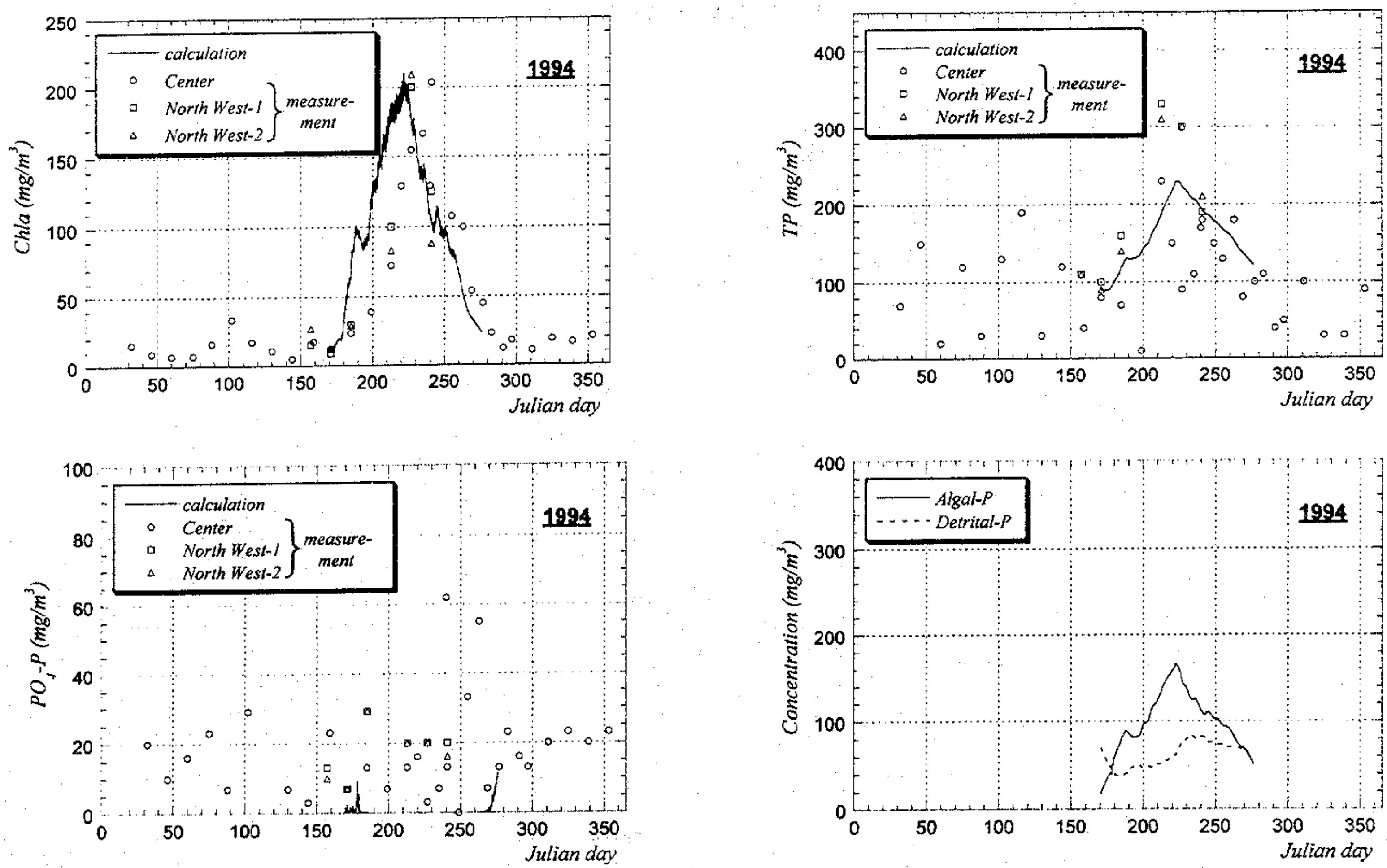
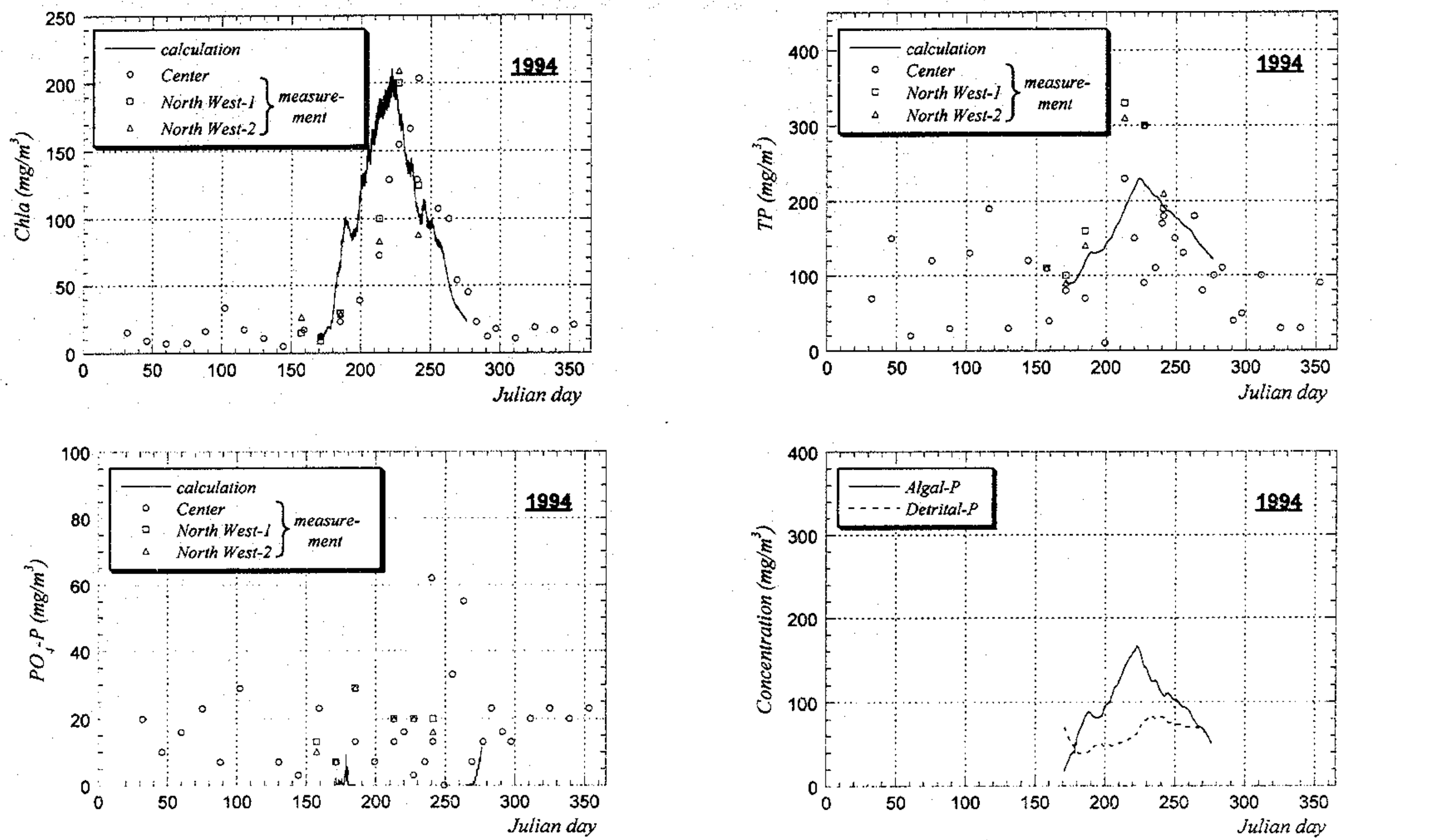


