major works involved in the installation of the new turbines are as follows:

1) Construction of a turbine table as foundation
2) Installation of the turbine and auxiliaries
3) Tube connections

4) Provision of a control panel and connection to the existing system
5) Miscellaneous works

5.3.3 Electrical Equipment

No significant changes are required for generators and transformers.

(1) Electrical Power Demands and General Description

Simultaneous power demands after boiler conversion are as follows:

- per boiler	610 kW
- common type consumers of boilers	70 kW

The above ratings are distributed as follows:

- at 0.4 kV main boiler distributor, per boiler	570 kW
- at boiler distributor, per boiler	40 kW
- at general distributor,	
- power supply of common type consumers	70 kW

Available power output due to eliminated coal-firing:

- at main boiler distributor, per boiler	1,260 kW
- at 3 kV, due to elimination of flue gas fan, per boiler:	336 kW
- at boiler distributor, per boiler:	12 kW

The mill legs on the 0.4 kV main boiler distributor will be eliminated in the course of the renovation. The Ward-Leonard drive has been removed previously.

The flue gas exhausting and air fan motors are supplied via frequency converter. Protection class of the frequency converter is IP54; it is placed in the 0.4 kV switching room.

Cooling of the switching room of the frequency converters is solved through 4 pcs of DENCO AIR unit and the related distributor and bus bars. This technical solution provides cooling without fresh air supply, thus there's no coal dust in the room and no filtering is required. The air space of the switching room should be separated from the air space of the boiler house.

The motor stop-valves of feed pumps in the oil pump house and the motor stop-valves of the boiler-house gas system are all designed to be intelligent drives. Local control boxes have been designed for testing plant operation of motors in the process control system.

(2) 0.4 kV Main Distributor and Boiler Distributor

At both distributors, the power supply of new distributors can be provided by utilization and possible alteration of the branches of eliminated consumers.

The flue gas fan and the air fan are connected to the 0.4 kV main distributor, while the other branches will be used as reserves. The air fan is connected to the current motor branches, while the flue gas fan is connected to the branch of an eliminated mall. Only the reductor in the flue gas fan branch of the distributor must be replaced.

A complete new jig design is only necessary for the branch of the flue gas recirculation blower motor in the boiler house. As far as the other consumers are concerned, the thermoswitch and possibly the fuse element has to be replaced.

(3) Power Supply for Common Consumers

A new switchboard must be installed within the building of the oil pump house for such consumers as the new oil pump plant, the air compressor, control unit of burner combustion. and the main motor stop-valve of the gas system. Cast aluminium construction is recommended. The distributor in the oil pump house will be supplied from the so-called station auxiliary switchboard. The main switch, which isolates the electrical power transmission equipment and the internal lighting of the building, will be installed outside the oil pump house, on the external wall of the building.

Also the power for the main gas stop-valve and the air compressor will be supplied via the station auxiliary switchboard.

Bilateral input of the station auxiliary switchboard is possible from one branch of the general distributor, each. The branch is equipped with isolator and break switch and the use of an automatically controlled changeover switch is proposed.

For the station auxiliary distributor, the existing VERTESZ distributor between boilers No. 5 and No. 6 located in the 0.4 kV switching room will be utilized.

5.3.4 Control System

The automization level of the operation of the reconstructed boilers is defined as follows:

- fully automatic continuous operation
- protective functions are activated without operator intervention in any mode
- start-up and scheduled shut-off of boilers and change of reference signal is carried out through operator interventions
- the boiler assigned by the competent manager of the boiler plant automatically regulates the bus bar pressure. (Any one of the conversed boiler will do.)

It is proposed to introduce a process control system built of advanced electronic, programmable units.

Operation is controlled exclusively from operator's consoles via monitor, keyboard, cursor control (mouse). Consequently, the traditional control panel and back panel setup is omitted, only the essential emergency buttons remain at the necessary places.

There will be five coordinate operator's consoles in a common control room, each suitable for interrogation and control of any boiler and common-mode equipment.

Display, logging and archiving of operational mode and interference is also performed by the process control unit, which provides efficient processing and analyzing functions. It renders the current error detecting system (developed only 5 years ago) unnecessary.

Figure 5.3.1 shows the structure designed on basis of the above described targets. Each boiler and common-mode secondary system has its own process control unit. These are connected through high-speed industrial data bus to each other (although they scarcely have data traffic between each other) to the operator's consoles in the control room and to the printers. This configuration allows equal operability of the consoles and thus requires relatively less monitors. If a task requires several operators and schemes for any boiler (such as start-up, clearance of breakedown), then simultaneously four or five consoles can be engaged to solve the problem.

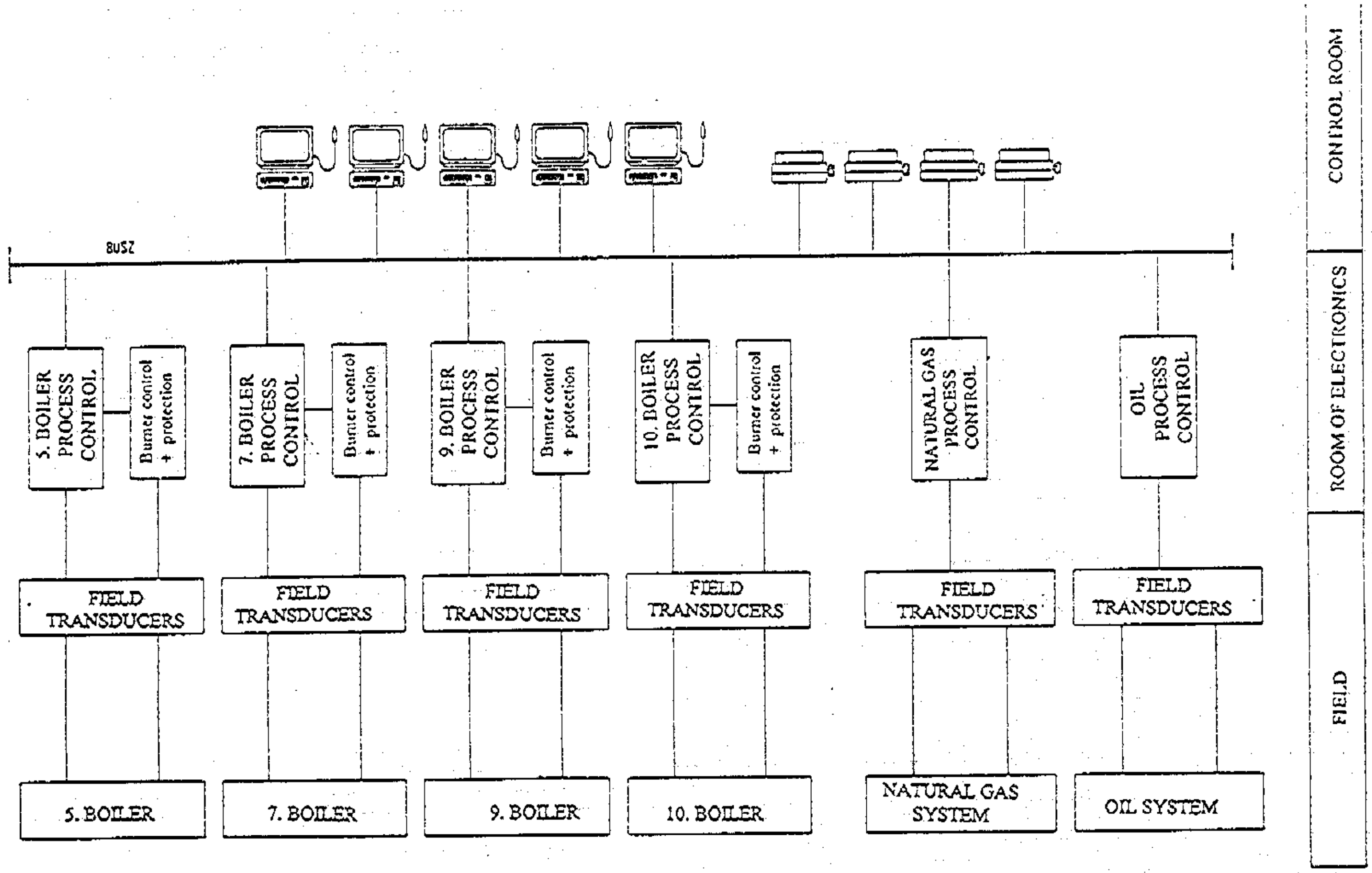


Figure 5.3.1 Concept of Control System

In case of the boilers, there is a separate unit assigned to functions requiring special safety (burner control, protections). This unit should have an appropriate qualification by competent authorities; it communicates with the boiler's process control unit via simple serial line (and via a few input/output signals). This channel ensures delivery and display of messages and operator's command to the operator's consoles.

Required input/output of process control units is as follows:

Boiler process control unit (without burner control, for one boiler only):	
Analogue input:	136
Binary input:	512
Analogue output:	16
Binary output:	96
Natural gas system:	
Analogue input:	8
Binary input:	64
Binary output:	32
Oil system:	
Analogue input:	8
Binary input:	96
Binary output:	64

The oil and gas receiving, storing and drawing stations do not require their own control unit, not even a monitor, as their process control unit communicates via data transmission channel; the schemes can be retrieved and manipulated on the monitor of any one of the boilers.

It seems practical to fit up the existing operating room II for the purpose of common control room of boilers and the two common-mode secondary systems. The operator room is along the partition wall of boiler house and turbine house, between the main pillars D11-D13, its dimension being 19,40 m x 4,50 m.

Field communication of the process control units is solved via field adapters, which can be simple switchboxes or remote peripheral devices of the process control unit.

Special attention should be paid to UPS of process control units and relevant peripheries. In order to provide 220 V uninterrupted power supply (monitors, printers etc.), a compact UPS unit is provided for each boiler and each common-mode secondary system, all placed in the room of electronics.

Chapter 6

Environmental Assessment and Protection Measures

Chapter 6 Environmental Assessment and Protection Measures

6.1 Summary

6.1.1 Present Environmental Conditions

(1) Ambient Air

1) With emission from Borsod Power Plant, SO_2 exceeds the environmental criteria.

2) The situation of air pollution has not been improved since 1993 when the air pollution control study by JICA was conducted in Sajo valley area.

(2) Groundwater

1) The groundwater pollution by Borsod Power Plant is limited to ions and arsenic (As) contaminations. The As concentration is high only near the sludge storage.

2) Yearly changes in the quality of the groundwater around the wells for water supply show decrease in NO_3^- and NH_4^+, and increase in conductivity, Cl^- and Na^+. The pH values is decreasing. SO_4^{2-} values vary depending on the wells.

3) High concentrations of ions including SO_4^{2-} and Cl- are found in Borsodszirak I/A. Further deterioration in the quality of water in the future may occur.

(3) River Water

1) The water quality of Sajo river has been rapidly improved from the serious contamination in the past. The concentrations of the both heavy metals and ions are low. The water quality of Bodva river is better than that of Sajo river .

2) No serious contamination is found in the sediment of Sajo river.

3) As and ions concentrations in Holt-Szuha River are affected by leachate from the sludge storage.

4) In Sajo River, the problem of thermal efferent from the cooling system is evident.

(4) Soil

1) Heavy metal contaminations in soil are found around the waste dumping and storage sites. Heavy metal pollution by Borsod Power Plant is limited to As contamination.

2) In the floodplain of Sajo river, the concentrations of heavy metals are high, affected by the previous industrial pollution of Sajo river.

3) At several points near Borsod Power Plant, the As concentration in soil exceeds the limit value specified in the soil and groundwater protection regulation.

(5) Natural Environment

1) Due to social and economic activities, many of natural plants and animals in this area have disappeared.

2) Species sensitive to environmental pollution have disappeared, and precious species can be no longer found in this area.

3) Aquatic life in Sajo river are gradually recovering.

4) Emissions from Borsod Power Plant and other sources are affecting national parks and nature conservation areas.

6.1.2 Environmental Impact Assessment

(1) Ambient Air

1) According to the short-term (30 minutes) prediction, even though the emission standards to be enforced on January 1, 2005 are met by Borsod Power Plant, the SO_2 concentration will exceed the environmental quality standards for protected areas II (400 Mμ/m^3 or 150 ppd) in some cases, if domestic coal or mixed coal with imported coal is used.

2) According to the prediction of the heating reason average pollutant concentrations, SO_2 concentration will exceed the environmental standard for protected areas I (70 μg/m^3 or 26 ppb) in large areas. The even when the planned protection measures are taken in the Power Plant NOx concentrations will meet the standard for protected areas I (100 μg/m^3 or 52 ppb). For SO_2, it is necessary to take measures for other sources than Borsod Power Plant.

3) The results of downwash analysis suggest that the height of newly constructed chimneys should be 130 m.

4) Stagnation modeling analyses were made for the case where a CFBC boiler is used for the new 150 MW unit and the existing boilers are converted to the natural gas firing type. The contribution of Borsod Power Plant to the SO_2 concentration at the maximum point is 32 ppb under the full load operation. The contribution is substantially reduced from the present. The maximum 30-minute SO_2 value satisfies the standard for protected areas II (400μg/m^3 or 150 ppd), but the background concentration itself exceeds the standard for protected areas I (250 μg/m^3 or 94 ppd). I (0.25 mg/m^3).

(2) Groundwater

1) Actual flow velocity of groundwater is 0.42 m/day. It will take about 40 years for the whole presently contaminated water to move to the source wells of water supply in Borsodszirak I/A.

2) It is estimated to take about 50 years for the groundwater quality to recover to conform the protection criteria for drinking water even though complete measures for preventing the groundwater are put into practice.

(3) Soil

1) It is important to take measures for preventing new contamination from occurring. Except for several sites with high concentration, there is no practical measures for clean-up. The situation will improve gradually over the years by natural remediation process.

2) The remediation of high concentration sites helps the recovery of the groundwater quality.

(4) Natural Environment

1) It is necessary to take measures for creating better environment as well as environmental protection measures.

2) A large amount of waste from Borsod Power Plant shall be treated not to damage the natural environment.

6.1.3 Environmental Protection Measures

For protecting environment, the following measures are recommended.

(1) Ambient Air

1) To apply the CFBC technology to the boiler of the new unit and to convert the existing boilers to the natural gas firing type.

2) The height of the stack originally planned to be 125 m should be changed to 130 m to prevent the down wash phenomenon.

3) For preventing coal ash scattering from sludge storage, soil coverage and planting are proposed.

(2) Groundwater and Soil

1) For sludge handling, a thick sludge transport system where sludge is transported through pipes should be used. Sludge should be stored inside impermeable sheets for preventing groundwater contamination. (The use of thick sludge transport system only can not prevent groundwater contamination.)

2) The wastewater from the deminalitation plant is temporarily stored, after neutralization, in reservoirs with impermeable sheets and discharged with other effluent. The study team recommends a discharge system where waste liquids are discharged according to the conditions of Sajo river and the sewerage system.

3) Strict control of illegal waste dumping

(3) River Water

Closed cooling water system should be employed to minimize the effect of thermal effluent.

(4) Vegetation

1) The above measures for air, groundwater, soil and river water should be strictly implemented.

2) It is recommended to construct wetland between Holt-Szuha river and the sludge storage area to create semi-natural vegetation.

(5) Environmental Protection During Construction

1) Prevention of water pollution in Sajo River caused by construction works
2) Observation of the rules and regulations applicable in Hungary

6.1.4 Environmental Monitoring Plan

Environment monitoring shall be performed as follows.

(1) Environment Monitoring During Construction

Environmental impacts of the construction should be properly monitored in conformity with the present rules and regulations in order to minimize the impacts.

(2) Environment Monitoring After Commissioning

1) Flue gas monitoring

2) Ambient air pollutant concentration monitoring

3) Establishment of a continuous monitoring network by combining 1) and 2) above.

4) Groundwater monitoring

5) Periodical monitoring of wastewater, noise, and traffic volume

6.2 Environmental Quality Standards and Emission Standards

Various environmental standards are established in Hungary. Regarding emission standards for exaust gas, the new standards will take effects on January 1, 2005.

The outlines of major environment and emission standards are as follows. The details of standards are setout in the Supporting Report.

6.2.1 Air Quality

Proposed Future Technological Emission Limit Values concerning New Firing Equipment Operated with Solid Fuels in Hungary is shown in Tables 6.2.1and 6.2.2. Standard of Air Pollutant is shown in Table 6.2.3.

Table 6.2.1 Proposed Future Technological Emission Limit Values concerning New Firing Equipment Operated with Solid Fuels

Input heat Load: P_{th} (MW_{th})

Air Pollutant	Emission Limit Value (mg/m^3)[(4)]		
	15-100 MW	100-500 MW	>500 MW
Solid Material	100	50	50
CO	250	250	250
NOx (given in NO_2)	600 [(1)]	400 [(1)]	400 [(1)]
SO_2 and SO_3 (given in SO_2)	2000[(2)]	2400 - 4 x P_{th}[(3)]	400
Chlorides (given in HCl)	200	100	100
Fluorides	30	15	15

Notes :

(1) In case of domestic lignite maximum 300 mg/m^3 (calorific value: <7000kJ/kg≒1700 kcal/kg), 200 mg/m^3 for fluidized bed combustion.

(2) In case of firing domestic coal 2,000 mg/m^3, or at least 60 % Desulphurating efficiency

(3) Limit value except for the following conditions is obtained by interpolating interval between the value for [15-100 MW] and that for [>500 MW]

- In case of firing domestic brown coal and lignite, at least 90% desulphurating efficiency.
- In case of firing imported coal maximum 400 mg/m^3.
- In case of Fluidized Bed Combustion Boiler using domestic coal, at least 85% desulphurating efficiency.

Concentration given in mg/m^3 refer to dy smoke-gas with 6% O_2 content at a nomal state (273 °K, 101.3 kPa)

Table 6.2.2 Proposed Future Technological Emission Limit Values concerning New Firing Equipment Operated with Gaseous Fuels

Input heat Load : P_{th} (MW_{th})

Air Pollutant	Emission Limit Value (mg/m^3) >15MW
Solid Material	5
CO	100
NOx (given in NO_2)	200
SO_2 and SO_3 (given in SO_2)	35

Note : Concentration given in mg/m³ refer to dry smoke-gas with 3% O_2 Content at normal state (273K,101.3kPa).

Table 6.2.3 Standard of Air Pollutant in Hungary

Air Pollutant	Concentration (mg/m^3) [(ppm 20°C)]		
	Specially Protected Area	Protected Area I	Protected Area II
SO_2			
- Annual average	0.030 [0.011]	0.070 [0.026]	0.100 [0.038]
- 24-hours average	0.100 [0.038]	0.150 [0.056]	0.300 [0.113]
- 30-minutes value	0.150 [0.056]	0.250 [0.094]	0.400 [0.150]
NO_2			
- Annual average	0.030 [0.016]	0.070 [0.037]	0.120 [0.063]
- 24-hours average	0.070 [0.037]	0.085 [0.044]	0.150 [0.078]
- 30-minutes value	0.085 [0.044]	0.100 [0.052]	0.200 [0.105]
NOx			
- Annual average	0.030 [0.016]	0.100 [0.052]	0.150 [0.078]
- 24-hours average	0.070 [0.037]	0.150 [0.078]	0.200 [0.105]
- 30-minutes value	0.085 [0.044]	0.200 [0.105]	0.400 [0.209]
SPM			
- Annual average	0.030	0.050	0.100
- 24-hours average	0.060	0.100	0.200
- 30-minutes value	0.100	0.200	0.300
Dust			
- Monthly total (g/m^2/30days)	12	16	21
- Annual total (g/m^2/year)	100	120	150

6.2.2 Soil, Grand-water and Drinking Water

Limit Value of Soil by Category for Protection of Grand-water is shown in Table 6.2.4. Limit Values for Toxicological Substances in Drinking Water is shown in Tables 6.2.5 and 6.2.6.