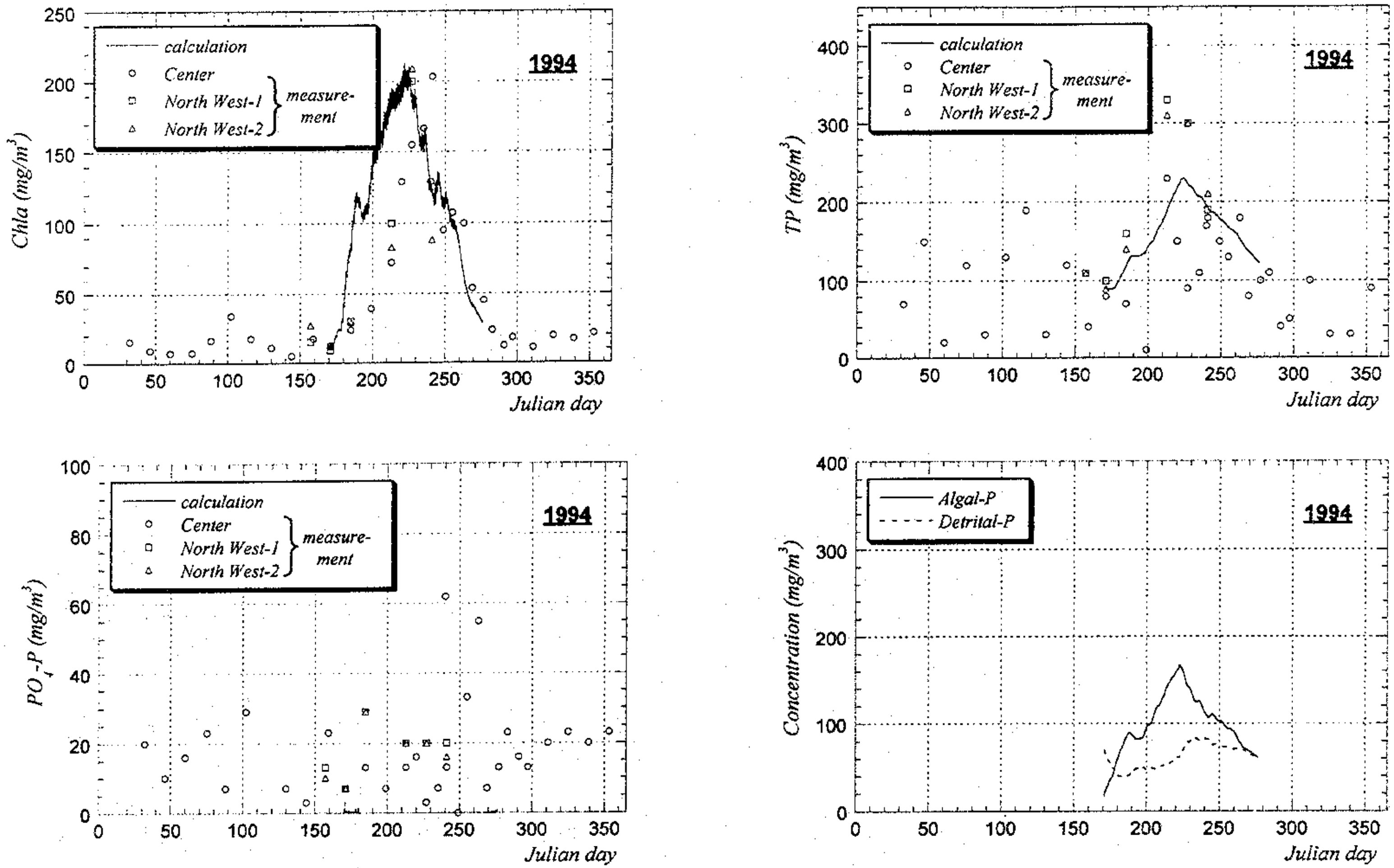
P_up_max = 6.000 half_sat =60.000 R_mineral = 0.040 T_mineral = 1.180
R_mortal = 0.092 T_mortal = 1.040 Growth_max= 1.800 Fop = 0.700
alph = 2.600 Ws-det = 0.100 Ws-bmass = 0.050 L_A/D = 13.30
gamma = 0.100 C_ex = 0.150 P_eq =30.000 P_release = 0.008
psi_min =0.0020 psi_max = 0.018 B/C ratio = 2.11 P/C ratio = 0.02
Saturation PAR = 4.50 CCHL_const =Light_function = non-inhibited
f(1)-0 = 7.000 f(2)-0 =90.000 f(3)-0 =11.100 f(4)-0 = 0.0
SS-0 = 8.0 kyear = 1994 Jday_start= 171 Jday_end = 300
deltat = 0.005

Figure C.62 Sensitivity Analysis of Model Parameters, Case III-3



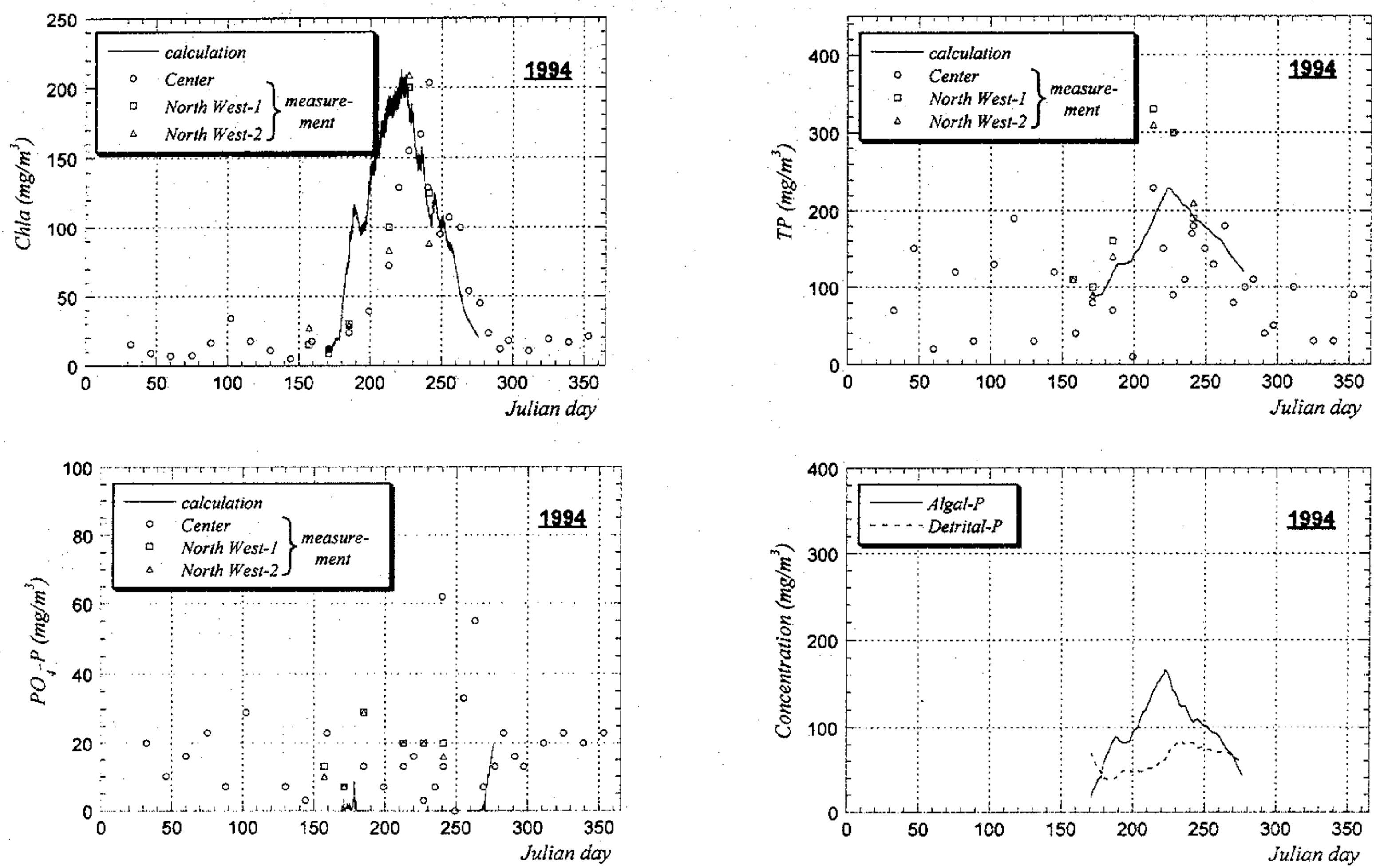
P_up_max = 9.000 half_sat =80.000 R_mineral = 0.040 T_mineral = 1.180
R_mortal = 0.092 T_mortal = 1.040 Growth_max= 1.800 Fop = 0.700
alph = 2.600 Ws-det = 0.100 Ws-bmass = 0.050 L_A/D = 13.30
gamma = 0.100 C_ex = 0.150 P_eq =30.000 P_release = 0.008
psi_min =0.0020 psi_max = 0.018 B/C ratio = 2.11 P/C ratio = 0.02
Saturation PAR = 4.50 CCHL_const =Light_function = non-inhibited
f(1)-0 = 7.000 f(2)-0 =90.000 f(3)-0 =11.100 f(4)-0 = 0.0
SS-0 = 8.0 kyear = 1994 Jday_start= 171 Jday_end = 300
deltat = 0.005

Figure C.63 Sensitivity Analysis of Model Parameters, Case III-4



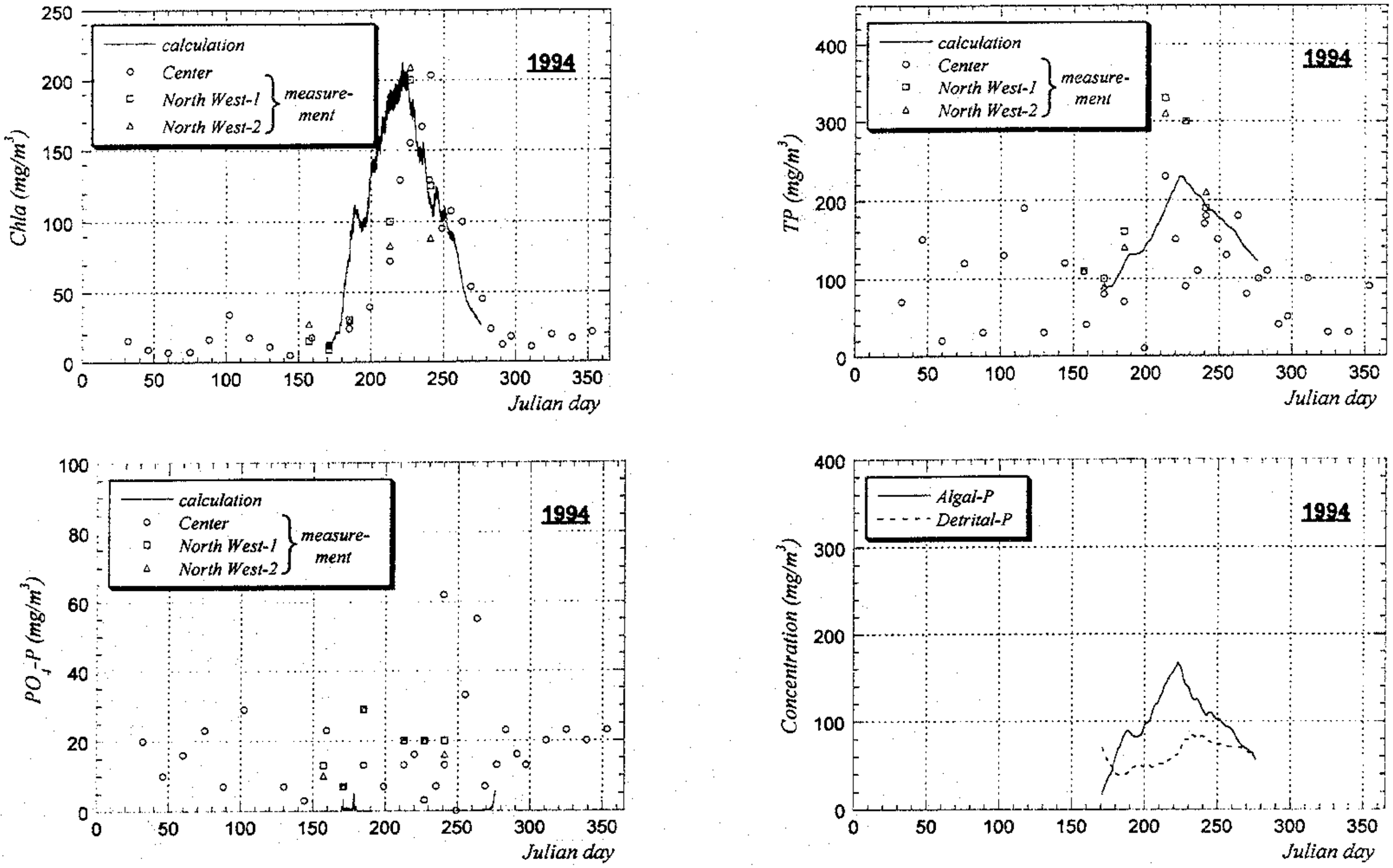
P_up_max = 1.500 half_sat =18.000 R_mineral = 0.040 T_mineral = 1.180
R_mortal = 0.092 T_mortal = 1.040 Growth_max= 1.800 Fop = 0.700
alph = 2.600 Ws-det = 0.100 Ws-bmass = 0.050 L_A/D = 13.30
gamma = 0.100 C_ex = 0.1500 P_eq =30.000 P_release = 0.008
psi_min =0.0020 psi_max = 0.018 B/C ratio = 2.11 P/C ratio = 0.02
Saturation PAR = 4.50 CCHL_const =Light_function = non-inhibited
f(1)-0 = 7.000 f(2)-0 =90.000 f(3)-0 =11.100 f(4)-0 = 0.0
SS-0 = 8.0 kyear = 1994 Jday_start= 171 Jday_end = 300
deltat = 0.005 Topt=28 Tmi=18