Table 6.2.4 Limit Value of Soil by Category for Protection of Grand-water

(unit : mg/kg)

	A	B	C_1	C_2	C_3	Prohibited Material
Chromium	30	100	150	400	800	T2
Copper	30	100	200	300	400	T2
Zine	100	250	500	1000	2000	T2
Arsenic	10	15	30	40	60	T2
Cadmium	0.5	1	2	5	10	T1
Mercury	0.15	0.5	1	3	10	T1
Lead	25	70	100	500	600	T2

Table 6.2.5 Limit Values for Toxic Substances in Drinking Water

Parameter	Unit	Limit Values	
		Adequate	Tolerable
Specific electric conductivity	μs/cm	1350	1600
pH	pH	7.0 ~ 8.0	6.8 ~ 8.5
Total dissolved substance	mg/l	1000	1200
Sulphate	mg/l	200	300
Iron	mg/l	0.2	0.3
Copper	mg/l	0.2	1.0
Zine	mg/l	0.2	1.0
Natrium	mg/l	200	-
Arsenic	μg/l	50	
Total mercury	μg/l	1	
Cadmium	μg/l	5	
Total Chromium	μg/l	50	
Lead	μg/l	50	

Table 6.2.6 Drinking Water Standards for Groundwater

Parameter	Unit	Adequate	Tolerable
COD	mg/l	2.5	3.5
Chlorides	mg/l	80	100
Ammonium	mg/l	0.1	0.2
Nitrite	mg/l	0.1	0.3
Nitrate	mg/l	20	40

6.3 Present Environmental Conditions

6.3.1 Geographical Background and Other Conditions

(1) Study Area

Borsod Power Plant is located in one of the major industrial areas, but there are densely built-up housing areas nearby. This objective area has been continuously developed until today since a long time ago without sufficient consideration made for the environment. Figure 6.3.1 shows the land use in the area of Sajo valley at present. The vicinity of Borsod Power Plant forms almost flat topography at a height of 126 to 135 m above the level of Baltic Sea, and gently inclined toward south-southeast direction along Sajo river. There is a wide sludge storage area about 1,500 m north of Borsod Power Plant, and a standby sludge storage area and a wastewater reservoir about 1,000 m northwest. There are also other places where the waste from Borsodchem Co. is stored, and waste has been illegally dumped. (See Figure 6.5.10.)

Borsod Power Plant and other large-scale plants are located along Route 26, and used as a main artery together with a railroad running in parallel to these plants. The whole neighborhood of Sajo river surrounded by three mountain systems Borsod, Csaerhat and Bukk influences the weather.

(2) Geological conditions

The foundations in this area consist of the cumulus deposits in the Carboniferous period and the Triassic period. The axis of Sajo valley is formed by a groove with a width of 3 to 6 km and with a length of 35 to 40 km in the geological structure of Sajo valley.

The permeable layers in the whole neighborhood of Borsod Power Plant are in gravel. Some portions were mined and became ponds, but redevelopment is in gradual progress. According to the information the study team obtained, waste was dumped in some sites of mining in the past.

(3) Rivers

The Sajo river, the most important river in this area, is originated in Slovakia. Borsod Power Plant is located at a distance of 81 km from the origin. Power plants used the water from the Sajo river and the Bodva river. The water from the Bodva river is also used as tap water. The volume of water running the Sajo river changes extremely; the minimum is about 5 m^3/s and the maximum exceeds 500 m^3/s. The average volume of water during 1968 through 1977 and in 1996 was 37.3 m^3/s and 27.8 m^3/s, respectively.

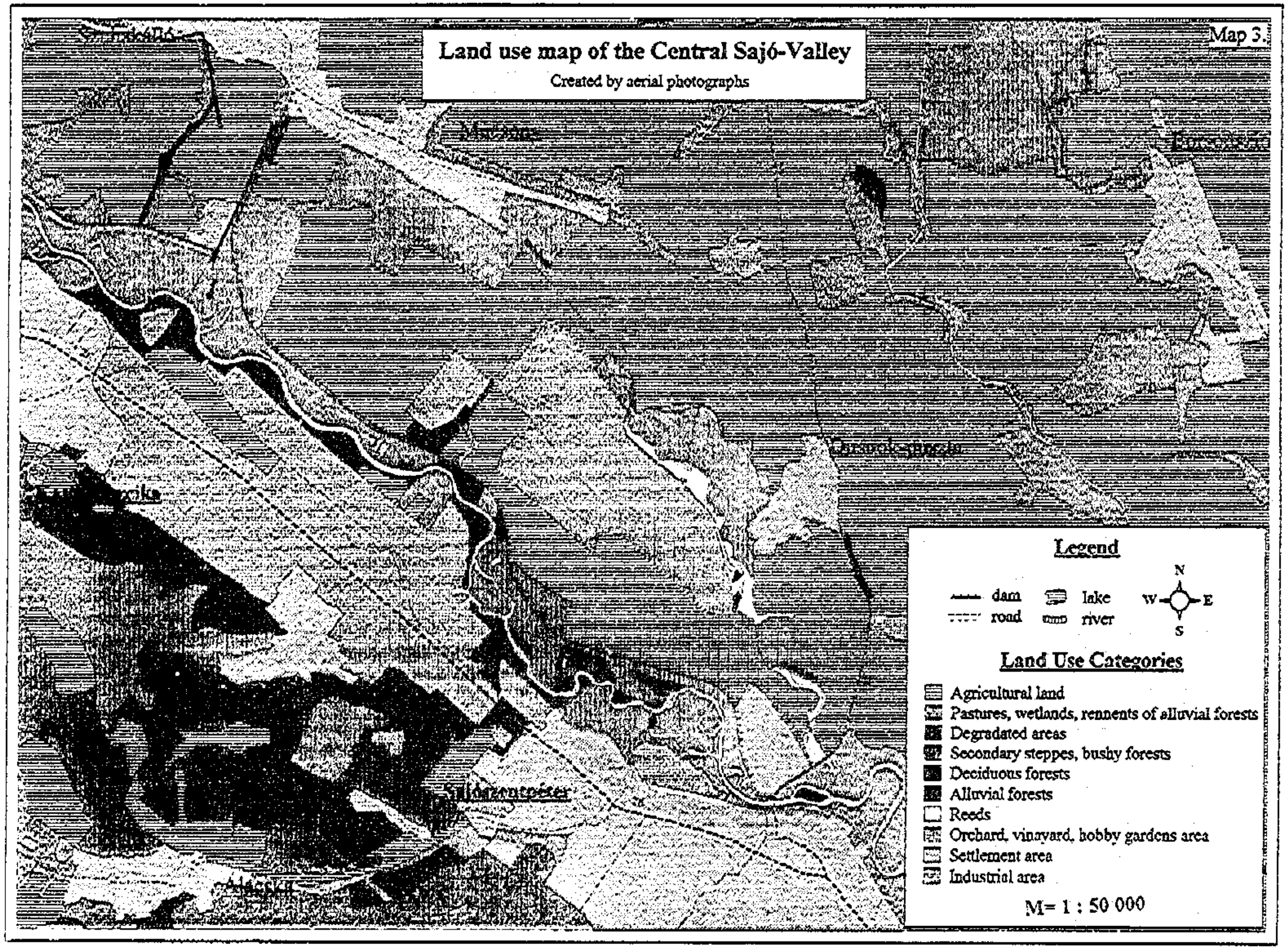


Figure 6.3.1 Land-use Map of the Central Sajo-Valley

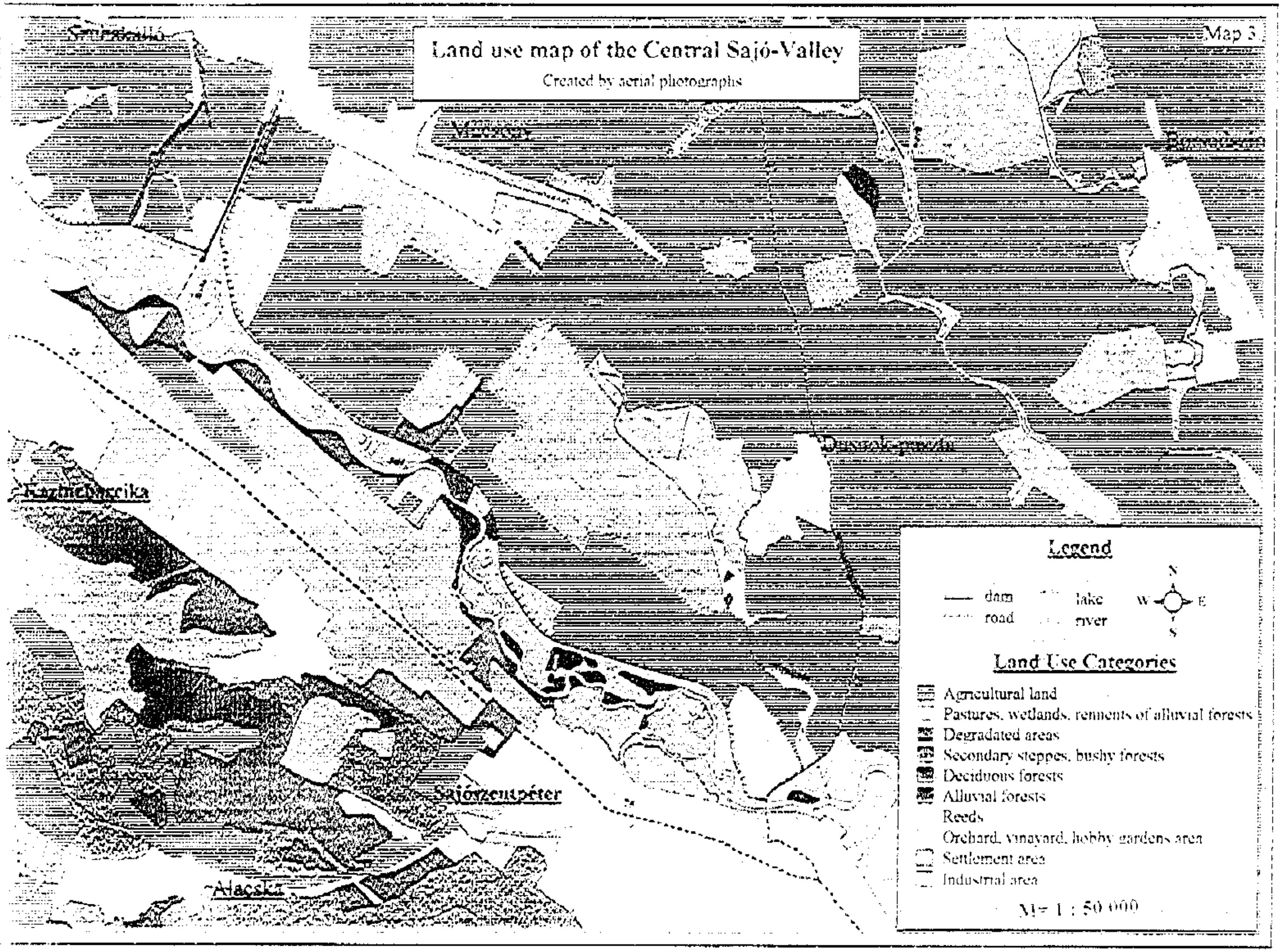
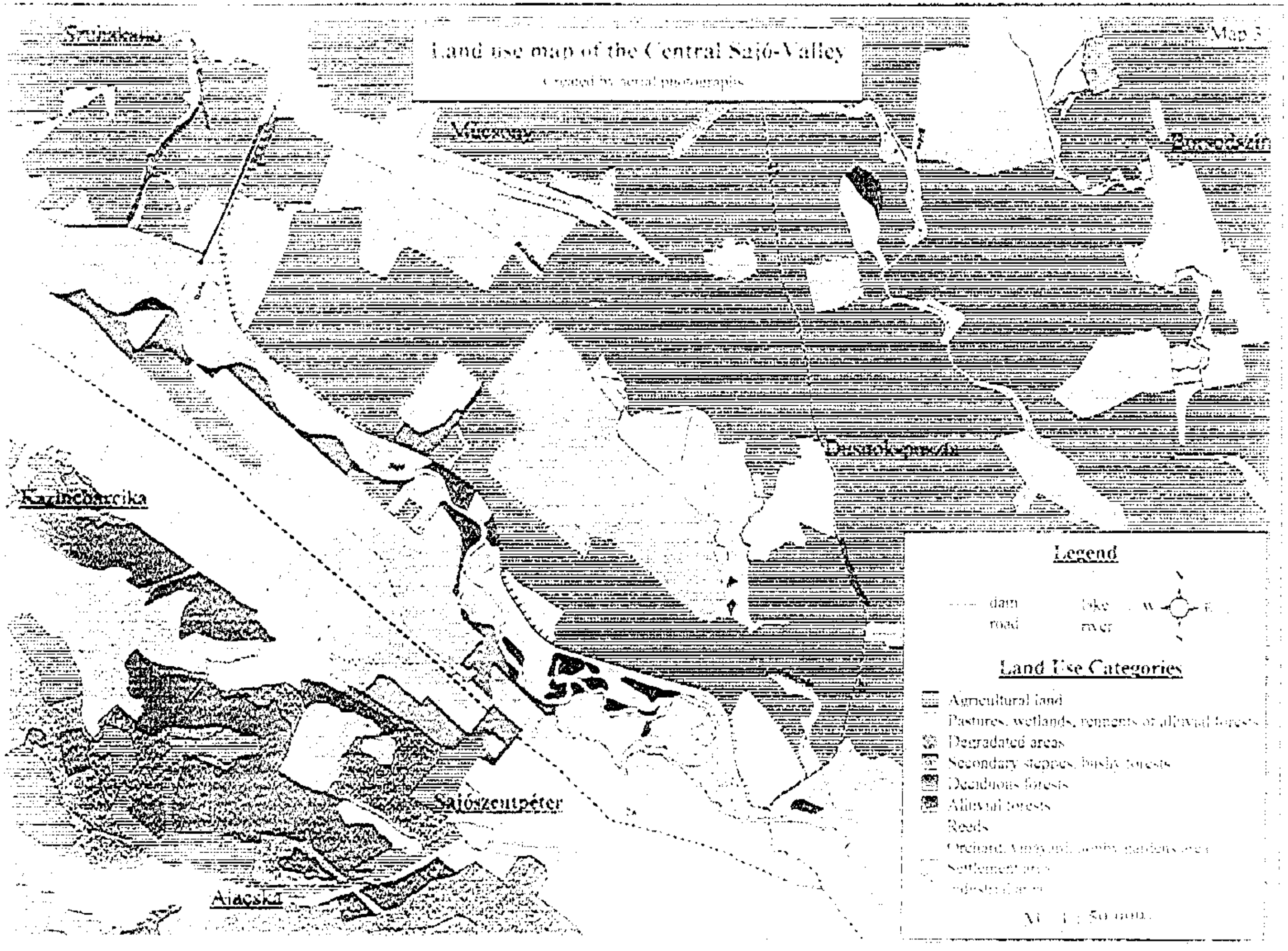


Figure 6.3.1 Land-use Map of the Central Sajó-Valley


Land use map of the Central Sajó-Valley
Map 3
Szuhakálló
Múcsony
Borsodszirák
Dusnok-puszta
Kazincbarcika
Sajószentpéter
Alacska
Legend
dam
road
lake
river
W
E
Land Use Categories
Agricultural land
Pastures, wetlands, remnents of alluvial forests
Degradated areas
Secondary steppes, bushy forests
Deciduous forests
Alluvial forests
Reeds

The quality of water and bottom sediment in the Sajo river has been extremely contaminated in recent years, but remarkable improved recently.

There are other small rivers including Suha, Tardona and Nyogo, in some parts of which wild animals are protected. However, polluted Holt-Szuha river requires special care.

(4) Soil

On regularly infiltrated flood-plains, typical flooded soil can be observed. The soil in this area has medium to low productivity and substantially high water capacity. The soil aquifer is in gravel. In hilly areas, the soil destruction by erosion is serious. Lowered pH values of the soil during the last ten years signifies this destruction.

(5) Land Use

The situation of land use is substantially influenced by mankind. A quarter of this area is used for housing or industrialized, a half is cultivated and remaining quarter is forests or semi-natural grass and plants fields.

(6) Industries

The industries in Sajo valley have tradition over some centuries due to the mineral resources and geographical conditions. Heavy industries form the main body of the industrial structure in this area. Representative items in this area are chemical, metallurgic, mining industries and power generation. In parallel to the changes in the state politics, the industrial structure in this area is on the way of correction. At present, the environment in this area is mainly affected by the following plants and factories.

Borsod Thermal Power Plant	Kazincbarcika
Borsodchem Co. (former BVK)	Kazincbarcika
Ytong Light Concrete Works (former Koszig)	Kazincbarcika
Mines of Borsod Coal Mines	this whole area
Sajoszentpeter Glass Works	Sajoszentpeter
North Hungarian Chemical Works	Sajoszentpeter
Borsod Ore Dressing Works	Sajoszentpeter
Dimag Co. (former LKM)	Miskolc

(7) Around Borsod Power Plant, there is no specifically designated area including nature protection area.

(8) In this area, there is neither precious species nor endemic animal, at present, because environmental destruction has been in progress.

(9) Near Borsod Power Plant, there are water purification plants, Borsodszirak I and I/A, that use the groundwater as the source for drinking water.

(10) Environmental pollution concerning air, soil, groundwater and plants has been obvious.

6.3.2 Meteorology

Meteorological data of the Avas observatory, Miskolc City, was collected and filed for the 10 year period(1986-1995). The data was also compared with meteorological data of permanent monitoring stations near the Borsod power plant to check for matching.

Meteorological conditions are closely related to environmental pollution. The amount of precipitation exerts influence on the water amount of Sajo River from which the power plant takes water and on increase in groundwater pollution. Wind speed, on the other hand, contributes to scattering of dust from the slag and fly ash storage area. In particular, air pollution is greatly governed by meteorological conditions, such as the wind direction, wind speed, and atmospheric stability. In winter, the temperature inversion layer is formed and also becomes foggy quite often. Unless any thorough environmental protection measure is taken, the lee-ward area may suffer a critical impact depending on meteorological conditions.

(1) Wind Direction and Speed

The prevailing wind direction is NNW, NW-N and SSE-S. The yearly average of wind speed is 2.6-2.8m/s.

Relationship between the Avas observatory in Miskolc about 20 km distanced from the Borsod power plant and the measuring stations of JM-1 and EC-2 was studied in terms of the wind direction and speed. Data used for the wind direction was the one for the year 1995. Data for the past five years was also shown for the Avas observatory.

Figure 6.3.2 shows the comparison between points of the wind rose. Data used for the wind speed was the monthly average data for years after 1993. The comparison between points for the wind speed is shown in Figure 6.3.3.

1) When comparing wind roses, the prevailing wind direction at JM-1 and EC-2 is NNW with which the distribution pattern agrees extremely well. Namely, the wind rose is in line with the topography of Sajo Valley. On the other hand, WNW and S are prevailing wind directions at the Avas observatory. Apart from difference in

the bearing by one degree, the entire wind system there is approximately equivalent to that at JM-1 and EC-2.

2) When the wind speed is compared between points, the wind speed at the Avas observatory located on a hill is highest and slightly lower at JM-1 located in a open area. The wind speed is lowest at EC-2 located inside the city of Sajoszentpeter, being equal to approximately one half of that at the Avas observatory. These data show the result reflecting topographical conditions. As so far described, there is not much difference among these points, except that the wind speed is low at EC-2.

3) The meteorological data at the Avas observatory is handled as representing the meteorology in the neighborhood of the Borsod power plant, provided however that above-described factors are taken into account. The same applies to other meteorological items, such as the air temperature, humidity, amount of precipitation, etc., because they are considered to proceed on the same level in view of positional relationship among measuring points.

4) The average of monthly maximum wind speed for past decade is 16.4m/s, the lowest is 6.3m/s, the highest is 40.0m/s (Reference to the Supporting Report).

(2) Air Temperature and Humidity

The yearly average temperature is 8-9℃. The lowest temperature is -25℃ in winter and the highest +35℃ in summer.

Figure 6.3.4 shows the monthly average, highest, and lowest temperatures for the past ten years. Relative humidity by month for the past ten years is shown in Figure 6.3.5.

The followings apply to the temperature and humidity for the past ten years:

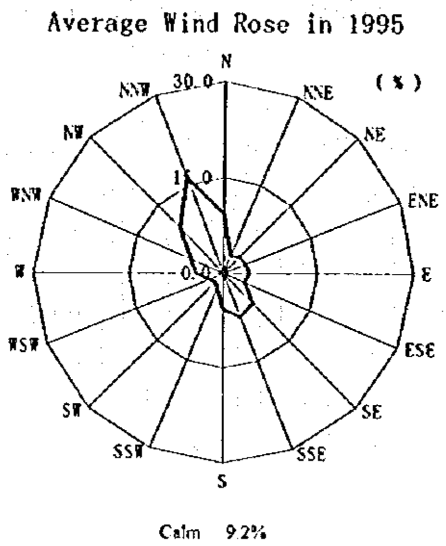
1) The monthly average temperature is high in July and August and low in December and January.

2) The fluctuation width for the past ten years is larger in winter than in summer in terms of the average, highest, and lowest values.

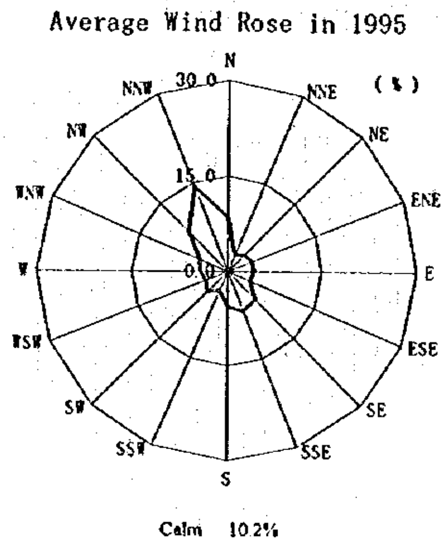
3) Depending on years, the lowest temperature in winter exceeds -25℃ by -5℃ even in terms of the monthly average.