Figure C.64 Sensitivity Analysis of Model Parameters, Case VI-1



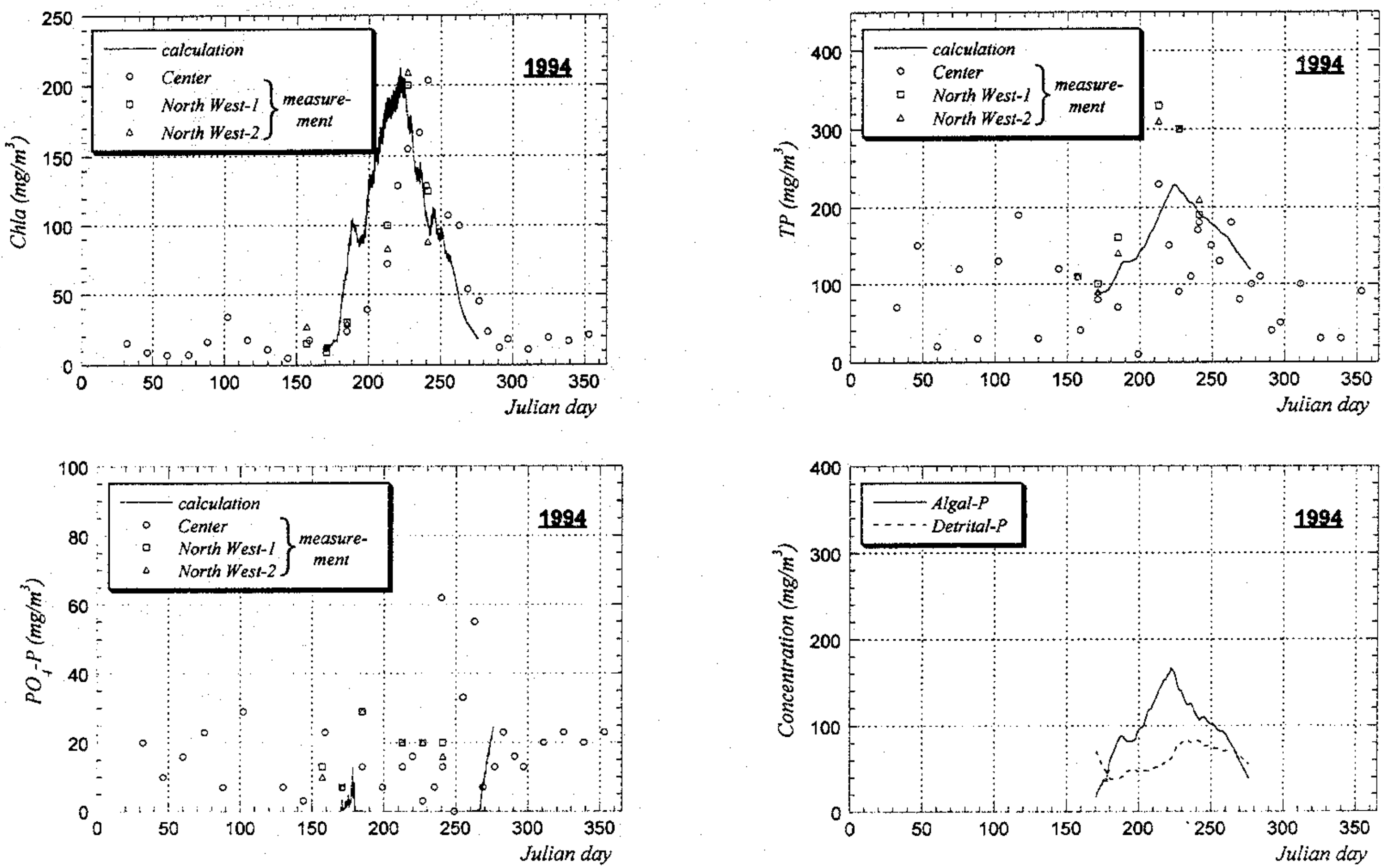
P_up_max = 1.500 half_sat =18.000 R_mineral = 0.040 T_mineral = 1.180
R_mortal = 0.092 T_mortal = 1.040 Growth_max= 1.800 Fop = 0.700
alph = 2.600 Ws-det = 0.100 Ws-bmass = 0.050 L_A/D = 13.30
gamma = 0.100 C_ex = 0.1500 P_eq =30.000 P_release = 0.008
psi_min =0.0020 psi_max = 0.018 B/C ratio = 2.11 P/C ratio = 0.02
Saturation PAR = 4.50 CCHL_const =Light_function = non-inhibited
f(1)-0 = 7.000 f(2)-0 =90.000 f(3)-0 =11.100 f(4)-0 = 0.0
SS-0 = 8.0 kyear = 1994 Jday_start= 171 Jday_end = 300
deltat = 0.005 Topt=28 Tmi=19

Figure C.65 Sensitivity Analysis of Model Parameters, Case VI-2



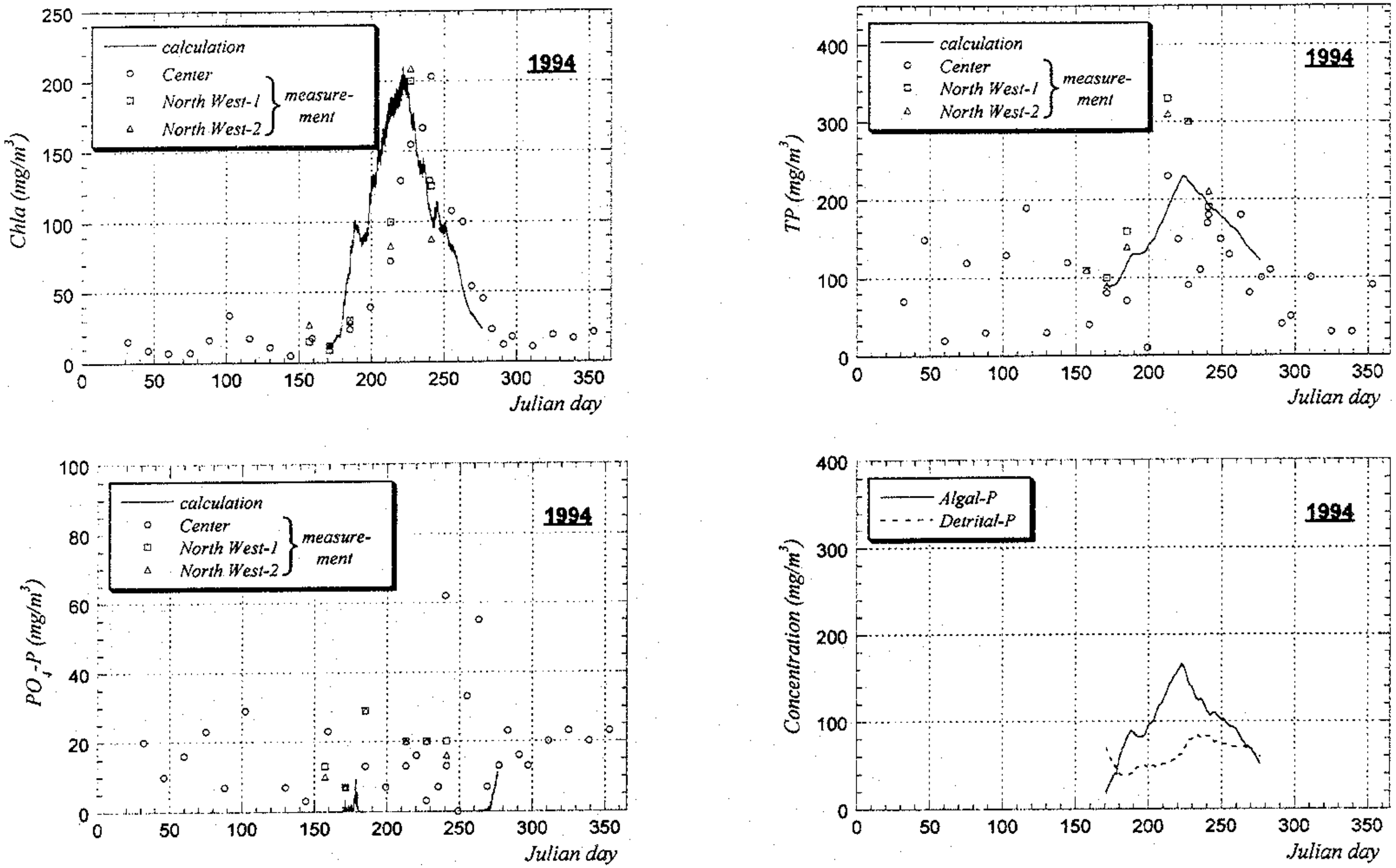
P_up_max = 1.500 half_sat =18.000 R_mineral = 0.040 T_mineral = 1.180
R_mortal = 0.092 T_mortal = 1.040 Growth_max= 1.800 Fop = 0.700
alph = 2.600 Ws-det = 0.100 Ws-bmass = 0.050 L_A/D = 13.30
gamma = 0.100 C_ex = 0.1500 P_eq =30.000 P_release = 0.008
psi_min =0.0020 psi_max = 0.018 B/C ratio = 2.11 P/C ratio = 0.02
Saturation PAR = 4.50 CCHL_const =Light_function = non-inhibited
f(1)-0 = 7.000 f(2)-0 =90.000 f(3)-0 =11.100 f(4)-0 = 0.0
SS-0 = 8.0 kyear = 1994 Jday_start= 171 Jday_end = 300
deltat = 0.005 Topt=29 Tmi=18