4) The monthly average humidity tends to be lower in summer and higher in winter. The yearly average humidity is 70-75%.

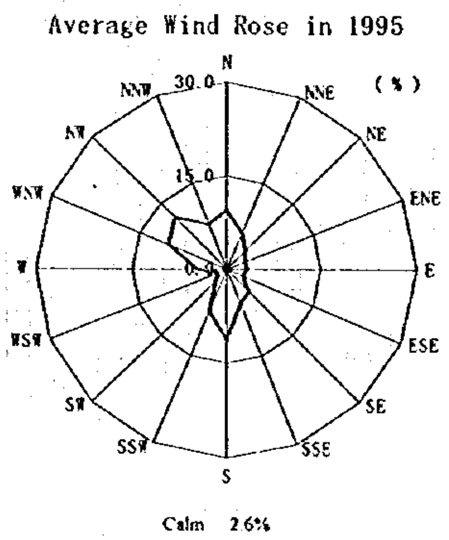
(IM1)



(EC2)



(Avas Observatory)



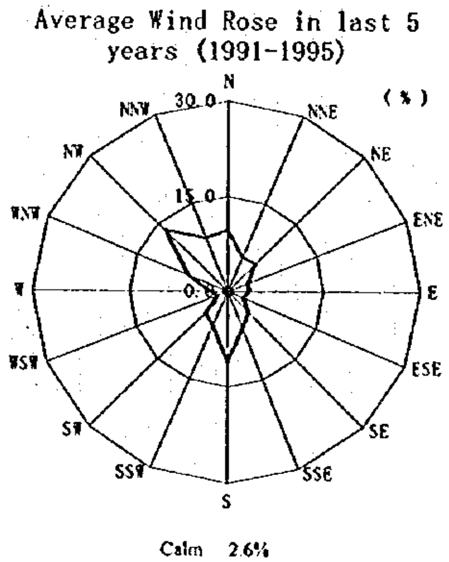
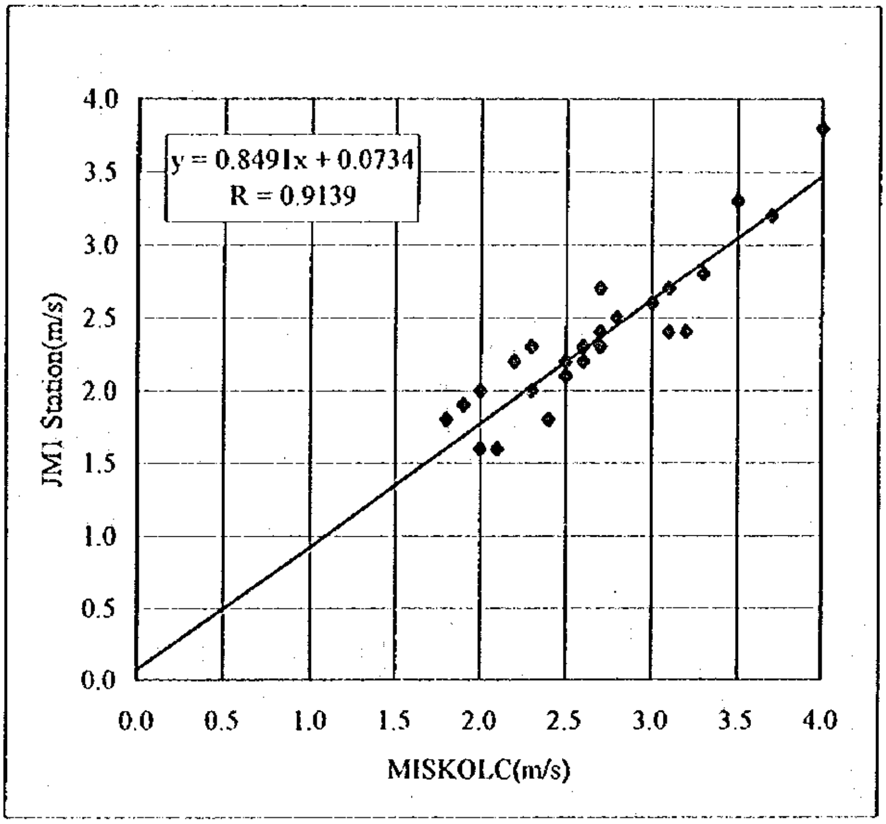


Figure 6.3.2 Comparison of Wind Direction Distribution Diagram



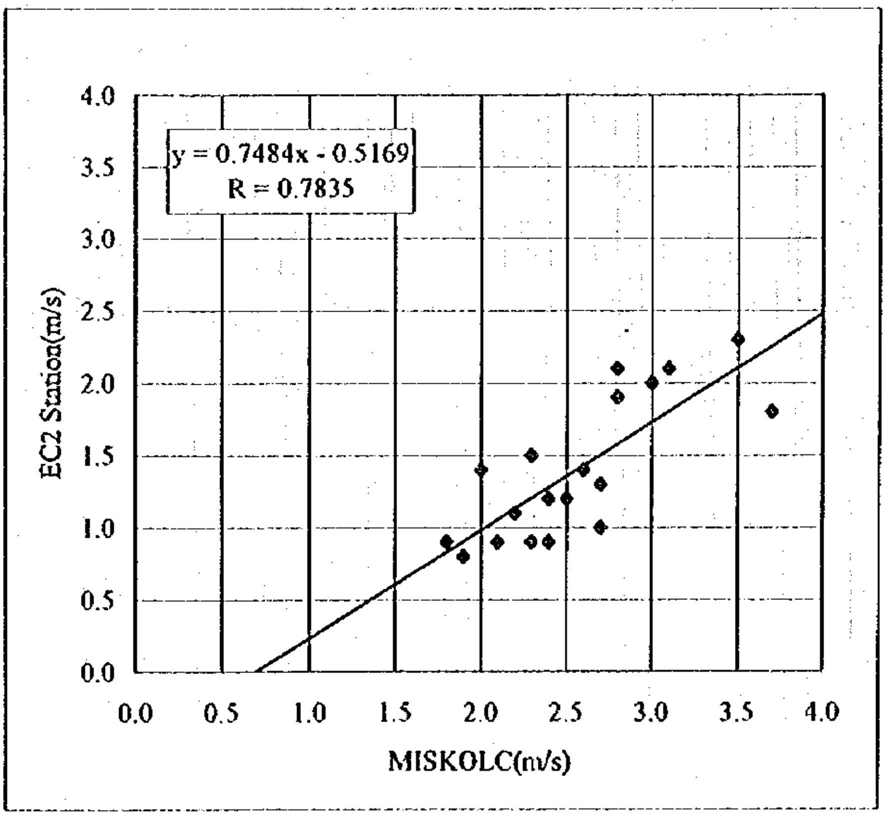


Figure 6.3.3 Correlation Between Each Measuring Point of Observed Wind Speed

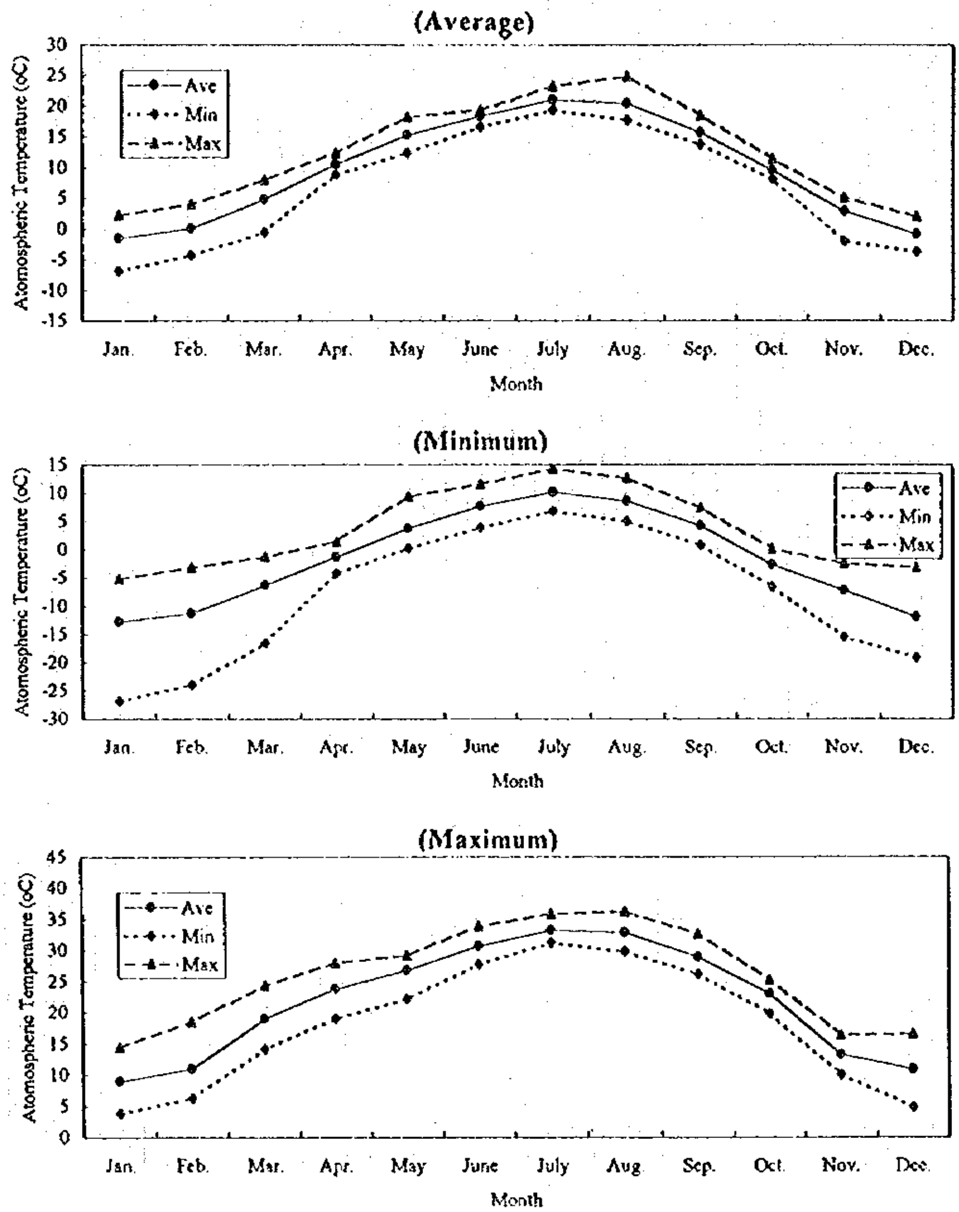


Figure 6.3.4 Average, Maximum and Minimum Values of Monthly Atmospheric Temperature in Last 10 Years (1986-1995)

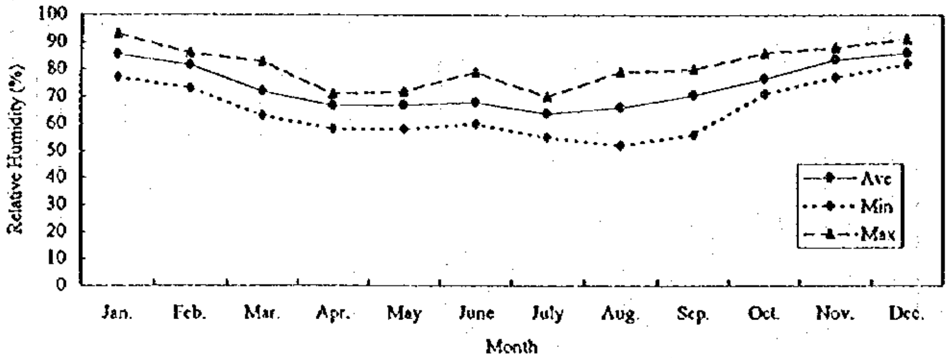


Figure 6.3.5 Average Values of Monthly Relative Humidity in Last 10 Years (1986-1995)

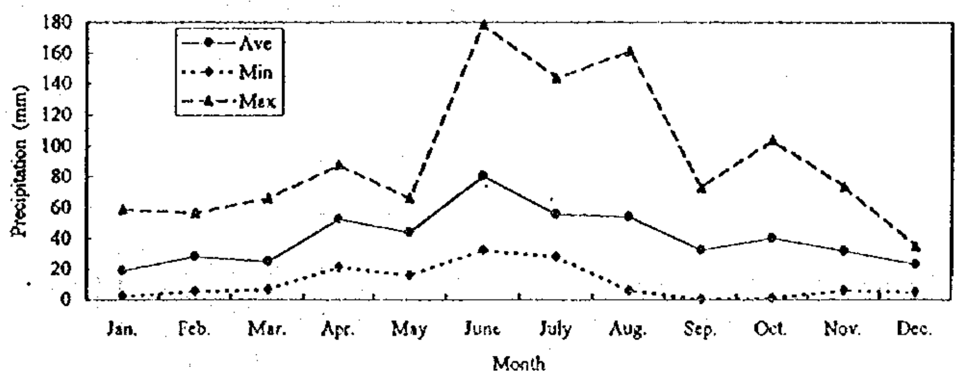


Figure 6.3.6 Average Values of Monthly Precipitation in Last 10 Years (1986-1995)

(3) Amount of Precipitation

The yearly average precipitation is about 650mm.

The monthly amount of precipitation for the past ten years at the Avas observatory is shown in Figure 6.3.6.

The figure shows that the monthly amount of precipitation varied greatly from year to year for the past ten years. When viewed in terms of the average, the amount of precipitation is large in April to August and becomes relatively stable on the lower level from November to March. In particular, there was no rainfall in a certain month during a period from August to March.

The largest amount of precipitation for the past ten years was 178 mm in June, 1995, followed by 161 mm in August, 1988.

6.3.3 Ambient Air Pollution

The survey was performed twice, in autumn and in winter, in order to assess the effect of pollutant emission from Bosord power plant on the ambient air. Three automatic continuous monitoring stations and eleven sampling stations for falling dust are used. Table 6.3.1 shows the monitering points and measured pollutants.

Suspended particulate matter (SPM) was sampled using high-volume air samplers, and falling dust was sampled using simplified dust measuring instruments. The heavy metal contents of SPM and falling dust are analyzed. The 10 sampling points for measuring falling dust are located within 3-4 km from Borsord Power Plant, and one, as a background, 7 km southeast of the plant. During this survey, the data from automatic continuous monitering stations since April 1996 around Borsord power plant were collected.

Figure 6.3.7 shows Locations of automatic ambient air quality measuring stations and point of measuring falling dust used in the present survey.

Table 6.3.1 The Measurement Points of Air Pollutants and Measured Items

Monitoring and Sampling Station	Location	Measuring Items
J-3	Eszak-Magyarországi 408 Tüzéptelep, Berente	SO_2, NO, NO_2, NO_X, CO, SPM
EC-2	Mentök, Sajószentpéter	SO_2, NO, NO_2, NO_X, CO, SPM, Wind Speed and Direction
EC-3	Chemical Secondary School, Kazincbarcika	SO_2, NO, NO_2, NO_X, CO, SPM
1 (EC-2)	Sajószentpéter, mentô állomás	Dust Fall
2 (J-3)	Berente, Tüzéptelep	Dust Fall
3	Berente, Hôerômü	Dust Fall
4	Kazincbarcika, BVK óvoda	Dust Fall
5	Mucsony, parókia udvar	Dust Fall
6	Dusnokpuszta, templom kert	Dust Fall
7	Alacska, Parókia (Dózsa u.1.)	Dust Fall
8	Sajószentpéter 2.akna (Rotó Elzett Kft. udvara)	Dust Fall
9	Sajószentpéter, (Katona József u.12.)	Dust Fall
10	Sajószentpéter, (Gyöngyvirág u.51.)	Dust Fall
11	Sajóecseg, (Széchenyi u.15.)	Dust Fall

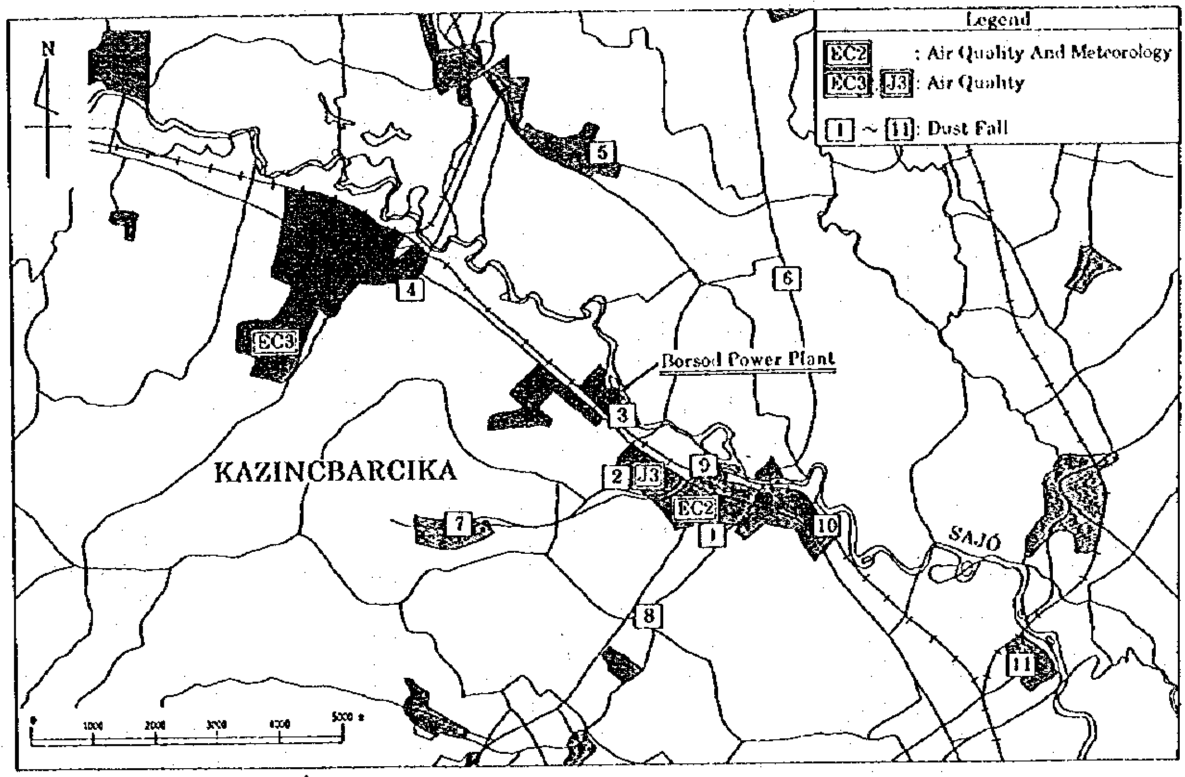


Figure 6.3.7 Location of Ambient Air and Dust Fall Monitoring Stations

(1) Survey Period

1) Automatic air pollutants equipment

Autumn : Oct. 29 - Nov. 5, 1996 (8 days)
Winter : Jan. 20 - Jan. 27, 1997 (8 days)

2) SPM

Autumn : Oct. 29 - Nov. 1, 1996 (4 days)
Winter : Jan. 20 - Jan. 23, 1997 (4 days)

3) Dust fall

Autumn : Nov. 1 - Nov. 30, 1996 (30 days)
Winter : Jan. 1 - Jan. 30, 1997 (30 days)

(2) Methods of Measurement and Analysis

1) Measurement of air pollutants

SOx	:	Ultraviolet absorption plus fluorescence method (UV)
NOx	:	Chemiluminescence detection method (CLD)
CO	:	Non-dispersive infrared absorption method (NDIR)
SPM	:	High-volume air sampler (Hi-Vol)
Dust fall	:	Simplified dust fall meter

2) Analysis of heavy metal and SO_4^{2-}

a) Subject of analysis: As, Cd, Cr, Cu, Fe, Hg, Mn, Pb, Zn, SO_4^{2-}

b) Analysis method: GF-AAS (Graphite Furnace Atomic Absorption Spectrophotometer)

Acidolysis method was applied for preparation of sample solution for composition analysis of SPM. SO_4^{2-} was extracted with water and analyzed with a spectrophotometer.

(3) Result

The outline of the result is as follows:

1) Automatic measurement data

Figures 6.3.8 and 6.3.9 show time variation of the automatic measurement data of each air pollutant.

The following observations are found in Figure 6.3.8 and Figure 6.3.9:

a) The level of SO_2 was highest between 8:30 and 9:00 on Nov. 4 at J-3 and EC-2. EC-2 recorded an extremely high pollution level of over 200 ppb. The direction and velocity of wind at the hight of 10 m from the ground were NNE and 0.7 m/s.

b) EC-3 recorded two peaks of SO_2 level: 13:30 - 14:30 on Nov. 4 and 11:00 - 11:30 on Nov. 5. The direction and velocity of wind then were ENE and 0.8 m/s. Although the position of EC-3 showed about an azimuth of disposition in the wind direction, there is a great possibility that these peaks are due to Borsod Power Plants.