Figure C.66 Sensitivity Analysis of Model Parameters, Case VI-3



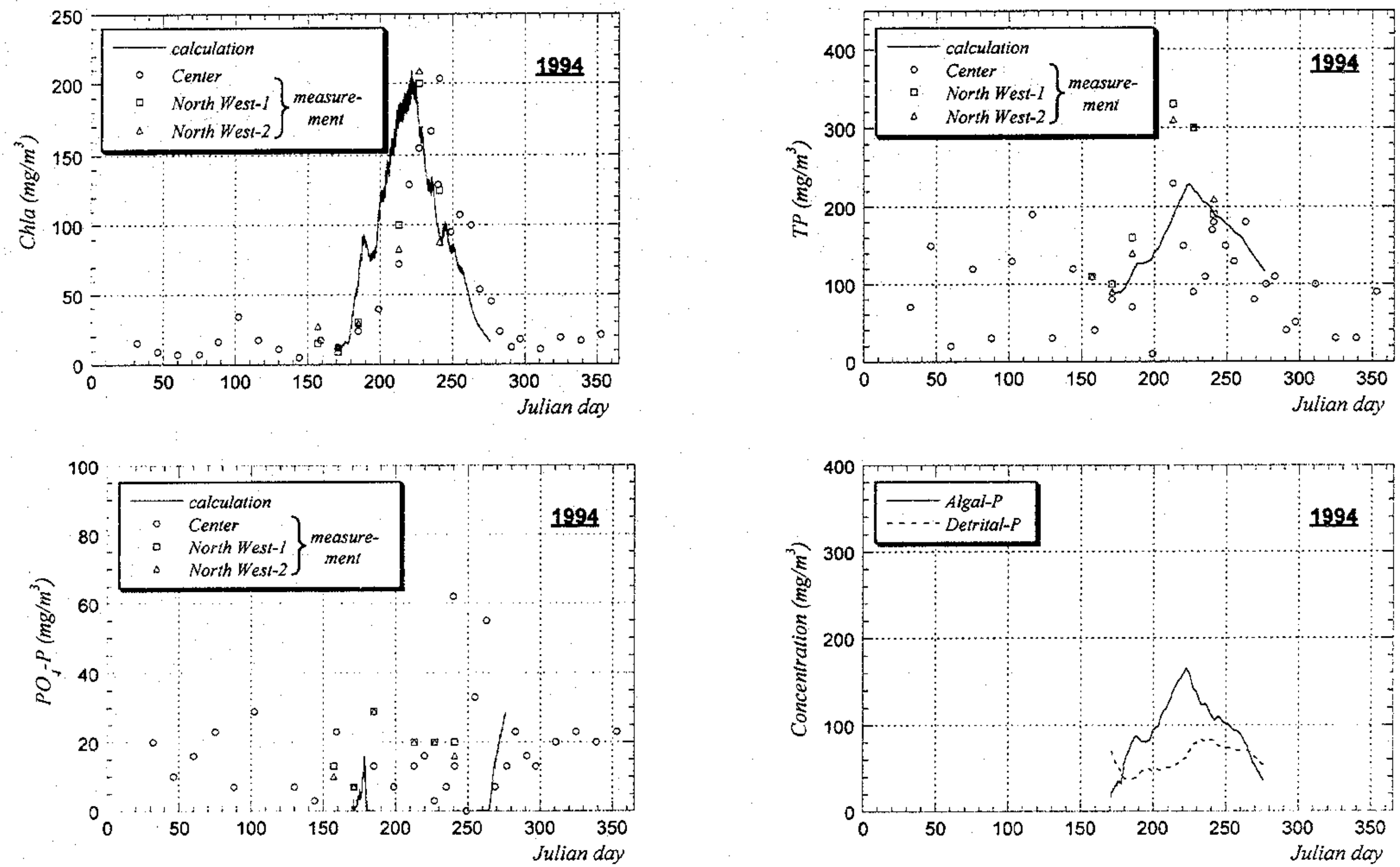
P_up_max = 1.500 half_sat =18.000 R_mineral = 0.040 T_mineral = 1.180
R_mortal = 0.092 T_mortal = 1.040 Growth_max= 1.800 Fop = 0.700
alph = 2.600 Ws-det = 0.100 Ws-bmass = 0.050 L_A/D = 13.30
gamma = 0.100 C_ex = 0.1500 P_eq =30.000 P_release = 0.008
psi_min =0.0020 psi_max = 0.018 B/C ratio = 2.11 P/C ratio = 0.02
Saturation PAR = 4.50 CCHL_const =Light_function = non-inhibited
f(1)-0 = 7.000 f(2)-0 =90.000 f(3)-0 =11.100 f(4)-0 = 0.0
SS-0 = 8.0 kyear = 1994 Jday_start= 171 Jday_end = 300
deltat = 0.005 Topt=29 Tmi=19

Figure C.67 Sensitivity Analysis of Model Parameters, Case VI-4



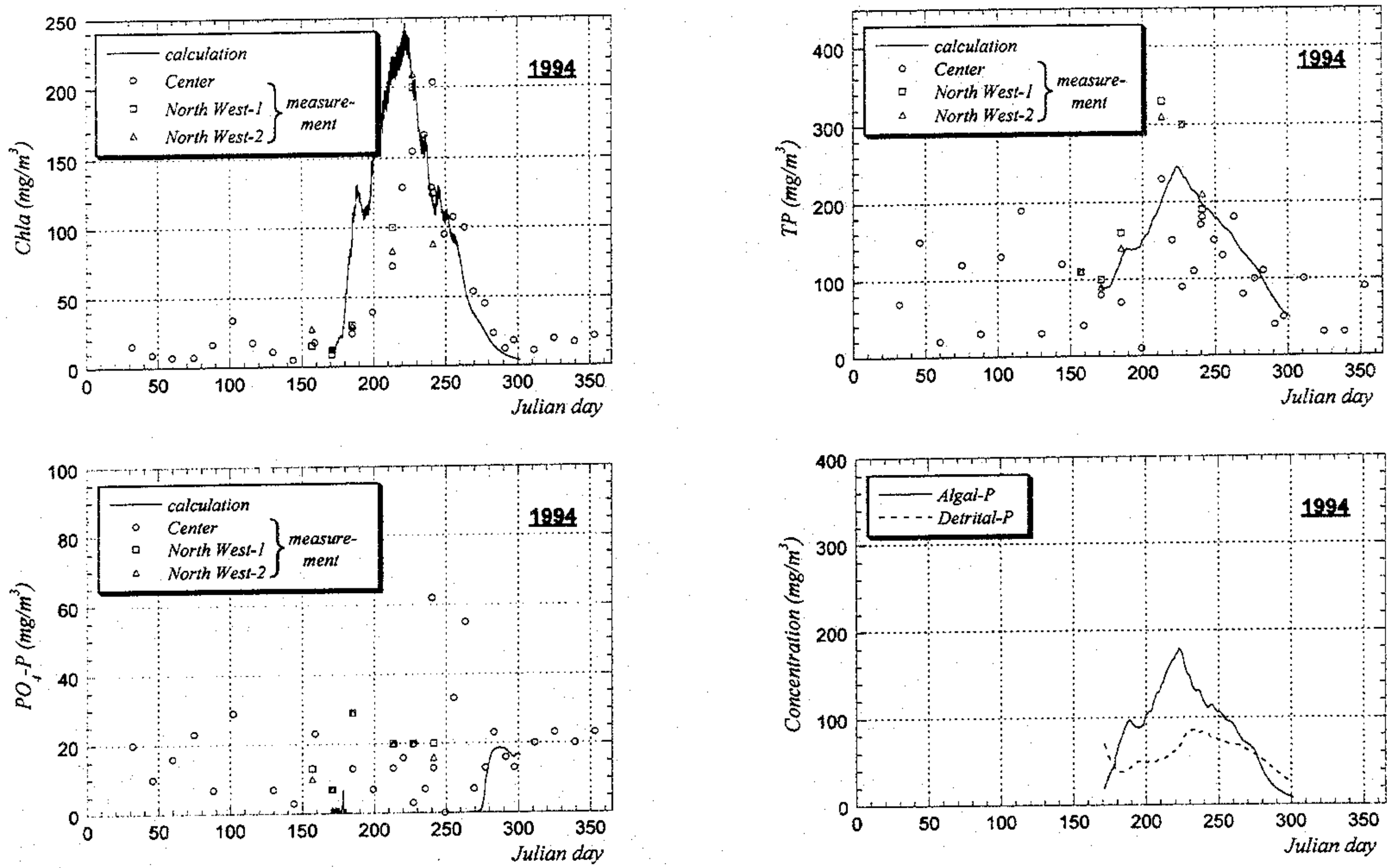
P_up_max = 1.500 half_sat =18.000 R_mineral = 0.040 T_mineral = 1.180
R_mortal = 0.092 T_mortal = 1.040 Growth_max= 1.800 Fop = 0.700
alph = 2.600 Ws-det = 0.100 Ws-bmass = 0.050 L_A/D = 13.30
gamma = 0.100 C_ex = 0.1500 P_eq =30.000 P_release = 0.008
psi_min =0.0020 psi_max = 0.018 B/C ratio = 2.11 P/C ratio = 0.02
Saturation PAR = 4.50 CCHL_const =Light_function = non-inhibited
f(1)-0 = 7.000 f(2)-0 =90.000 f(3)-0 =11.100 f(4)-0 = 0.0
SS-0 = 8.0 kyear = 1994 Jday_start= 171 Jday_end = 300
deltat = 0.005 Topt=30 Tmi=18