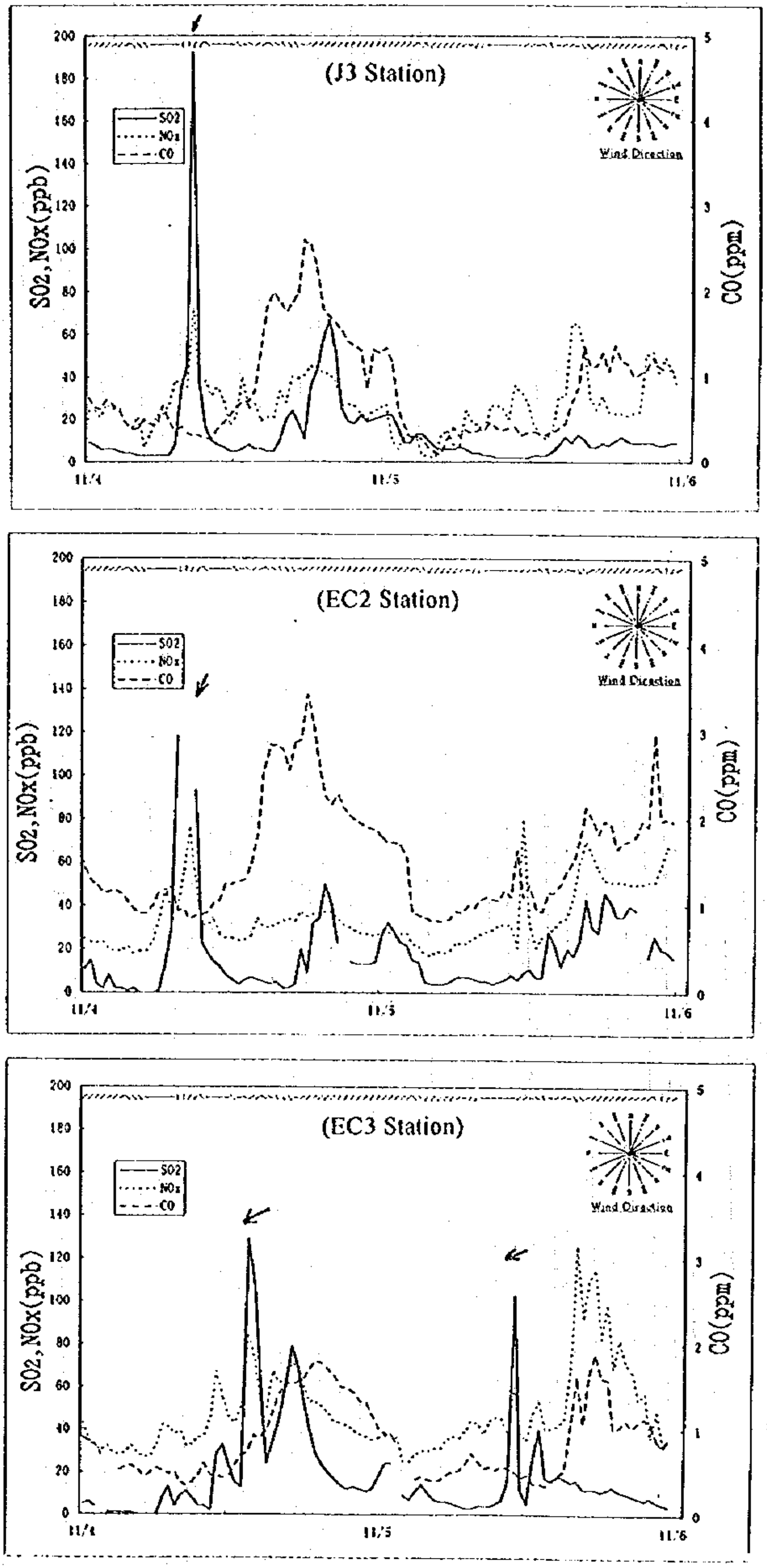


Figure 6.3.8 The Chronological Transition of the Automatic Measurement Data of Each Air Pollutant in Autumn

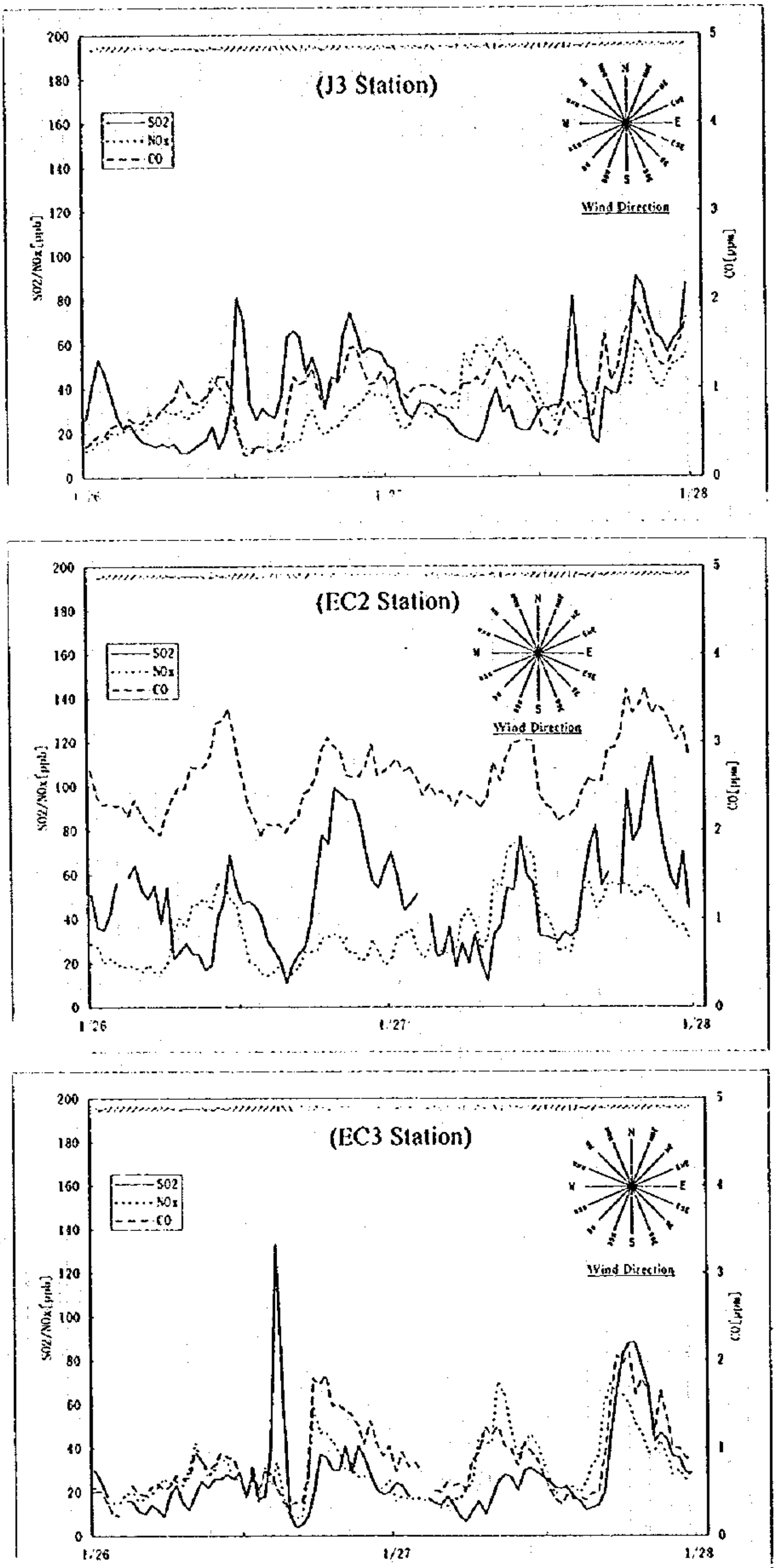


Figure 6.3.9 The Chronological Transition of the Automatic Measurement Data of Each Air Pollutant in Winter

c) In the times zones free from direct influences of Borsod Power Plant, when weak winds blow in autumn, NOx concentration changes to high levels, but in some cases, SO_2 concentration remains on low levels. On the other hand, in winter when NOx concentration is high, SO_2 concentration shows also high in parallel. In winter, the solid fuels for heating are supposed to have an effect. In both cases, the background concentration is raised due to the effect of the mobile sources and area sources such as domestic heating.

2) SPM and heavy metals

During the three-day SPM sampling in the autumn, the wind speed was about 1 m/s on the first half and about 6 m/s on the latter half, while the wind speed was 1 to 2 m/s in the winter. The prevailing wind direction is SW in both seasons.

SPM was filtered on filter paper sheets for mass measurement and analysis of heavy metal content. The result of heavy metal analysis of SPM is shown in Table 6.3.2.

From the results of analysis mutually compared, the following can be said:

a) TSP increases in winter but does not exceed the 24-hour value specified in the environmental protection standard II (0.2 mg/m^3).

b) As concentration in Kazincbarcika (EC-3), and Hg, Cd and Cr concentration in Sajoszentpeter (EC-2) tends to be higher, respectively, but other components do not show remarkable changes between autumn and winter.

c) Increase in SO_4^{2-} in winter is supposed to be remarkably influenced by the solid fuels used for heating, judging from the wind direction during the survey.

d) It is impossible to conclude that the high concentration of As and Hg is due to the influence of Borsod Power Plant, based on the data obtained in this Study including the weather conditions showing that the southwest winds are eminent.

Table 6.3.2 The Result of Heavy Metals Analysis of SPM

Component	Berente (J3)		Sajosznlpeter (EC2)		Kazincbarcika (EC3)	
	Concentration (μg/m³)	Content (%)	Concentration (μg/m³)	Content (%)	Concentration (μg/m³)	Content (%)
(Date : October 29, 1996 - November 1, 1996)						
TSP	55.1	100.0000	76.6	100.0000	34.3	100.0000
As	0.0012	0.0022	0.0017	0.0022	0.0029	0.0085
Cd	0.0006	0.0011	0.0015	0.0020	0.0013	0.0038
Cr	0.0107	0.0194	0.0158	0.0206	0.0137	0.0399
Cu	0.013	0.0236	0.033	0.0431	0.015	0.0437
Fe	0.699	1.2686	2.07	2.7023	0.601	1.7522
Hg	0.0006	0.0011	0.0014	0.0018	0.0004	0.0012
Mn	0.0196	0.0356	0.0356	0.0465	0.0199	0.0580
Pb	0.024	0.0436	0.049	0.0640	0.031	0.0904
Zn	0.087	0.1579	0.126	0.1645	0.045	0.1312
SO_4^{2-}	16.89	30.6534	9.34	12.1932	7.71	22.4781
(Date : January 20 -23, 1997)						
TSP	122.5	100.0000	83.5	100.0000	76.6	100.0000
As	0.0018	0.0015	0.0025	0.0030	0.0032	0.0042
Cd	0.0022	0.0018	0.0025	0.0030	0.0019	0.0025
Cr	0.012	0.0098	0.019	0.0227	0.014	0.0183
Cu	0.025	0.0204	0.032	0.0383	0.066	0.0861
Fe	0.864	0.7055	0.674	0.8068	0.532	0.6943
Hg	0.0013	0.0011	0.0026	0.0031	0.0014	0.0018
Mn	0.028	0.0229	0.022	0.0263	0.023	0.0300
Pb	0.076	0.0621	0.066	0.0790	0.078	0.1018
Zn	0.136	0.1110	0.108	0.1293	0.085	0.1109
SO_4^{2-}	30.8	25.1491	31.3	37.4675	16.8	21.9245

Note : Content(%) - Ratio of Component for DUST

Analysis of Hg - Analysis Method is Vaporization by Heating and Atomic Absorption Photometry

3) Dust fall

The dust fall was measured and the heavy metals contained in dust were analyzed to find the amount settled per unit area. Table 6.3.3 shows the results of analyzing heavy metals contained in the dust fall in autumn and winter and Figure 6.3.10 shows wind rose at EC-2 station

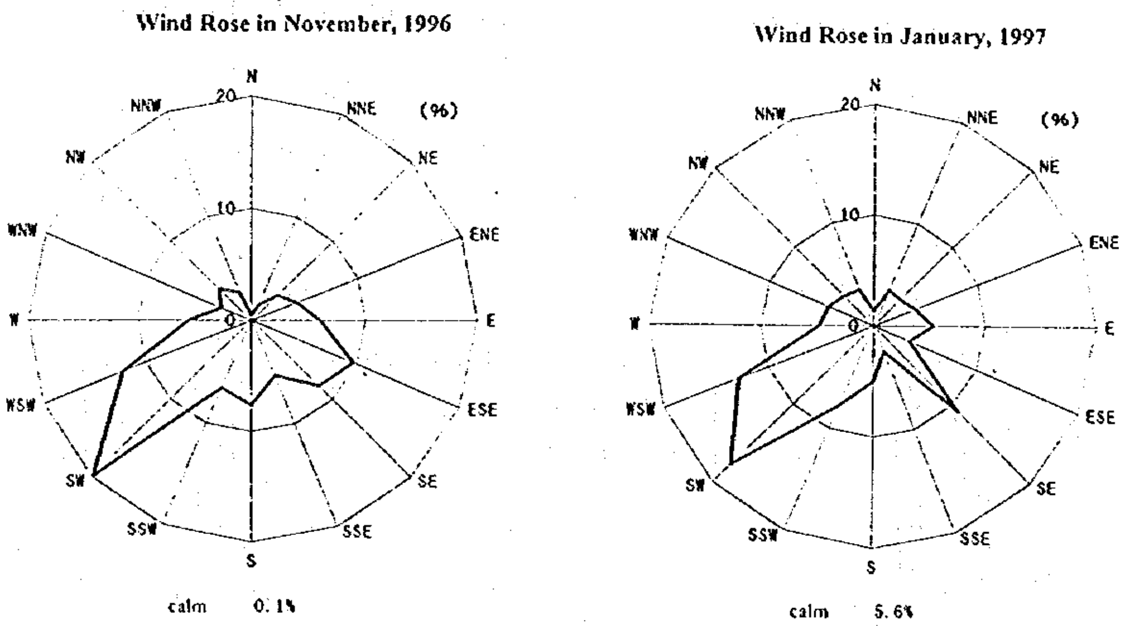


Figure 6.3.10 Wind rose at EC2 Station

From the dust fall data, the following can be said:

a) On the spot No.3 arranged at the south end of Borsod Power Plant, the dust fall showed the highest value in all seasons, but was smaller than that specified in the environmental protection criteria (12 $g/m^2/30days$) applicable to special protection areas. The winds at this time was mostly head winds.

b) Hg contained in the dust fall on the spot No.3 showed the largest value among all the spots. As and Pb contained in the dust fall on this spot also showed remarkable larger values.

c) It was the spot No. 5 that showed the largest fall of As. The spot No. 5 is positioned due north of Borsod Power Plant, and is off the southwest, the prevailing wind direction, by two azimuths. The largest fall of As is, most probably, due to the effect of Borsod Power Plant. At the EC-2 station where a wind vane and anemometer is installed, the winds tend to blow southwest on the ground along the valley due to geographical conditions even in the case south winds blow up in the sky. This can be also read from the frequency of the wind direction measured at Avas Meteorological Observatory Station during the past five years, included in the Supporting Report. The frequency of south winds is high, and that of southwest winds is about the one third.

d) The spots No. 2, 3, 7 and 10 show comparably large fall of Pb, Zn and Cu, a typical feature of diesel cars. This means these spots are more subjected to the effect of cars. (See "Content of each component by the source, included in the Supporting Report.)

Figure 6.3.11 shows monthly averaged dust fall by the spot during the past three years. The spot S-2 located near Sajoszentpeter placter shows the largest dust fall. This dust fall corresponds to 146.4 g / m^2 /square meter per year, when converted to annual fall, a value near to that specified in the environmental protection standard II (150 g / m^2 / year). Figure 6.3.12 is a quotation from the report of the master plan survey implemented in the Sajo valley . Each area shows the average value of several sampling points. Monthly changes in the dust fall in Kazincbarcika, Sajoszentpeter and Miskolc show independent characteristics of each city.

Table 6.3.3 Result of Heavy Metals Analysis of Dust Fall

Component	Unit	1 (EC2)	2 (J3)	3	4	5	6	7	8	9	10	11
(Nov.1996)												
Dust Fall	g/m^2/30days	2.3	2.3	7.2	2.1	1.5	3.0	2.4	1.6	3.8	3.6	2.2
As	mg/m^2/30days	0.023	0.024	0.180	0.055	0.323	0.019	0.055	0.017	0.094	0.074	0.047
Cd	mg/m^2/30days	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Cr	mg/m^2/30days	0.110	0.078	0.160	0.090	0.058	0.032	0.075	0.045	0.145	0.225	0.078
Cu	mg/m^2/30days	0.035	0.028	0.095	0.043	0.010	0.020	0.060	0.028	0.060	0.122	0.032
Fe	mg/m^2/30days	22.0	22.0	30.8	31.8	14.8	12.0	31.8	8.2	33.8	32.6	24.6
Hg	mg/m^2/30days	0.028	0.017	0.035	0.013	0.010	0.012	0.011	0.019	0.012	0.018	0.013
Mn	mg/m^2/30days	1.040	0.992	0.815	0.850	0.590	0.705	1.120	0.590	0.705	0.920	0.685
Pb	mg/m^2/30days	0.738	0.593	1.090	0.862	0.195	0.180	3.740	0.258	0.642	0.700	0.348
Zn	mg/m^2/30days	0.688	1.680	1.650	1.560	1.930	0.555	1.120	2.240	1.100	1.860	1.060
(Jan.1997)												
Dust Fall	g/m^2/30days	1.2	2.2	3.0	2.0	2.3	2.3	2.5	2.0	2.7	2.9	2.1
As	mg/m^2/30days	0.020	0.025	0.169	0.032	0.308	0.030	0.041	0.013	0.072	0.099	0.047
Cd	mg/m^2/30days	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Cr	mg/m^2/30days	0.162	0.230	0.070	0.030	ND	0.040	ND	ND	0.078	0.185	ND
Cu	mg/m^2/30days	0.070	0.187	0.088	0.110	0.063	0.105	0.058	0.105	0.123	1.402	0.102
Fe	mg/m^2/30days	13.8	93.0	27.7	52.2	17.7	19.4	10.2	45.0	35.4	65.0	32.1
Hg	mg/m^2/30days	0.021	0.016	0.033	0.015	0.010	0.010	0.013	0.016	0.009	0.017	0.014
Mn	mg/m^2/30days	0.630	0.987	0.460	0.825	0.415	0.770	0.375	0.585	0.640	1.225	0.332
Pb	mg/m^2/30days	0.422	0.772	0.620	0.323	0.340	0.395	0.422	0.192	0.385	1.020	0.360
Zn	mg/m^2/30days	0.442	3.952	1.453	1.095	1.123	1.495	1.938	1.623	1.283	2.510	0.945