Figure C.68 Sensitivity Analysis of Model Parameters, Case VI-5



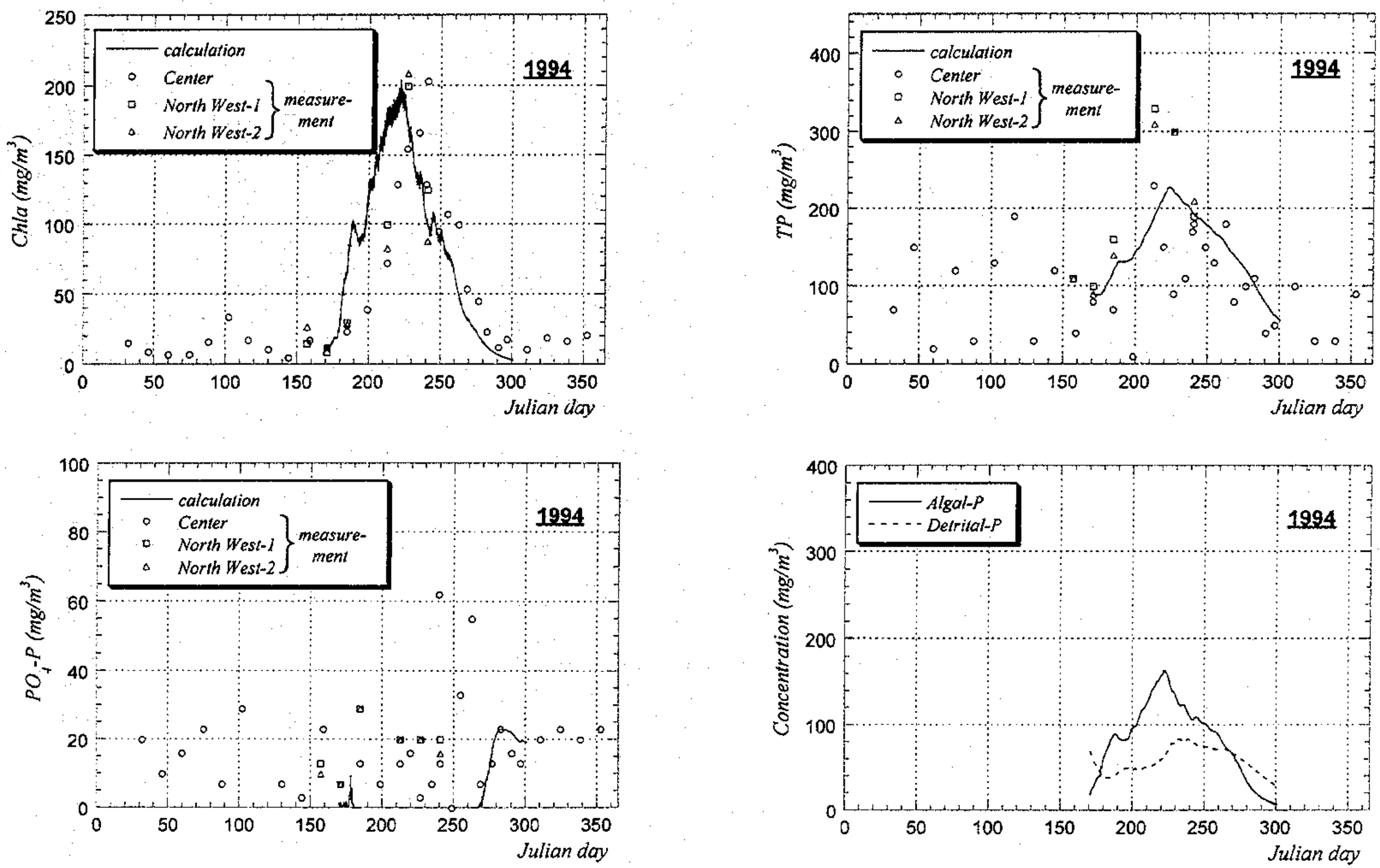
P_up_max = 1.500 half_sat =18.000 R_mineral = 0.040 T_mineral = 1.180
R_mortal = 0.092 T_mortal = 1.040 Growth_max= 1.800 Fop = 0.700
alph = 2.600 Ws-det = 0.100 Ws-bmass = 0.050 L_A/D = 13.30
gamma = 0.100 C_ex = 0.1500 P_eq =30.000 P_release = 0.008
psi_min =0.0020 psi_max = 0.018 B/C ratio = 2.11 P/C ratio = 0.02
Saturation PAR = 4.50 CCHL_const =Light_function = non-inhibited
f(1)-0 = 7.000 f(2)-0 =90.000 f(3)-0 =11.100 f(4)-0 = 0.0
SS-0 = 8.0 kyear = 1994 Jday_start= 171 Jday_end = 300
deltat = 0.005 Topt=30 Tmi=19

Figure C.69 Sensitivity Analysis of Model Parameters, Case VI-6



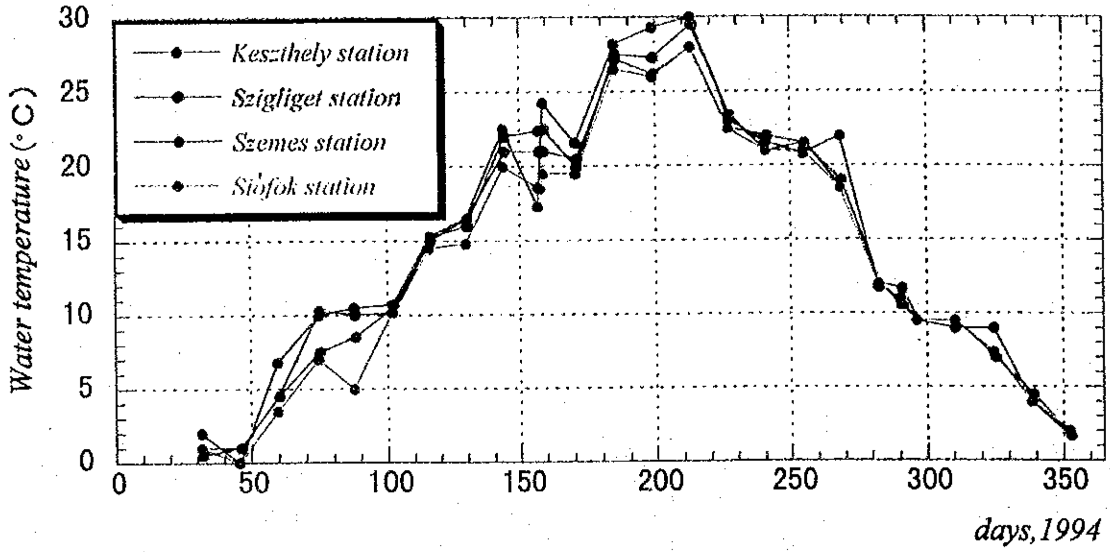
P_up_max = 1.500 half_sat =18.000 R_mineral = 0.040 T_mineral = 1.180
R_mortal = 0.092 T_mortal = 1.040 Growth_max= 1.800 Fop = 0.700
alph = 2.600 Ws-det = 0.100 Ws-bmass = 0.050 L_A/D = 13.30
gamma = 0.100 C_ex = 0.150 P_eq =30.000 P_release = 0.008
psi_min = 0.002 psi_max = 0.018 B/C ratio = 2.11 P/C ratio = 0.02
Saturation PAR = 4.50 CCHL_const =Light_function = non-inhibited
f(1)-0 = 7.000 f(2)-0 =90.000 f(3)-0 =11.100 f(4)-0 = 0.0
SS-0 = 8.0 kyear = 1994 Jday_start= 171 Jday_end = 300
deltat = 0.005 depth=1.98 volume=7.174e+07

Figure C.70 Sensitivity Analysis of Model Parameters, Case VII-1



P_up_max = 1.500 half_sat =18.000 R_mineral = 0.040 T_mineral = 1.180
R_mortal = 0.092 T_mortal = 1.040 Growth_max= 1.800 Fop = 0.700
alph = 2.600 Ws-det = 0.100 Ws-bmass = 0.050 L_A/D = 13.30
gamma = 0.100 C_ex = 0.150 P_eq =30.000 P_release = 0.008
psi_min = 0.002 psi_max = 0.018 B/C ratio = 2.11 P/C ratio = 0.02
Saturation PAR = 4.50 CCHL_const =Light_function = non-inhibited
f(1)-0 = 7.000 f(2)-0 =90.000 f(3)-0 =11.100 f(4)-0 = 0.0
SS-0 = 8.0 kyear = 1994 Jday_start= 171 Jday_end = 300
deltat = 0.005 depth=2.42 volume=8.7683e+07

Figure C.71 Sensitivity Analysis of Model Parameters, Case VII-2



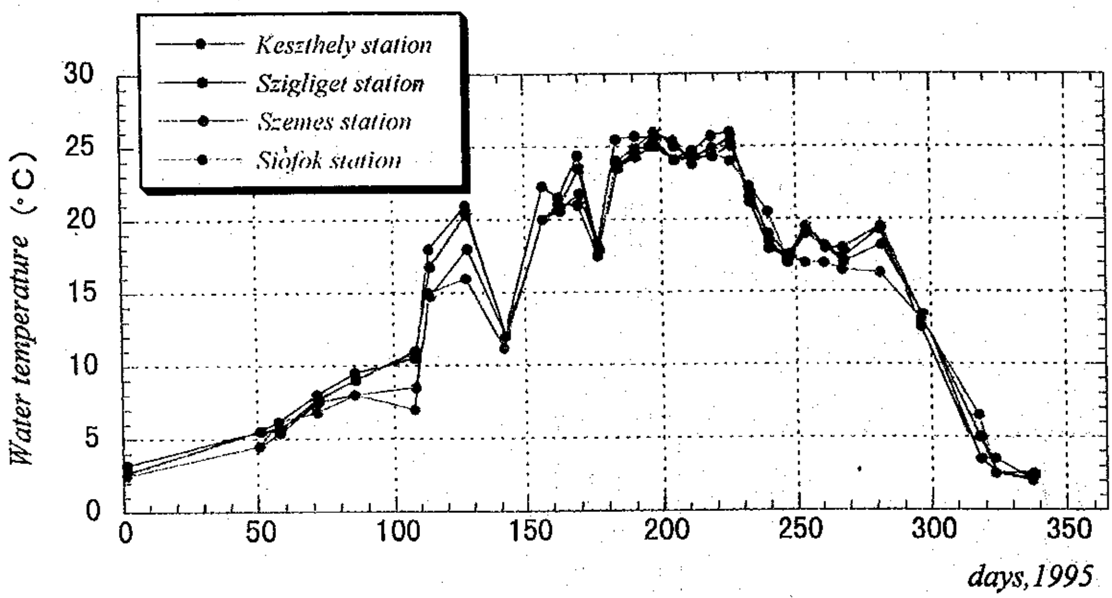


Figure C.72 Water Temperatures in Each Basin of Lake Balaton (KDT-VIZIG)

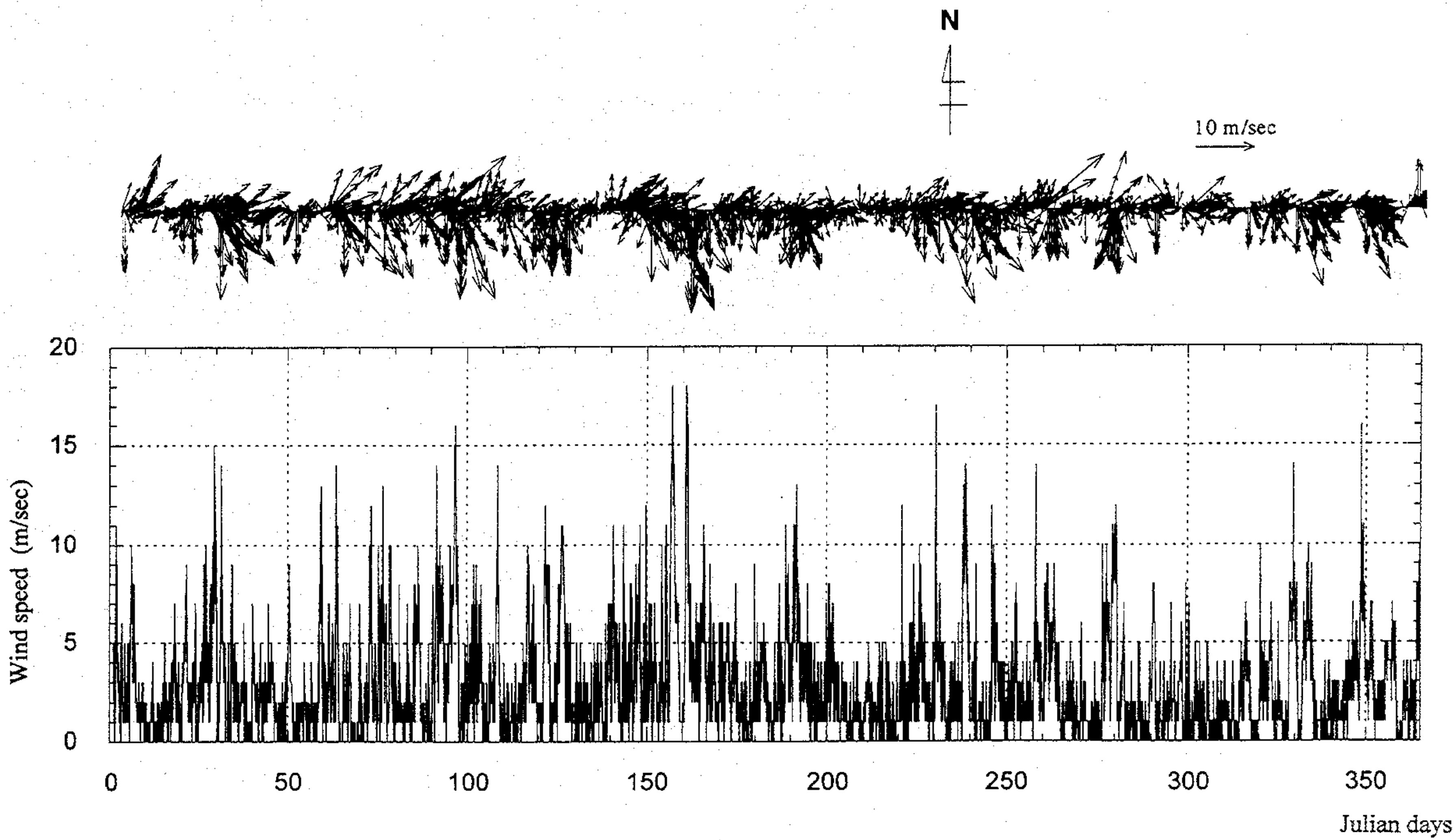


Figure C.73 Wind-vector and Wind-speed at the Siófok weather station, 1994 (OMSZ)