Note : Cd ND → <0.008

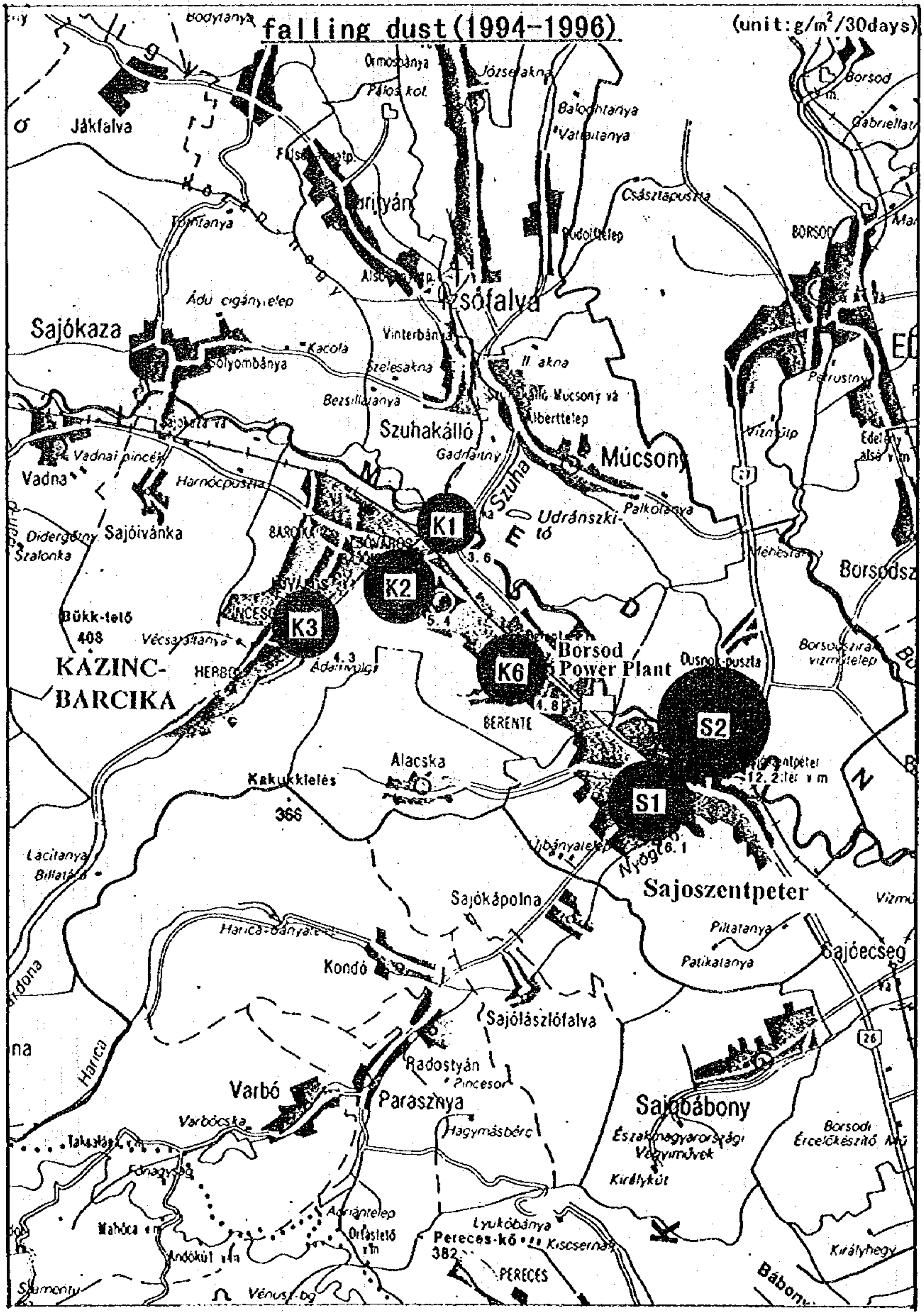


Figure 6.3.11 Monthly Average of Dust Fall

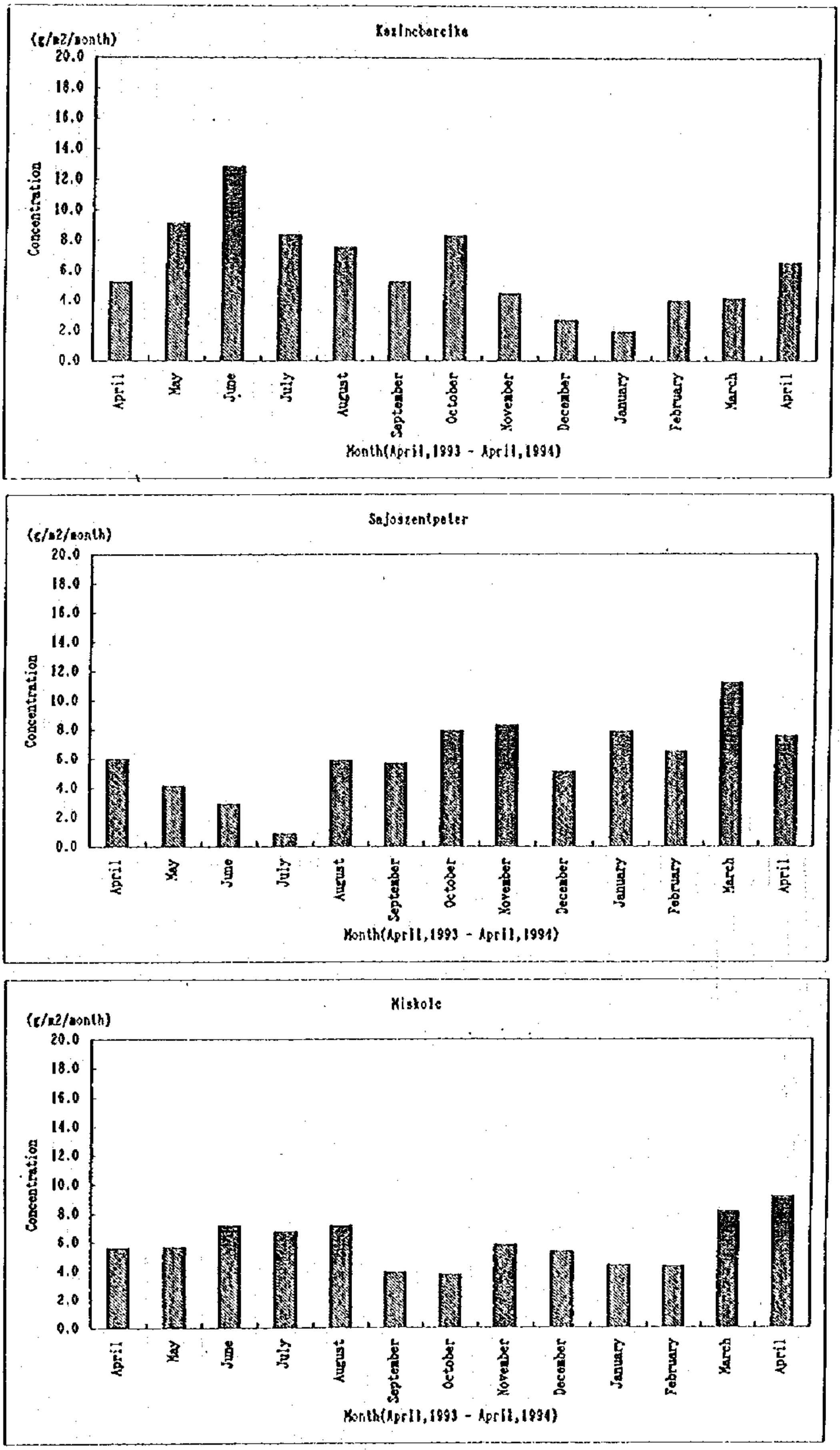


Figure 6.3.12 Monthly Variation of Dust Fall (Source: JICA Sajo-Valley M/P study, 1995)

4) Comparison of existing data on SO_2 with environmental standard

Existing data was collected, collated and compared to the environmental quality standards applicable to SO_2. Data was collected between May. 16, 1993 and Nov. 30, 1996. Data taken by 30 minutes, daily and yearly averages were found and compared with the environmental standard.

The environmental standard and measurement result of SO_2 are shown in Tables 6.3.4 through 6.3.7.

The followings are observed.

a) Peak value of 30 minutes period was beyond the standard at all measurement points each year.

b) Peak value of daily average exceeded the standard at J-2 each year. Peak values at J-1, J-3, and EC-2 have also exceeded the standard value in certain years.

c) No station has seen any yearly average which exceeds the standard value. Although the value at EC-2 is over the standard in 1996, this value is not reliable because the data is insufficient.

d) No noticeable improvement has been found in the SO_2 concentration since the time of JICA's air pollution control study for the Sajo valley area in 1993.

e) According to the data collected in the past, the level of concentration expressing air quality rises in heating season. This is the effect of weather conditions in addition to domestic heating.

In conclusion, the air pollution in the surveyed area is mainly of short-term and of high-level.

Table 6.3.4 Ambient Air Quality Standard of SO_2

unit : ppb

	Protected Area I (J1)	Protected Area II (J2, J3, EC2, EC3)
30 minutes average	94	150
24 hours average	56	113
Annual average	26	38

Table 6.3.5 Summary of Measured Results of SO_2 (30 Minutes Average)

unit : ppb

Protected Area		I	II			
Station		J1	J2	J3	EC2	EC3
1993 (May - Dec)	98%	36	108	94		
	Max	200	501	467		
	The Number of Data	10413	11002	10937		
1994	98%	41	132	95	112	75
	Max	178	498	500	604	532
	The Number of Data	8561	12206	13500	7615	8777
1995	98%	27	124	52	96	73
	Max	154	453	309	482	376
	The Number of Data	3336	16783	7449	15133	16731
1996 (Jan - Nov)	98%	***	101	42	98	64
	Max	***	396	74	611	267
	The Number of Data	0	12301	2161	6723	11675
All	98%	38	119	84	99	70
	Max	200	501	500	611	532
	The Number of Data	22310	52292	34047	29471	37183

[shaded] : Over Ambient Air Quality Standard

Table 6.3.6 Summary of Measured Results of SO_2 (24 Hour Average)

unit : ppb

Protected Area		I	II			
Station		J1	J2	J3	EC2	EC3
1993 (May - Dec)	98%	30	74	60		
	Max	55	212	200		
	The Number of Data	217	230	227		
1994	98%	28	70	60	71	53
	Max	32	138	179	162	80
	The Number of Data	180	279	313	168	186
1995	98%	23	75	34	64	47
	Max	119	120	48	90	87
	The Number of Data	74	353	157	312	357
1996 (Jan - Nov)	98%	-	76	-	65	45
	Max	-	132	22	131	55
	The Number of Data	-	265	46	149	262
All	98%	28	75	58	69	46
	Max	119	212	200	162	87
	The Number of Data	471	1127	743	629	805

(shaded) : Over Ambient Air Quality Standard

Table 6.3.7 Summary of Measured Results of SO_2 (Annual Average)

unit : ppb

Protected Area		I	II			
Station		J1	J2	J3	EC2	EC3
1993 (May - Dec)	Annual Average	5	14	13		
	The Number of Data	8	8	8		
1994	Annual Average	9	18	19	26	14
	The Number of Data	6	10	10	5	6
1995	Annual Average	7	18	8	20	11
	The Number of Data	2	12	5	10	12
1996 (Jan - Nov)	Annual Average	-	18	14	48	28
	The Number of Data	-	9	1	5	8
All	Annual Average	7	17	14	22	12
	The Number of Data	16	39	24	20	26

(shaded) : Over Ambient Air Quality Standard

5) Vapor Hg in the atmosphere

Data on vapor Hg in the atmosphere are presented in the report of JICA's said air pollution control study for the Sajo Valley area. This report was prepared after a one-year measurement survey started in May 1993. The yearly average of the vapor Hg in the atmosphere is shown in Figure 6.3.13. Among the eight measurement stations, J-2, J-3 and EC-2 which are located in Kazincbarcika and Berenten showed a high level of pollution, indicating the presence of a source in the vicinity. However, levels of pollution are not so serious as to cause environmental problems.

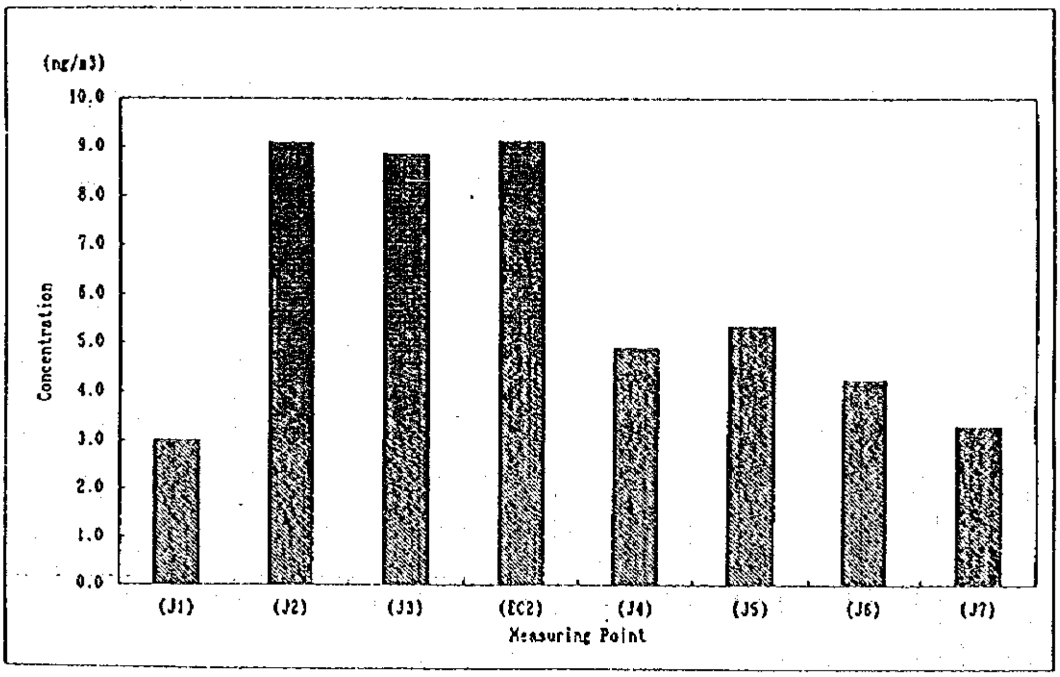


Figure 6.3.13 Annual Average of Vapor Hg in Ambient Air

6.3.4 Survey on the Groundwater and Surface Water

Surveys and local investigation have already confirmed the As and ions contamination of the groundwater and surface water around the sludge storage area. The related Hungarian parties such as EKF and Borsod Power Plant have already been aware of such contamination and its impact.

Because of deteriorated contamination of groundwater due to the coal ash sludge storage, adverse effect may be given to water source of the Eszakmagyarszagi Regional is Vizuvek Rt (ERV Co.) Borsodszirak Waterworks I and I/A. Borsod Power Plant have recently established a new well for observation. Monthly water level check and quarterly check on water contaminants including heavy metal ions are also carried out. ERV Co. is conducting its own survey on a continuous basis.

The Study Team prepared a distribution map of the contamination levels by measuring different points simultaneously. At the same time, continuous measurement data of groundwater was also collected. The following processes were carried out according to the result;

- Current situation of groundwater contamination was reevaluated.
- Hydrodynamics of the groundwater was studied based on the level of groundwater.

Outline and results of survey are shown below:

(1) Sampling period

Oct. 24 - 30, 1996

(2) Surveyed locations and sampling points

Few measurement wells at Borsodchem Co. were allowed for use as survey points, but considered not essential to understand the impact of the Borsod Power Plants.

The locations of sampling points for underground and surface water are shown in Figure 6.3.14. Geographical distribution of the observation wells and sampling points for surface water are shown in the Supporting Report.

Sludge storage pond	:	2 samples
Monitoring wells	:	61 samples
Water quality of the Sajo river	:	4 samples at upstream and downstream of the Power Plants
Water quality of Bodva river	:	2 samples
Water quality of Szuha river	:	1 sample
Stand-by storage pond	:	1 sample
Sediment of the Sajo river	:	sample at the downstream of the Power Plants
Leachate from storage	:	2 samples
	Total	74 samples

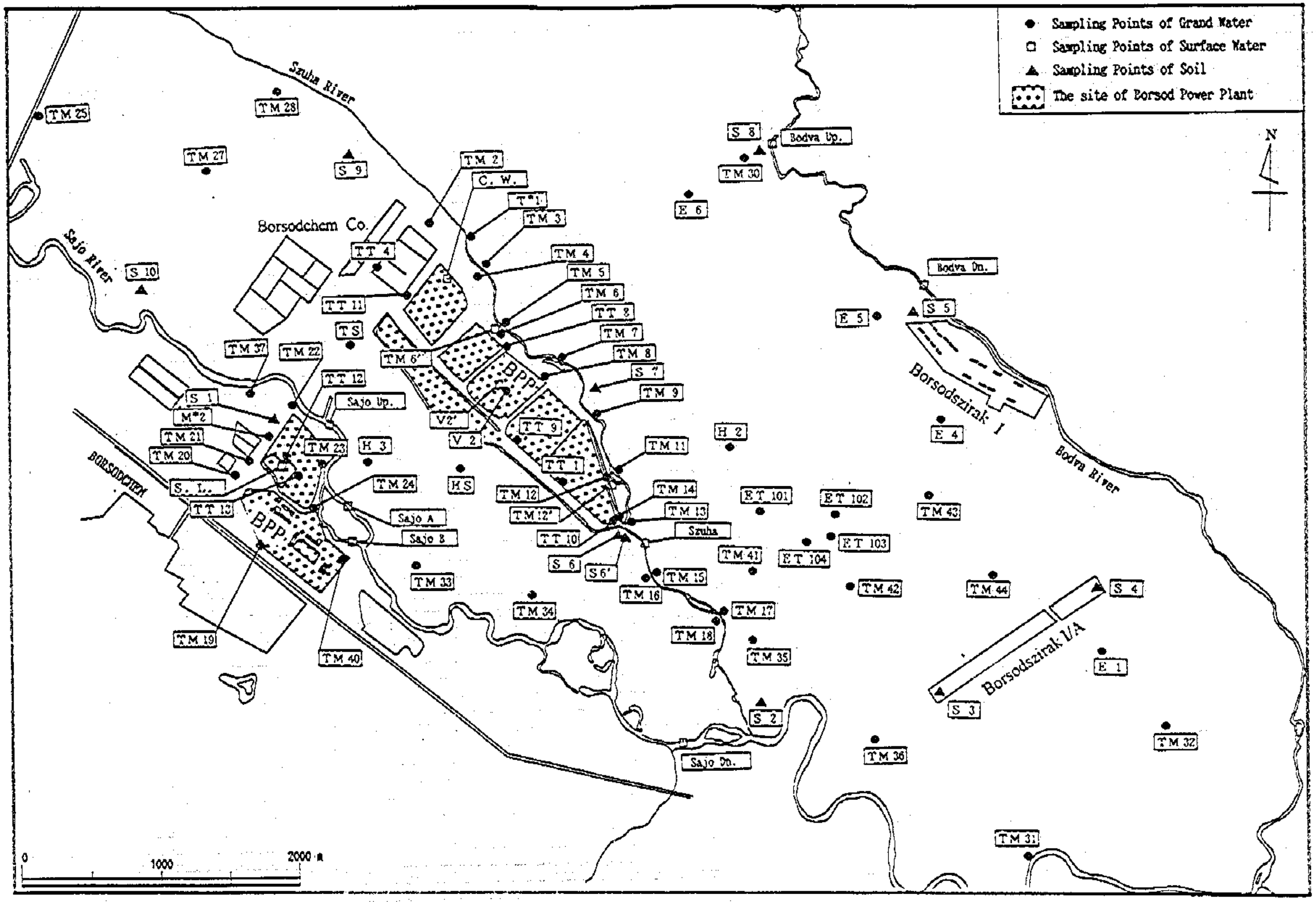


Figure 6.3.14 Sampling Points of Ground Water and Surface Water

(3) Analyzed items

Analyzed items are:

T-Hg, Org-Hg, As, Cr, Cd, Pb, Cu, Zn, Mn, Fe, Ca, K, Mg, Na, S, SO_4^{2-}, NO_3^-, NO_2^-, Cl^-, NH_4^+, pH, electric conductivity, soluble residue, COD, dissolved oxygen, water temperature, and appearance.

Since sufficient T-Hg for analysis was found in the samples, Org-Hg was considered as below the detection limit.

(4) Sampling method

1) Observation well

a) Water level and depth were measured to find the water quantity in the well.

b) A groundwater sampler was put to the bottom of the well. Water of more than 3 times the amount in the well was drained, then representative water of the aquifer near the well was collected.

c) Two kinds of water collecting bottle were prepared:

- For heavy metals: Nitric acid was added to transparent samples in 1 liter polyethylene bottles to fix any heavy metal content. Turbid samples were filtered before adding nitric acid.

- For ion contents: Samples were stored in 1 liter glass bottles and stored in a cool and dark place.

2) Surface water

Surface water was directly collected with a polyurethane bucket or a water collector. Storage method of the water collector and samples were similar to those for water of the observation wells.

3) Sediment of the Sajo river

Sampling of sediment at the downstream of the Power Plants was carried out with a boat and sludge collector. The collected sludge was stored in polyurethane bottles.

(5) Methods of analysis

1) Pre-treatment of samples

Turbid samples were filtered before analysis. For heavy metal analysis, 0.5 ml of strong nitric acid was added to 100 ml of samples to make acidic solution. Samples for ion analysis were used without any pre-treatment.

2) Analysis methods of heavy metals and ions

Analysis methods of heavy metals and ions in water are shown in Table 6.3.8. ICP-OES-2 in the table was not included in the survey plan.

Table 6.3.8 Analysis Methods of Heavy Metals and Ions in Sample Water

Method	Heavy metals and ions in sample water
ICP-OES-1	Cr, Cu, Fe, Mn, Zn
ICP-OES-2	Ca, K, Mg, Na, S
GF-AAS	As, Cd, Pb
CV-Hg-AAS	Hg
UV-SP	NH_4^+, NO_2^-, NO_3^-, Cl^-, SO_4^{2-}

Note:
ICP-OES : Inductively Coupled Plasma Optical Emission Spectrophotometer
GF-AAS : Graphite Furnace Atomic Absorption Spectrophotometer
CV-Hg-AAS : Cold Vapour Mercury AAS
UV-SP : Ultraviolet-Vis Spectrophotometer

Site measurement of pH, electric conductivity, temperature and dissolved oxygen were carried out at the time of sampling by using a portable water quality meter. The analysis methods of the soluble residue, COD and ions all followed the standard regulations stipulated in Hungary.

(6) Result

1) Result of analysis

The results of groundwater and surface water analysis are shown in Tables 6.3.9 and 6.3.10 respectively.

The following observations are found in the results of groundwater analysis:

a) Groundwater temperature of most sample groups of TT, TM-8, TM-14, TM-19 and V-2 was higher than other points. These samples showed a high level of As contamination .

b) Most samples showed pH 7-8, but some exceeded this range. TT-10 (pH 10.63) and TM-14 (pH 10.30) were extraordinary. These points belong to group a).

c) Electric conductivity and concentration of soluble residues, ions, and An and Na greatly varied among the measurement points. Some points showed extremely high levels of contamination, clearly indicating the impact of pollutants in the vicinity.

d) When the level of Cl^- is high, that of Na becomes always high, but the level of SO_4^{2-} does not necessarily show a similar pattern. The level of SO_4^{2-} is high throughout the survey area.

e) Among As, Cd, Hg and Pb, the most dangerous contaminants for the human health, only As requires consideration. However, some points showed relatively higher level of Pb, which also requires caution.

2) Groundwater level

a) Contour lines of groundwater level.

The contour lines of groundwater level is shown in Figure 6.3.15 and 6.3.16. The direction of groundwater flow under stable condition is shown in Figure 6.3.17.

i) According to the water levels measured between Oct. 24 and Oct. 30, 1996, a peak was seen around the stand-by pond. The water level tended to decline toward the East. A higher water level was observed at north side of BVR Co. I/A and TM-30. Due to such trend, a decline in the water level was found between Dusnokpuszta and Borsodszirak. Accordingly the direction and velocity of groundwater correspond to these water levels. (Figure 6.3.15)

Table 6.3.9 (1) Results of the Groundwater Surveying (Monitoring Wells)

Sampling:1996.10.24-30

Sample Name	Temp °C	pH	Conduct-ivity μ S/cm	Dissolved Solids mg/l	DO mg/l	COD mg/l	NH_4^+ mg/l	NO_2^- mg/l	NO_3^- mg/l	Cl^- mg/l	SO_4^{2-} mg/l	As μg/l	Cd μg/l	Cr μg/l	Cu μg/l	Fe μg/l	Hg μg/l	Mn μg/l	Pb μg/l	Zn μg/l	Ca mg/l	K mg/l	Mg mg/l	Na mg/l	S mg/l
TM-2	13.5	7.78	758	606	5.0	2.10	2.60	<0.01	<0.1	50	239	43.9	<0.2	11	<8	106	<0.2	386	<2	17	69	15.3	14.4	91	72
TM-3	12.3	7.65	1712	1370	-	1.60	0.54	<0.01	<0.1	59	785	3.6	<0.2	9	<8	1700	<0.2	259	<2	10	149	31.3	50.8	193	256
TM-4	13.5	8.35	1172	938	-	2.55	4.26	<0.01	0.3	45	715	39.0	<0.2	<6	<8	155	<0.2	164	<2	5	194	24.1	3.7	119	212
TM-5	12.0	7.80	1945	1556	3.7	2.40	11.12	<0.01	<0.1	67	1035	9.1	0.5	<6	9	1560	<0.2	1650	<2	11	376	19.3	8.1	114	338
TM-6	12.9	7.59	1833	1466	-	2.45	6.73	<0.01	<0.1	72	990	31.6	<0.2	<6	<8	1010	<0.2	2250	<2	6	354	18.3	7.0	100	290
TM-7	13.6	7.13	1770	1416	-	3.75	2.64	0.03	<0.1	66	715	27.6	<0.2	<6	<8	3730	<0.2	1760	<2	6	230	17.3	24.0	154	186
TM-8	14.4	7.81	622	498	3.1	2.00	0.49	<0.01	<0.1	75	164	45.6	<0.2	<6	<8	660	<0.2	1120	<2	5	95	6.7	11.0	19	48
TM-9	13.4	7.59	1318	1054	3.9	2.15	2.52	0.02	<0.1	55	580	8.9	<0.2	<6	<8	1160	<0.2	1100	<2	9	224	26.8	22.8	102	205
TM-11	12.7	7.50	1885	1508	-	3.00	1.91	0.02	<0.1	126	770	10.2	<0.2	<6	<8	1870	<0.2	1300	<2	9	153	24.6	31.4	256	162
TM-12	13.3	7.48	1763	1410	-	2.50	2.04	<0.01	<0.1	75	725	29.7	<0.2	<6	<8	2950	0.3	1770	4	<2	217	28.7	26.8	141	216
TM-13	12.3	8.54	1922	1538	-	3.60	4.08	<0.01	<0.1	61	868	22.0	<0.2	<6	<8	66	<0.2	725	<2	6	346	27.6	10.3	120	330
TM-14	14.6	10.30	1880	1504	-	4.95	3.76	<0.01	0.2	54	1070	54.8	<0.2	<6	<8	56	<0.2	26	5	8	413	31.8	0.5	73	368
TM-15	13.4	7.53	1886	1509	3.5	1.95	1.86	<0.01	<0.1	57	1071	<0.6	<0.2	<6	<8	64	<0.2	277	25	<2	316	24.9	33.3	108	301
TM-16	13.5	7.74	1050	840	3.6	2.00	1.51	<0.01	<0.1	47	560	<0.6	0.7	<6	<8	215	<0.2	1100	5	4	204	23.6	23.3	80	182
TM-17	13.1	7.31	1606	1285	-	3.20	3.96	0.02	<0.1	139	735	4.4	<0.2	<6	10	1990	<0.2	350	5	3	251	17.6	35.9	240	231
TM-18	12.3	7.33	1720	1376	-	1.10	2.66	0.02	<0.1	130	715	1.7	<0.2	<6	<8	2170	<0.2	557	<2	5	235	25.0	39.5	268	229
TM-19	15.5	6.62	3882	3499	-	2.50	0.12	0.05	31.0	1030	294	0.9	<0.2	<6	<8	<6	<0.2	906	<2	<2	378	1.9	111.0	313	88
TM-20	12.6	6.72	2085	1627	-	1.60	0.05	0.01	79.0	258	445	<0.6	<0.2	<6	<8	253	<0.2	25	<2	17	296	2.4	85.3	68	124
TM-21	11.9	6.79	4917	4206	-	3.20	0.09	0.27	51.0	1600	670	<0.6	<0.2	<6	<8	76	<0.2	536	<2	5	303	26.2	33.3	926	203
TM-22	11.5	7.00	6684	4639	-	4.20	0.13	<0.01	23.0	2000	760	<0.6	<0.2	<6	<8	<6	<0.2	2440	<2	8	401	29.5	47.6	1100	228
TM-23	13.7	6.92	5567	4526	-	4.30	1.47	<0.01	0.7	1630	815	80.0	<0.2	<6	<8	6040	<0.2	6110	<2	<2	430	24.9	23.8	792	239
TM-24	13.5	7.08	1733	1462	-	3.90	2.58	<0.01	0.3	255	600	20.0	<0.2	<6	<8	4620	<0.2	3000	<2	6	275	16.0	20.1	144	196
TM-25	13.0	7.27	1417	1134	-	1.60	0.03	0.01	<0.1	43	470	1.1	<0.2	<6	<8	1000	<0.2	1000	<2	7	161	27.1	52.1	119	145
TM-27	12.0	6.99	2370	1896	-	4.10	0.24	<0.01	<0.1	365	620	<0.6	<0.2	<6	21	9190	<0.2	229	<2	<2	376	5.4	44.4	149	193
TM-28	12.0	6.94	1865	1492	4.4	4.70	0.85	<0.01	<0.1	135	670	2.9	<0.2	<6	<8	20200	<0.2	518	<2	27	205	9.5	39.7	196	212
TM-30	11.7	7.44	794	568	2.6	3.30	1.80	<0.01	<0.1	18	62	0.7	<0.2	<6	<8	884	<0.2	169	<2	13	71	17.2	19.8	90	15
TM-31	12.9	7.04	1364	1091	-	2.75	0.07	0.03	<0.1	59	595	<0.6	<0.2	<6	<8	5750	<0.2	697	<2	6	297	4.8	53.3	21	202
TM-32	12.3	7.36	1456	1165	-	2.40	0.03	<0.01	<0.1	78	695	<0.6	<0.2	<6	<8	3930	<0.2	574	<2	<2	292	3.0	54.8	20	212
TM-33	12.2	7.26	817	589	-	1.70	0.17	<0.01	<0.1	21	245	1.2	<0.2	<6	<8	2150	<0.2	234	<2	<2	147	1.5	24.0	10	72
TM-34	11.8	7.15	906	822	-	2.30	0.43	<0.01	<0.1	39	410	<0.6	0.5	<6	<8	4030	<0.2	858	<2	5	198	1.8	27.5	11	123
TM-35	12.3	7.13	2043	1634	-	1.00	<0.01	<0.01	1.1	186	600	<0.6	<0.2	<6	<8	39	<0.2	12	<2	5	273	9.8	41.7	273	191

Table 6.3.9 (2) Results of the Groundwater Surveying (Monitoring Wells)

Sampling: 1996.10.24-30

Sample Name	Temp ℃	pH	Conductivity μS/cm	Dissolved Solids mg/l	DO mg/l	COD mg/l	NH_4^+ mg/l	NO_2^- mg/l	NO_3^- mg/l	Cl^- mg/l	SO_4^{2-} mg/l	As μg/l	Cd μg/l	Cr μg/l	Cu μg/l	Fe μg/l	Hg μg/l	Mn μg/l	Pb μg/l	Zn μg/l	Ca mg/l	K mg/l	Mg mg/l	Na mg/l	S mg/l
TM-36	11.5	7.47	784	627	-	1.20	0.29	0.01	<0.1	64	195	<0.6	<0.2	<6	<8	1700	<0.2	327	<2	8	138	6.6	24.2	52	67
TM-37	12.9	6.87	5282	3779	-	3.60	0.67	0.01	89.0	1451	640	<0.6	<0.2	<6	<8	952	<0.2	1180	<2	<2	322	19.5	50.6	831	185
TM-40	13.7	6.72	1093	996	5.1	1.50	0.02	<0.01	9.9	28	390	<0.6	<0.2	<6	<8	23	<0.2	5	<2	7	198	4.5	41.5	23	110
TM-41	12.0	7.42	1639	1311	-	1.85	0.08	0.01	<0.1	149	945	0.7	<0.2	<6	<8	2730	0.3	558	<2	3	309	11.3	50.2	223	320
TM-42	12.7	7.20	1467	1174	-	2.25	<0.01	0.55	82.0	169	470	<0.6	<0.2	<6	<8	103	<0.2	729	<2	4	237	34.1	61.2	84	131
TM-43	12.1	7.48	1132	906	-	1.20	<0.01	<0.01	19.7	70	355	<0.6	<0.2	<6	<8	13	<0.2	<1	<2	4	148	4.8	39.8	83	106
TM-44	12.3	7.38	1716	1373	-	1.00	<0.01	<0.01	36.0	176	585	<0.6	<0.2	<6	<8	33	0.3	2	<2	7	241	5.4	66.1	105	180
TT-1	15.7	7.65	1840	1472	-	2.40	2.20	<0.01	0.8	39	925	9.4	<0.2	9	<8	694	<0.2	743	<2	45	372	21.8	7.5	56	320
TT-4	15.2	7.00	4717	3615	-	2.80	8.60	0.01	<0.1	1016	885	140.0	<0.2	<6	<8	3470	<0.2	7940	<2	9	476	14.7	69.4	545	281
TT-8	12.9	8.15	1609	1287	1.6	2.50	2.56	<0.01	<0.1	39	925	20.0	<0.2	<6	<8	1010	<0.2	1310	<2	<2	362	20.4	5.5	60	296
TT-9	15.6	8.05	1597	1278	2.9	2.00	2.11	<0.01	<0.1	49	870	6.9	<0.2	<6	<8	669	<0.2	1030	<2	14	326	21.8	6.7	54	257
TT-10	14.3	10.63	1954	1563	-	3.30	3.80	<0.01	<0.1	47	1155	70.4	<0.2	15	<8	454	<0.2	16	<2	10	439	30.9	0.2	72	346
TT-11	16.1	8.45	2023	1839	-	2.40	0.28	<0.01	<0.1	59	1120	214.0	<0.2	<6	17	38	<0.2	179	<2	<2	355	24.7	11.3	115	355
TT-12	12.0	7.60	5845	4042	-	3.60	1.98	<0.01	38.0	1670	650	3.6	<0.2	<6	<8	101	<0.2	524	<2	<2	256	35.4	26.0	970	161
TT-13	13.7	7.68	6235	4506	-	3.30	1.42	<0.01	<0.1	1820	1150	75.0	<0.2	<6	<8	1480	<0.2	685	<2	5	283	39.5	32.2	1120	209
E-1	12.3	6.94	1629	1721	-	1.10	0.04	<0.01	<0.1	179	660	<0.6	<0.2	<6	<8	467	<0.2	2450	<2	<2	384	4.3	64.7	49	209
E-4	12.7	7.17	1597	1263	-	1.20	0.02	0.05	56.0	108	1205	<0.6	<0.2	<6	<8	28	<0.2	20	<2	<2	252	5.9	71.1	103	178
E-5	12.7	7.38	627	520	-	1.00	0.02	0.04	16.2	34	122	<0.6	<0.2	<6	<8	36	<0.2	391	<2	<2	119	4.2	14.3	13	38
E-6	11.5	7.17	2013	1841	-	0.90	0.02	<0.01	<0.1	215	485	<0.6	<0.2	16	<8	18	<0.2	2	<2	<2	254	5.7	104.0	202	132
ET-101	11.7	7.40	1743	1394	-	2.10	2.35	0.02	22.0	227	399	1.4	<0.2	<6	<8	3750	<0.2	737	<2	37	240	21.6	51.3	138	207
ET-102	11.9	7.37	1729	1383	6.4	0.95	0.08	<0.01	7.2	178	512	<0.6	<0.2	<6	<8	35	<0.2	3	<2	<2	265	8.8	61.6	103	173
ET-103	11.9	7.86	487	390	-	22.00	4.68	<0.01	<0.1	6	10	3.7	<0.2	<6	<8	1040	<0.2	171	<2	9	81	9.8	17.9	17	251
ET-104	12.3	7.51	4007	3206	-	2.90	16.90	<0.01	<0.1	960	670	<0.6	<0.2	<6	<8	131	<0.2	3050	<2	<2	200	21.3	48.1	748	207
H-2	12.3	7.14	2101	1279	-	1.15	0.02	<0.01	<0.1	215	725	<0.6	<0.2	<6	<8	862	<0.2	45	<2	<2	298	7.0	55.2	192	217
H-3	11.1	7.32	933	714	-	2.90	0.84	<0.01	<0.1	110	164	0.7	<0.2	<6	<8	16100	<0.2	1390	<2	3	126	4.1	23.4	42	54
HS	11.2	7.31	1415	1240	-	1.50	0.46	<0.01	<0.1	74	790	1.0	<0.2	<6	<8	3700	<0.2	270	<2	<2	272	3.6	24.1	110	224
M*2	11.7	6.94	6090	5234	-	2.80	0.02	0.80	46.0	2090	675	<0.6	<0.2	<6	<8	77	<0.2	1340	<2	7	400	40.7	43.9	1140	205
T1*	13.9	8.31	1957	1566	3.4	3.00	10.64	<0.01	<0.1	103	970	43.6	<0.2	<6	<8	185	<0.2	223	<2	84	268	26.1	7.9	217	322
TS	12.4	7.28	1892	1514	-	3.00	0.76	<0.01	<0.1	207	660	<0.6	<0.2	<6	<8	20200	<0.2	1450	<2	<2	332	3.6	51.8	108	219
V-2	14.3	8.22	1190	952	-	2.50	0.88	<0.01	<0.1	34	715	56.4	<0.2	<6	<8	929	<0.2	3300	<2	6	252	12.3	5.2	46	206

Table 6.3.10 Results of the Surfacewater Surveying (River and Pond)

Sampling:1996.10.24-30

Sample Name	Temp °C	pH	Conduct-ivity μ S/cm	Dissolved Solids mg/l	DO mg/l	COD mg/l	NH_4^+ mg/l	NO_2^- mg/l	NO_3^- mg/l	Cl^- mg/l	SO_4^{2-} mg/l	As μg/l	Cd μg/l	Cr μg/l	Cu μg/l	Fe μg/l	Hg μg/l	Mn μg/l	Pb μg/l	Zn μg/l	Ca mg/l	K mg/l	Mg mg/l	Na mg/l	S mg/l
TM-6'	13.9	7.43	1766	1413	-	3.85	4.39	0.06	0.7	54	715	65.2	<0.2	<6	<8	7140	0.3	2810	<2	9	350	19.5	8.7	95	302
TM-12'	6.4	7.41	1494	1195	2.3	2.70	1.20	0.10	1.2	59	1010	7.2	<0.2	<6	<8	526	<0.2	2690	<2	<2	226	19.6	20.4	95	200
V-2'	17.1	12.64	5980	4784	-	12.80	1.44	<0.01	4.0	24	1060	14.4	<0.2	<6	<8	<6	<0.2	<1	<2	<2	862	24.8	0.0	55	377
C.W.	17.5	7.97	684	442	-	63.00	0.44	0.30	10.0	40	740	2.3	<0.2	<6	<8	<6	<0.2	47	<2	<2	73	9.7	21.2	32	31
S.L.	-	9.53	3978	2895	-	6.40	0.33	<0.01	54.0	1160	109	1.0	<0.2	<6	<8	141	<0.2	7	<2	8	170	27.4	31.2	691	102
Sajo U	7.3	8.29	467	418	11.0	3.80	0.28	0.19	9.4	37	385	1.5	<0.2	<6	<8	209	<0.2	49	<2	7	71	5.8	20.5	17	26
Sajo D	9.8	8.31	482	531	11.7	3.10	0.20	0.16	8.9	39	80	1.2	<0.2	<6	<8	229	<0.2	47	<2	<2	69	5.9	20.2	18	25
Sajo A	7.9	8.45	523	426	12.6	3.30	0.39	0.21	9.8	41	91	1.3	<0.2	<6	<8	209	(0.2)	57	<2	6	76	6.7	21.6	19	25
Sajo B	12.9	8.43	528	406	10.6	3.30	0.89	0.19	8.3	39	89	1.4	<0.2	<6	<8	223	<0.2	60	<2	14	75	6.8	21.5	19	25
Bodva U	8.1	8.27	405	-	11.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bodva D	8.9	8.23	451	482	11.0	3.20	0.21	0.14	12.7	26	77	1.9	<0.2	<6	<8	183	<0.2	36	<2	6	73	4.8	12.9	13	23
Szuha	11.1	8.44	1411	1319	11.8	2.50	0.16	0.10	2.9	49	755	3.5	<0.2	<6	10	48	<0.2	374	<2	3	288	11.2	28.9	81	269

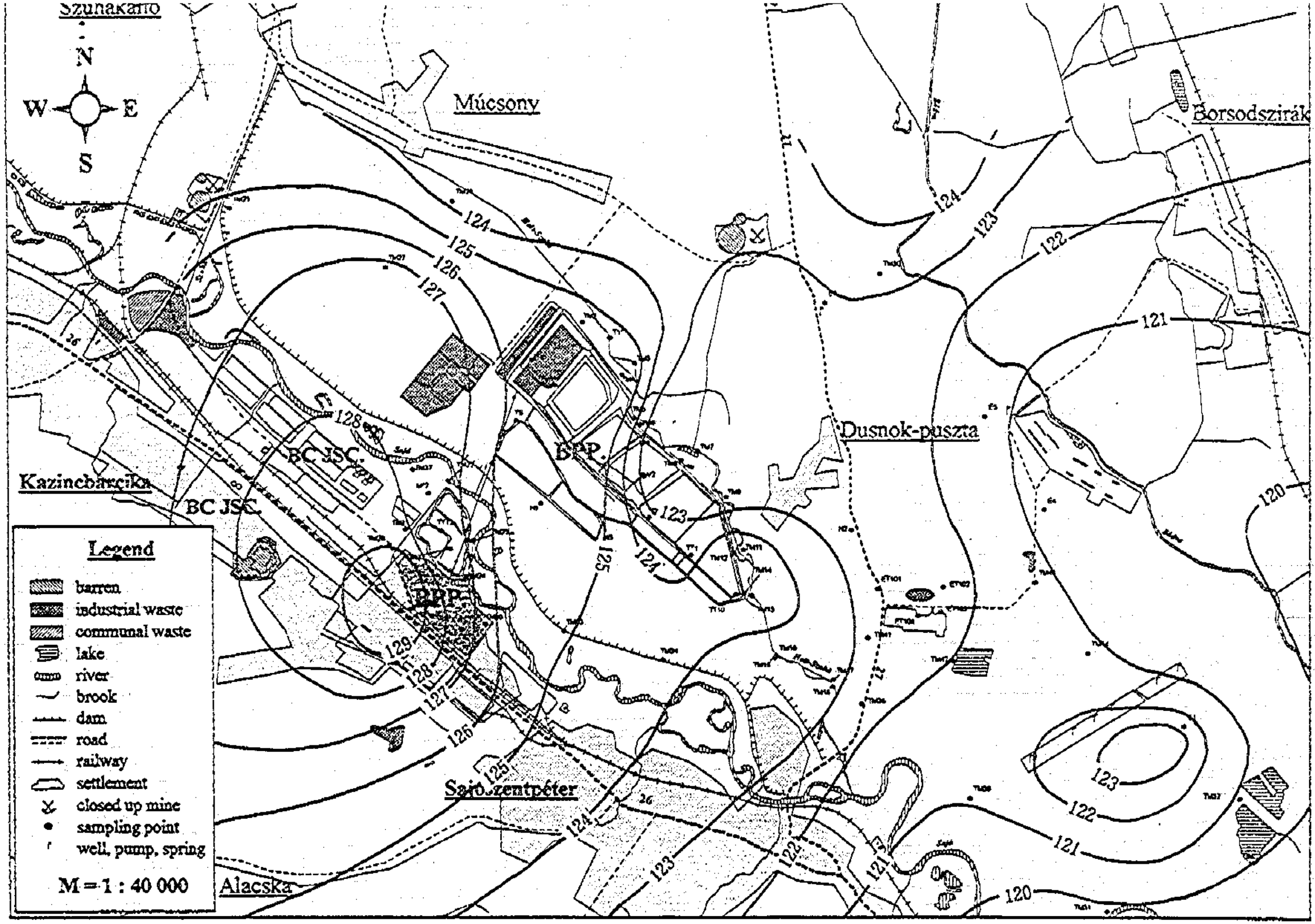


Figure 6.3.15 Isopleth of Groundwater Level

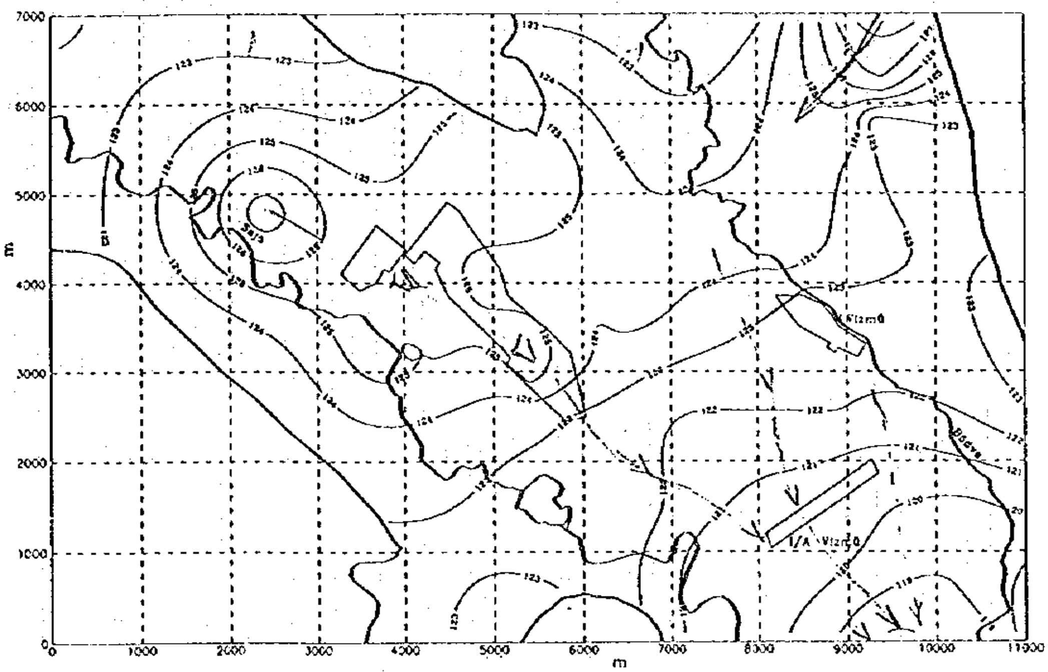


Figure 6.3.16 Isopleth of Groundwater at the Most Stable Level

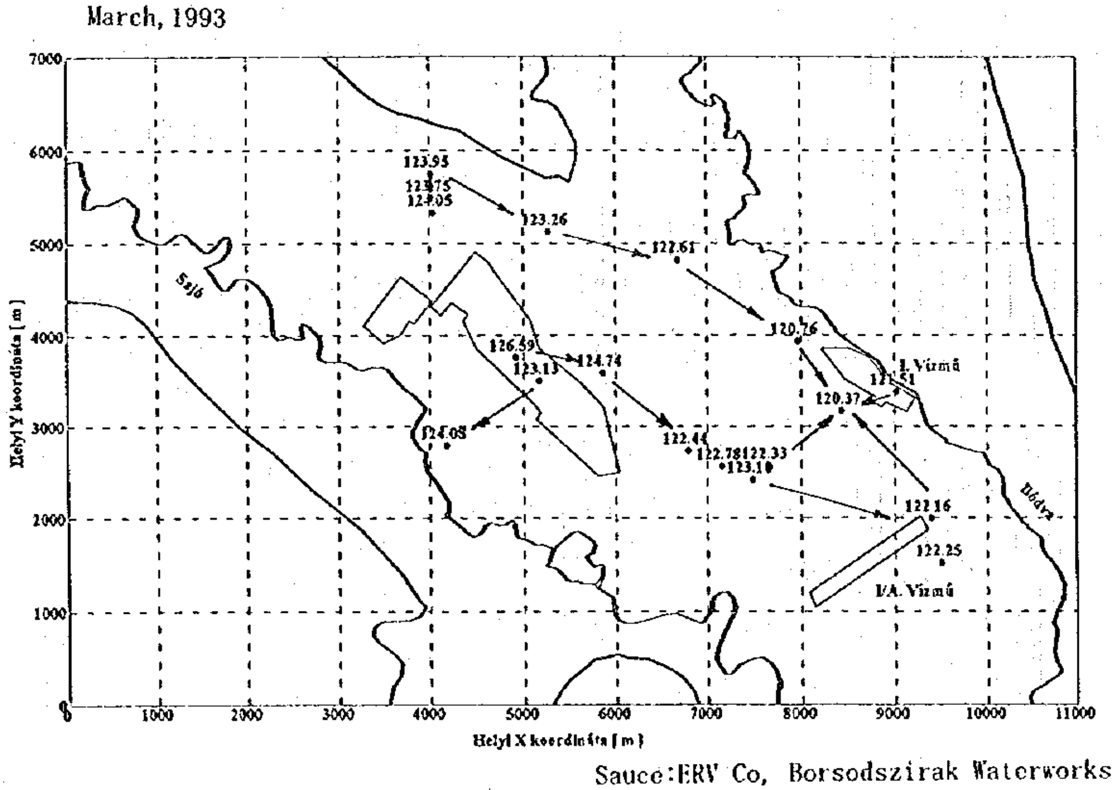


Figure 6.3.17 Flow Direction of Groundwater at Most Stable Level

ii) According to the stablest water level the water level is high at the sludge storage, northwestern part of the disposal site of Borsodchem Co. and northern part of EVR Co. Borsodszirak Waterworks I. Judging from such distribution of the sites of equal water level, the impact of the sludge storage and other disposal sites on the service water sources particularly to EVR Co. I/A requires consideration. (Figure 6.3.16 and Figure 6.3.17)

iii) Groundwater level and lines of equal water level is seasonally or yearly variable.

b) Groundwater level

Survey was carried out about the relation among the groundwater level, water level of rivers and precipitation, and yearly variation of the groundwater level. The results of the yearly variation of the groundwater level is shown in Figure 6.3.17 through 6.3.20 and detailed results include in the Supporting Report. The data in Figure 6.3.16 through 6.3.18 are provided from ERV Co..

The following is the findings of the survey:

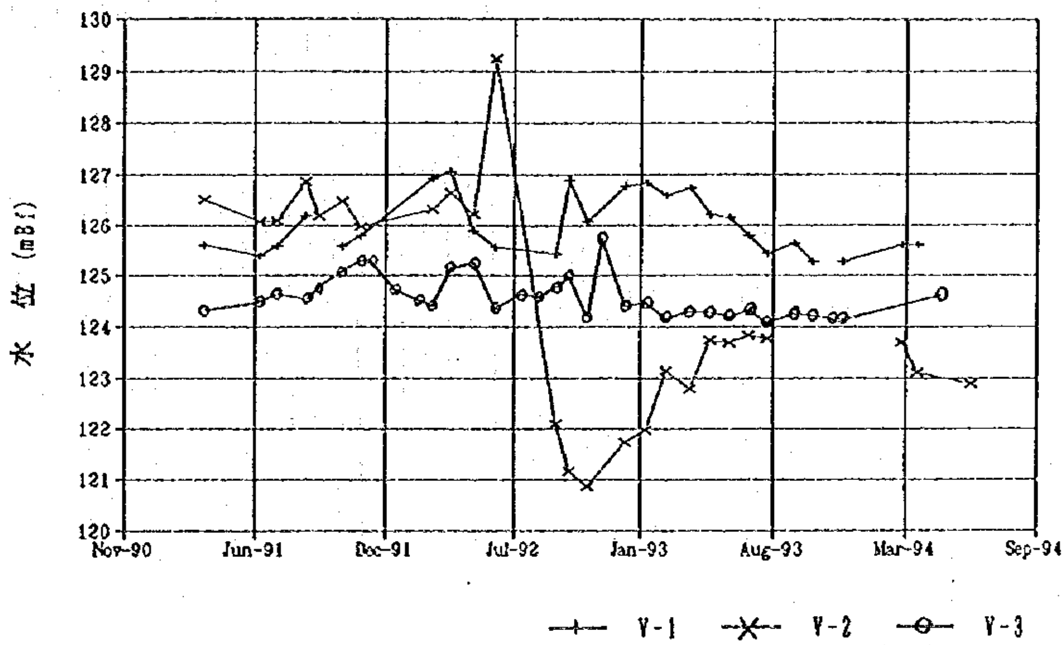
i) The levels of the Sajo river and groundwater are closely related with each other.

ii) Relation between the annual precipitation and the yearly average of groundwater level is not clear. This is probably due to the fluctuation of the river water level because of the precipitation even when the annual amount of precipitation is the same.

iii) Relevancy between monthly precipitation and monthly average of groundwater level is often found when the highs and lows are compared.

iv) Concerning the level of observation wells V-1 to V-3 and E-1 to E-3 , large fluctuations are seen at V-2 between the second half of 1991 and the first half of 1992.

It may be that V-2 was improved at this time.



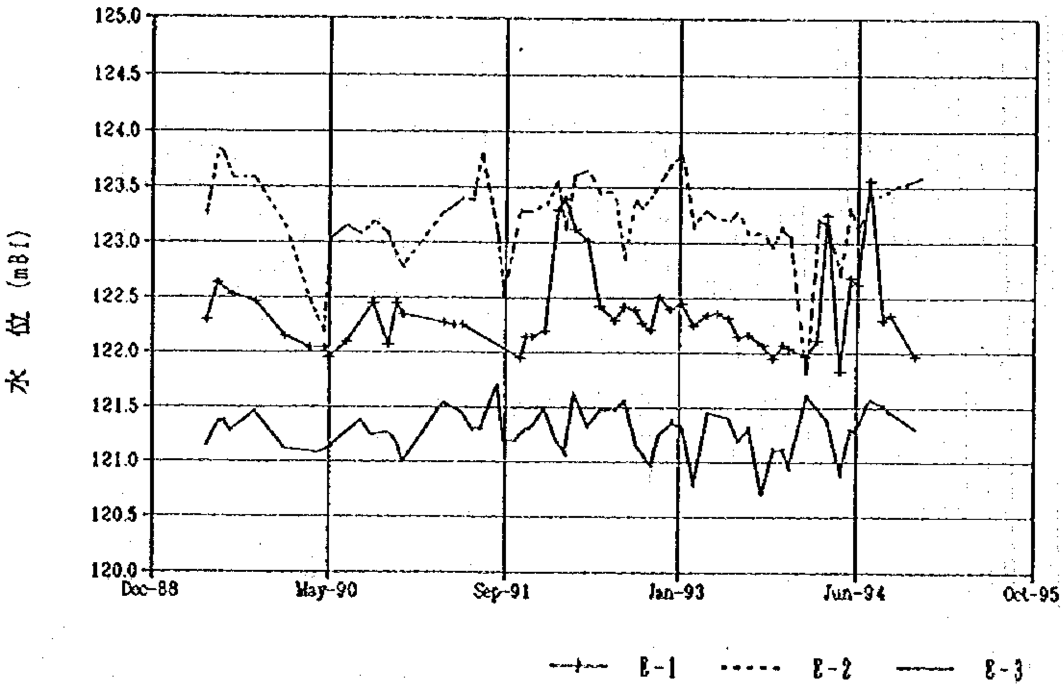


Figure 6.3.18 Variation of Groundwater Level at Monitoring Wells

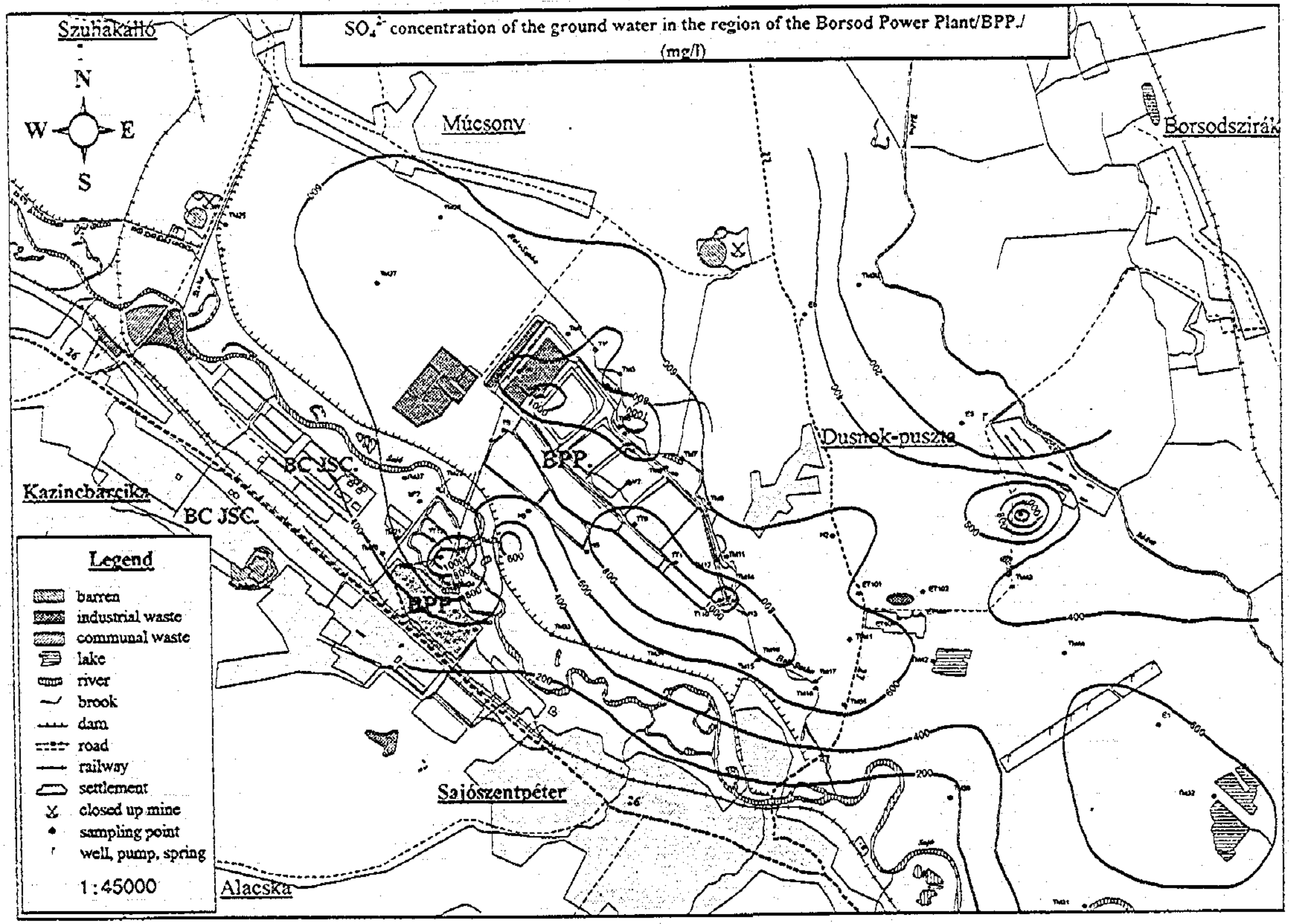


Figure 6.3.19 SO$_4^{2-}$ Concentration of the Groundwater in the Surroundings of Borsod Power Plant

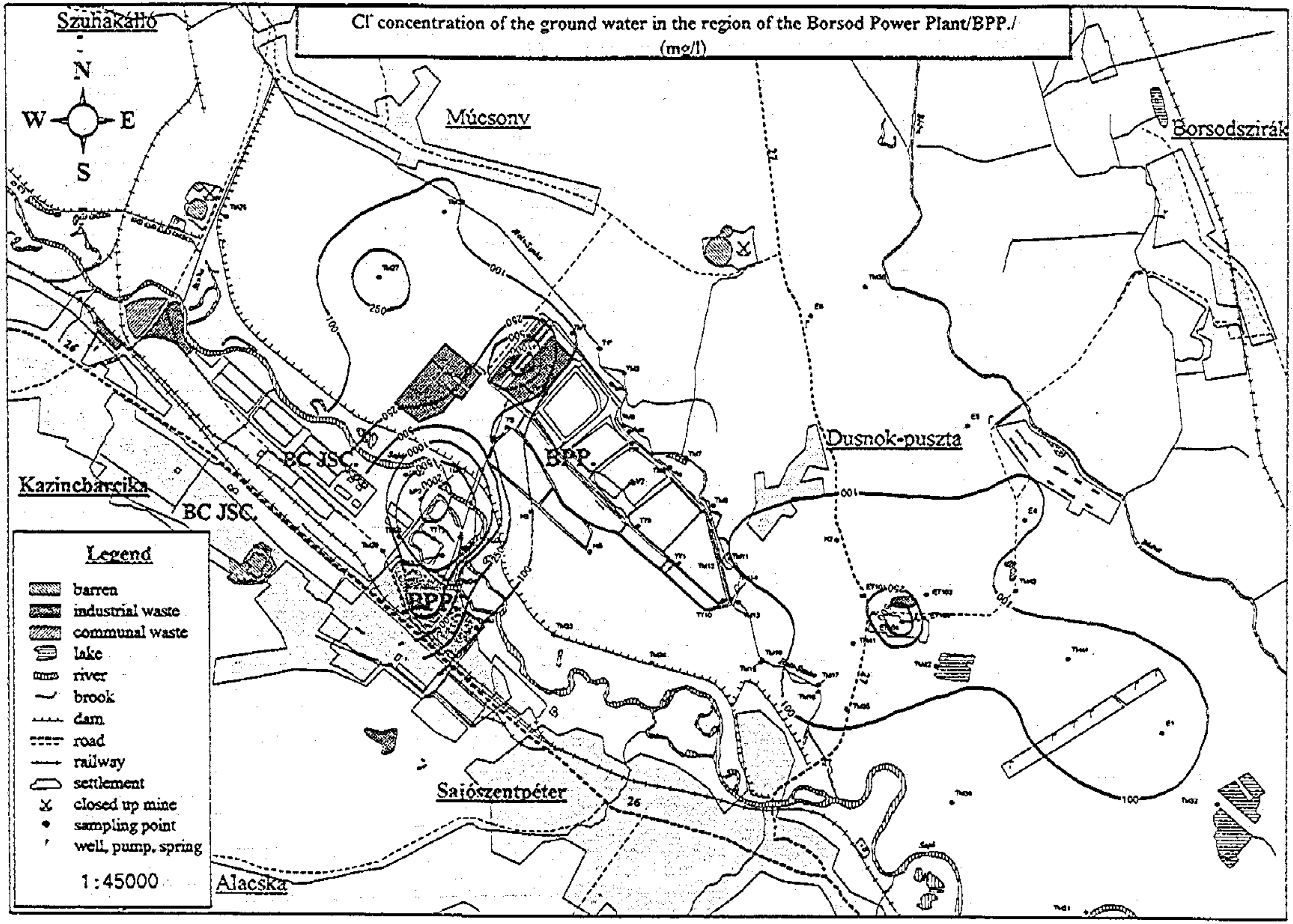


Figure 6.3.20 Cl⁻: Concentration of the Groundwater in the Surroundings of Borsod Power Plant

3) Pollutant concentration in groundwater

Figure 6.3.19 through Figure 6.3.27 show isopleth for concentration of heavy metals, ions, etc.

a) As far as the contamination by ions is concerned, high concentration appears without fail around the pond of standby storage area and in the vicinity of the site where coal grading sludge and the waste from Borsodchem Co. were stored. Other spots also show high concentration depending of the type of contaminants. These figures of isopleth for concentration of each component suggests the presence of many waste dumping areas.

b) Contaminants in heavy metals discharged from the facilities in Borsod Power Plant and that may harm mankind's health is limited to As. Contamination in high concentration that may invite serious problems is limited in sludge storage areas and the vicinity of wastewater storage reservoirs, only. For the sources of water supply, ions, pH values and electric conductivity are causing problems at present rather than heavy metals.

c) Ions including NH_4^+ are supposed to be brought also by agriculture and stock farming.

d) Regulatory values of ions in relation to drinking water are shown in the following table. As the comparison to the figures of concentration isopleth indicates, widespread contamination has been extended. In the sources of water supply from the block Borsodszirak I/A, many ions have already exceeded the allowable limits.

Designation	Unit	Adequate	Tolerable
SO_4^{2-}	mg/l	200	300
Cl^-	mg/l	80	100
NH_4^+	mg/l	0.1	0.2
Electric conductivity	μS/cm	1350	1600
Total dissolved substance	mg/l	1000	1200

e) Although Na^+ and Ca^{2+} are not shown in the figure, Na^+ and Ca^{2+} correlate closely with Cl^- and SO_4^{2-}, respectively, and show almost the same distribution.

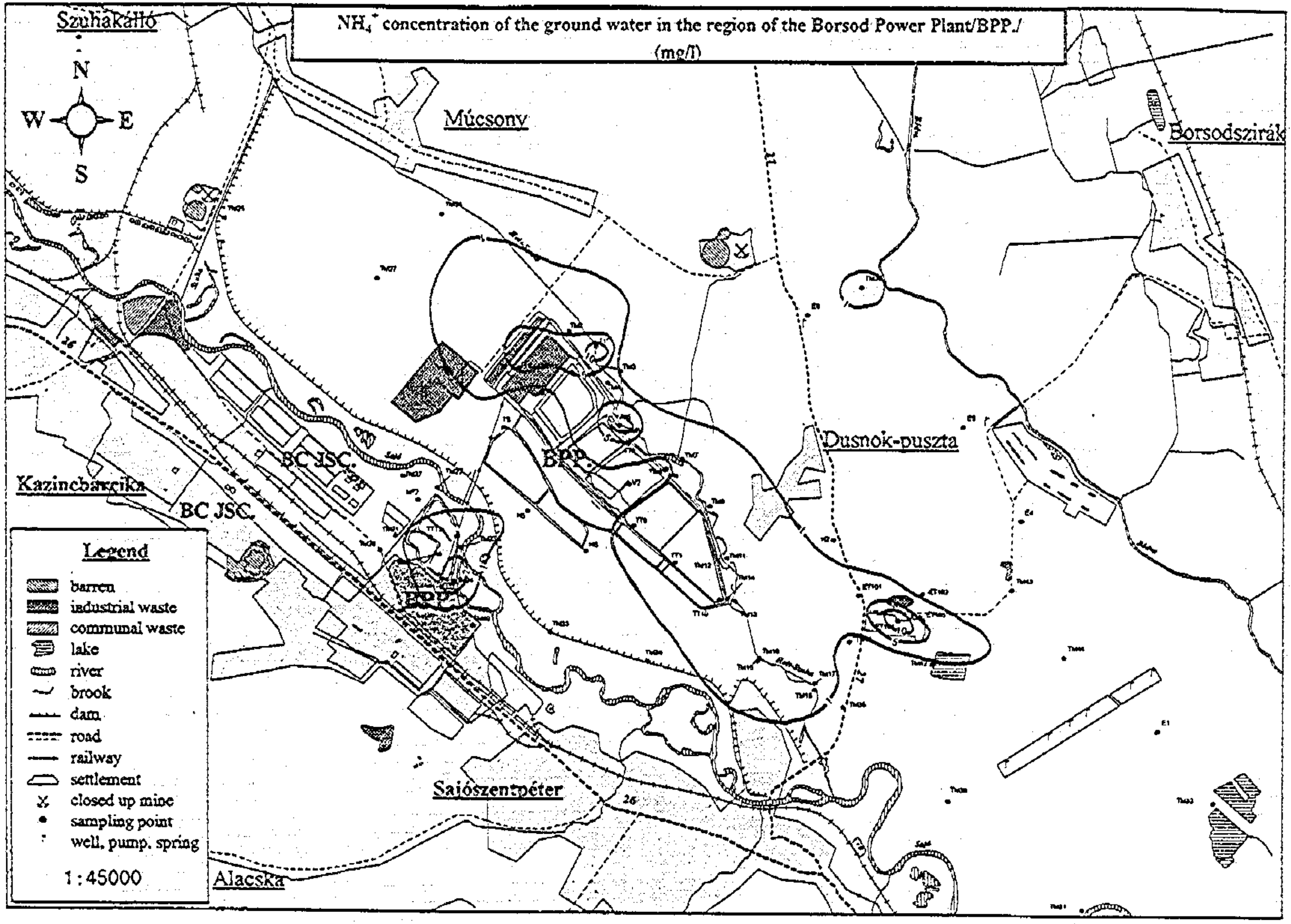


Figure 6.3.21 NH$_4^+$ Concentration of the Groundwater in the Surroundings of Borsod Power Plant

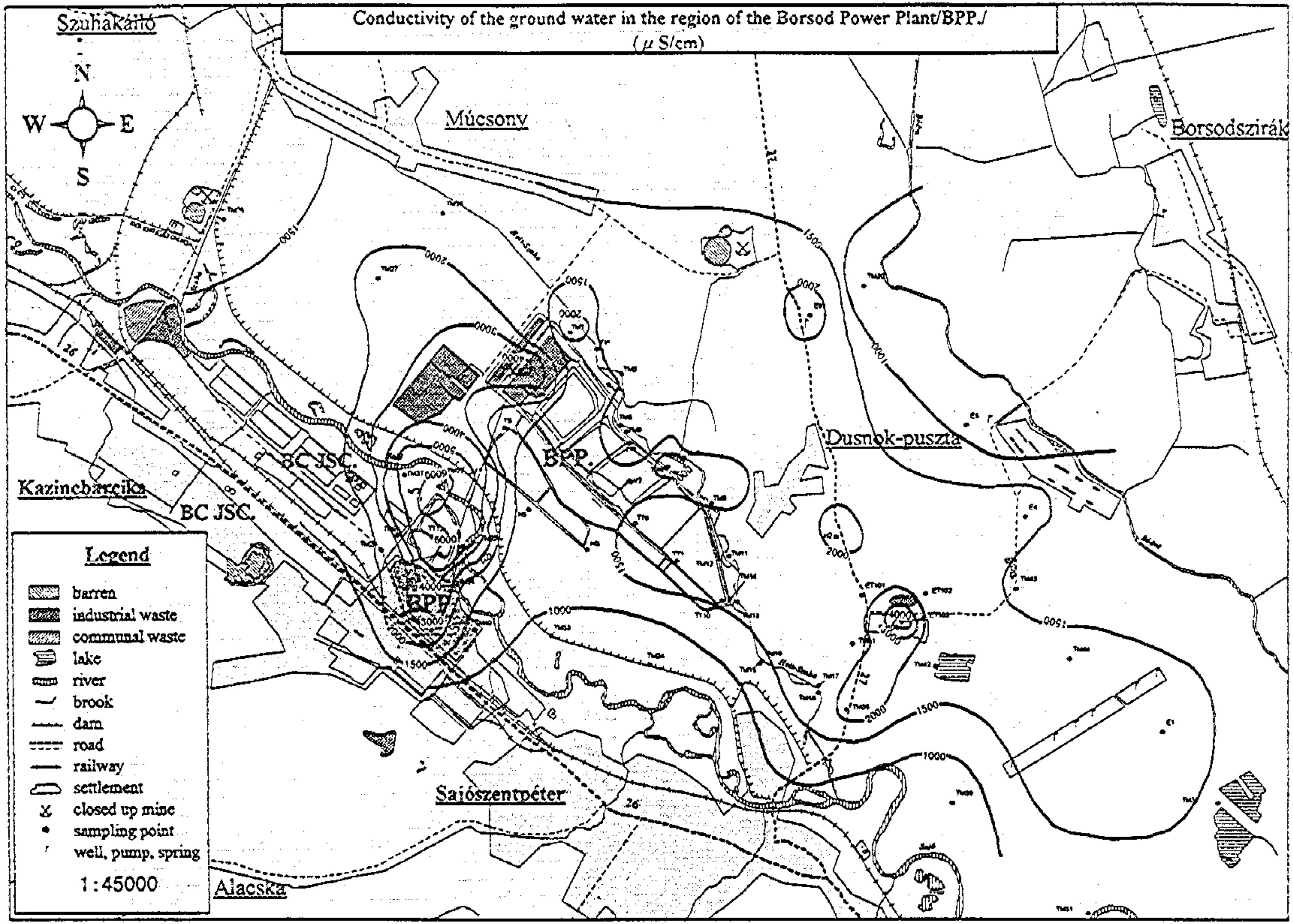


Figure 6.3.22 Conductivity of the Groundwater in the Surroundings of Borsod Power Plant

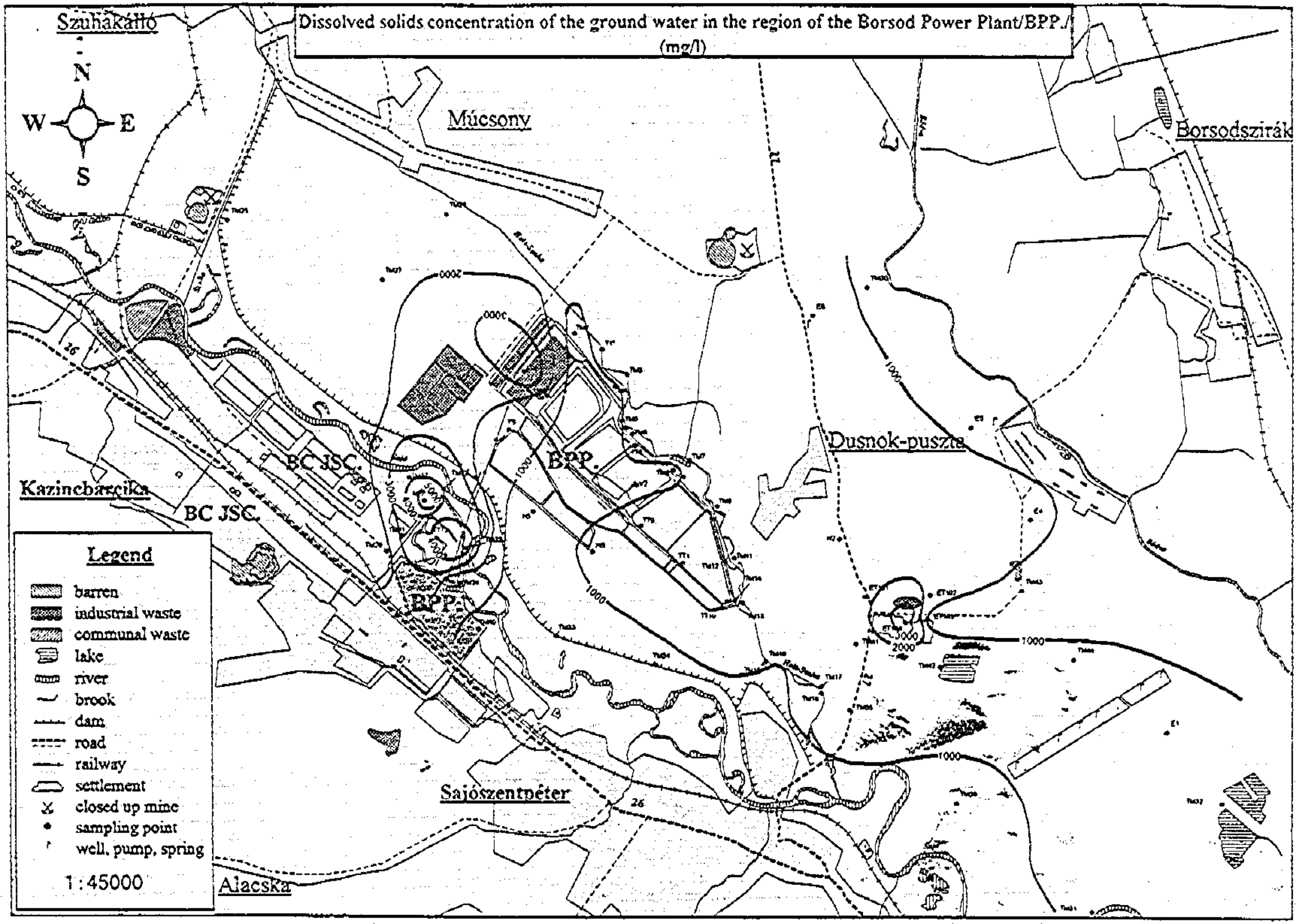


Figure 6.3.23 Dissolved Solids Concentration of the Groundwater in the Surroundings of Borsod Power Plant

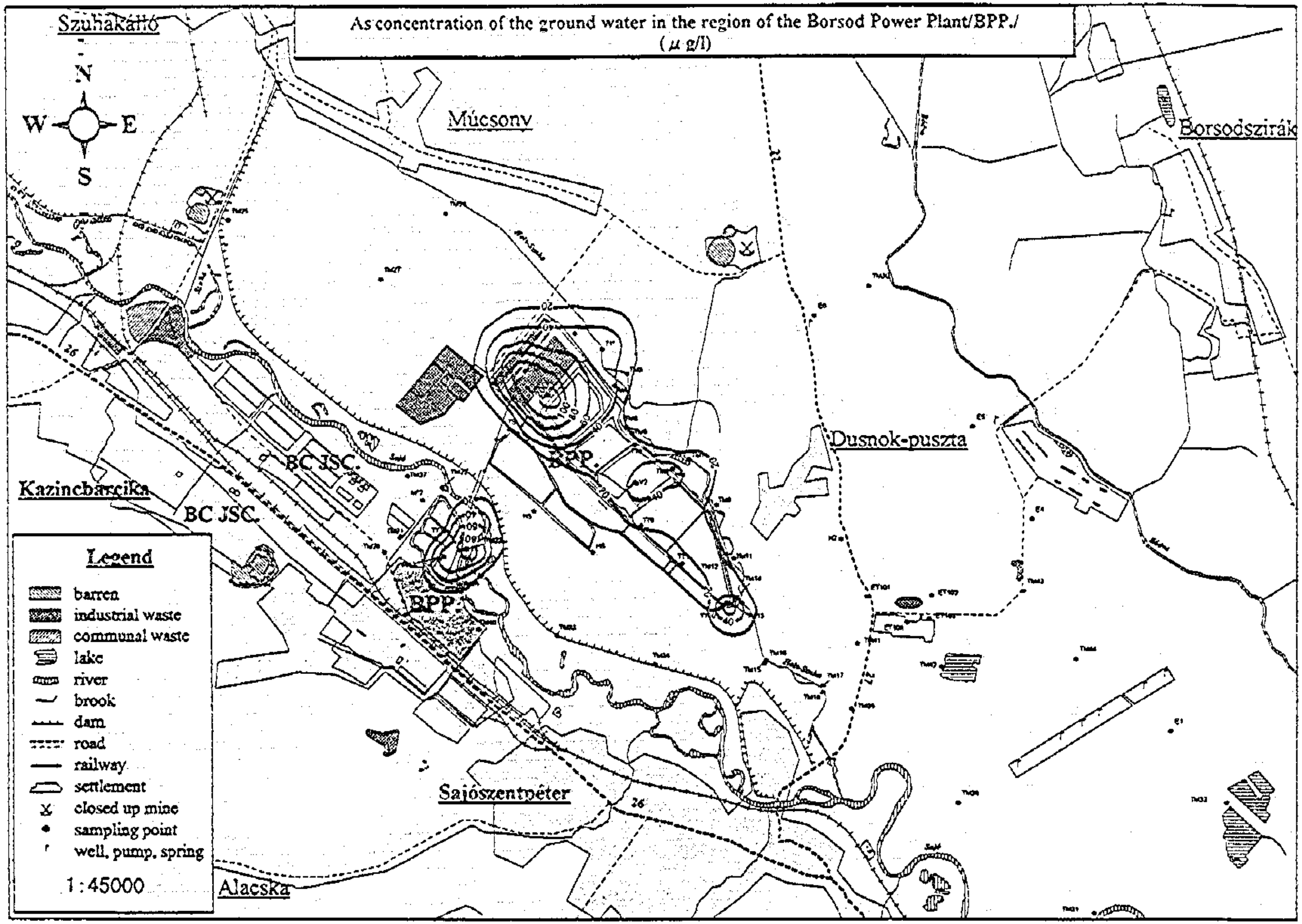


Figure 6.3.24 As Concentration of the Groundwater in the Surroundings of Borsod Power Plant

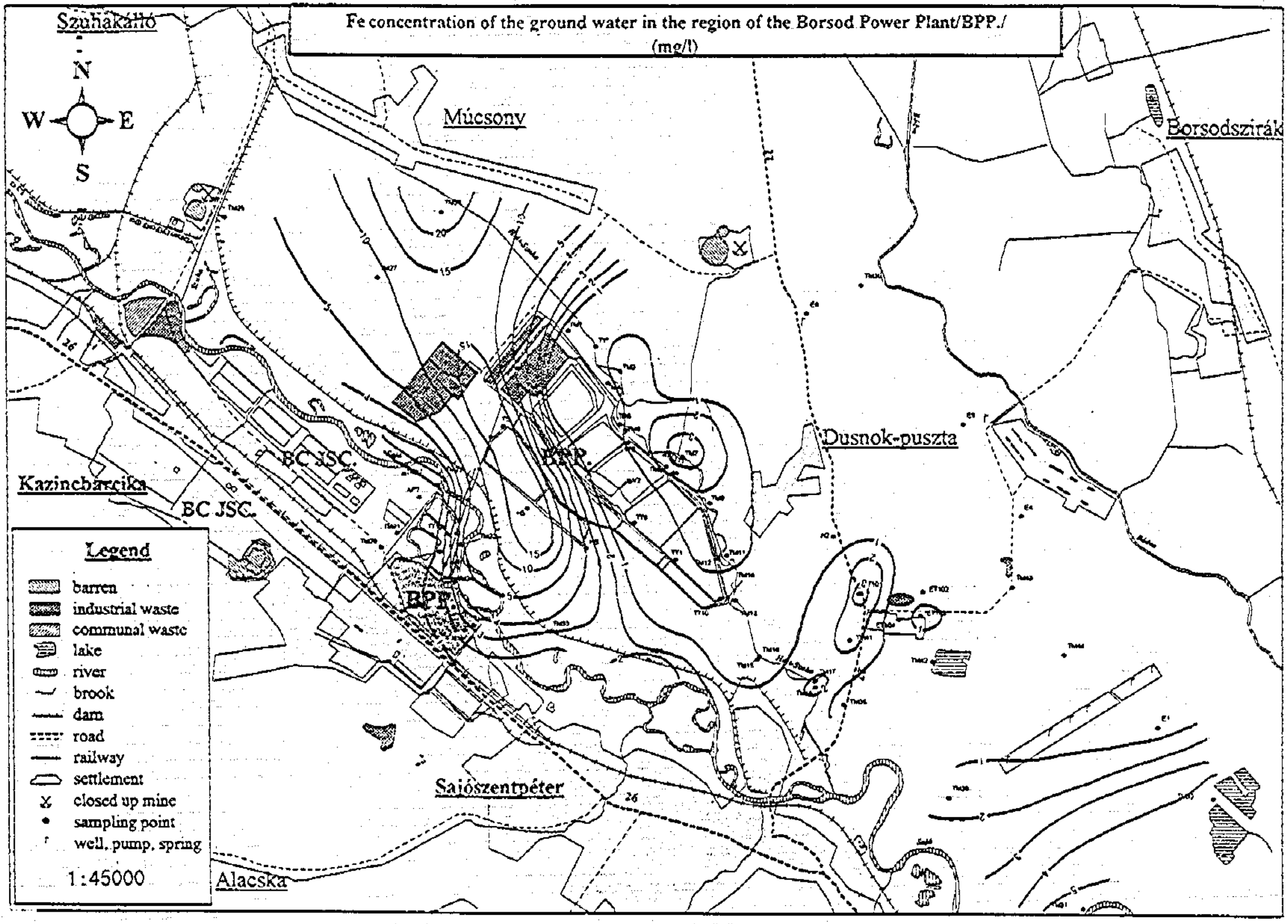


Figure 6.3.25 Fe Concentration of the Groundwater in the Surroundings of Borsod Power Plant