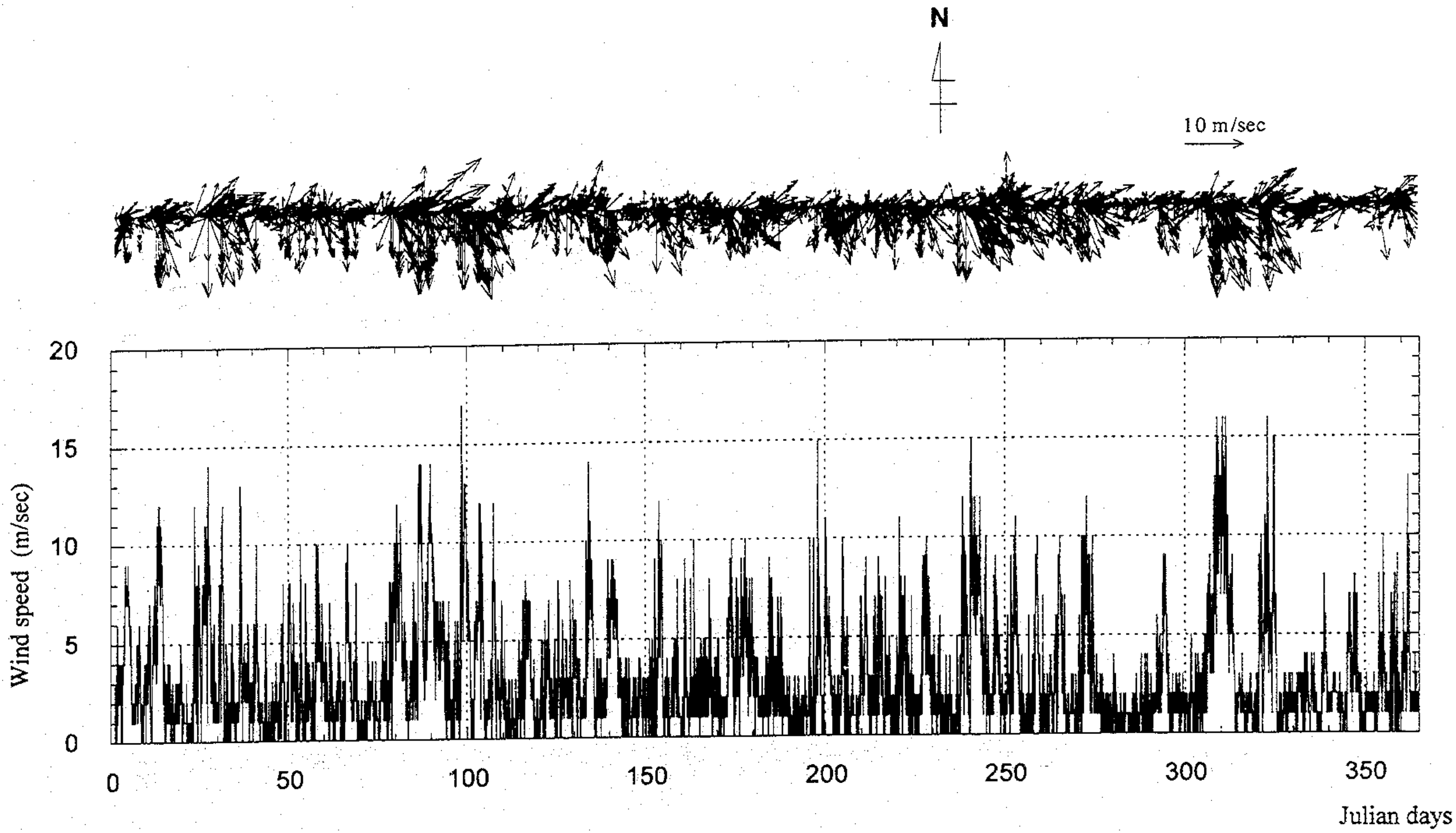


Figure C.74 Wind-vector and Wind-speed at the Siófok weather station, 1995 (OMSZ)

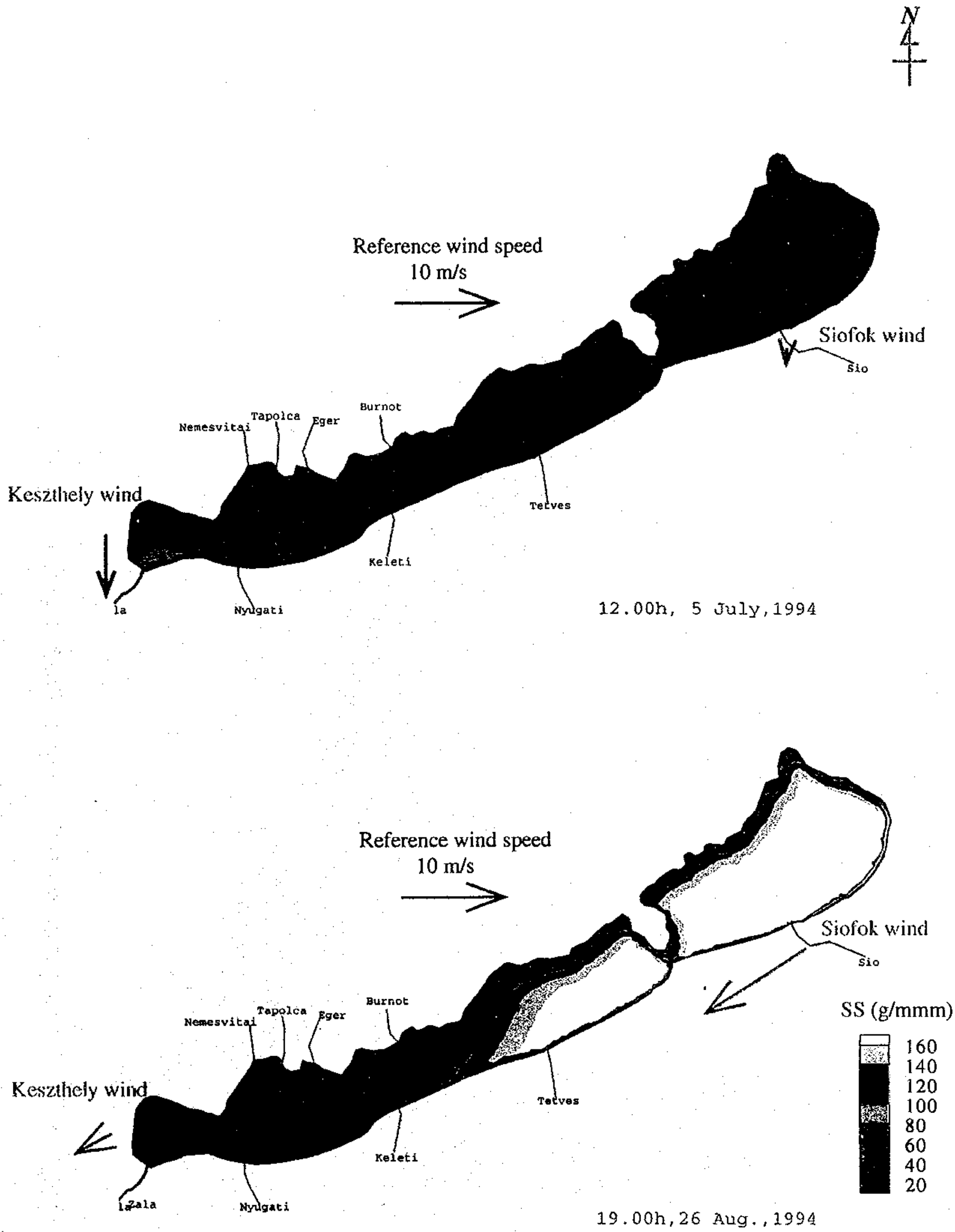


Figure C.75 Suspended Sediment Distribution Calculated by WQSM

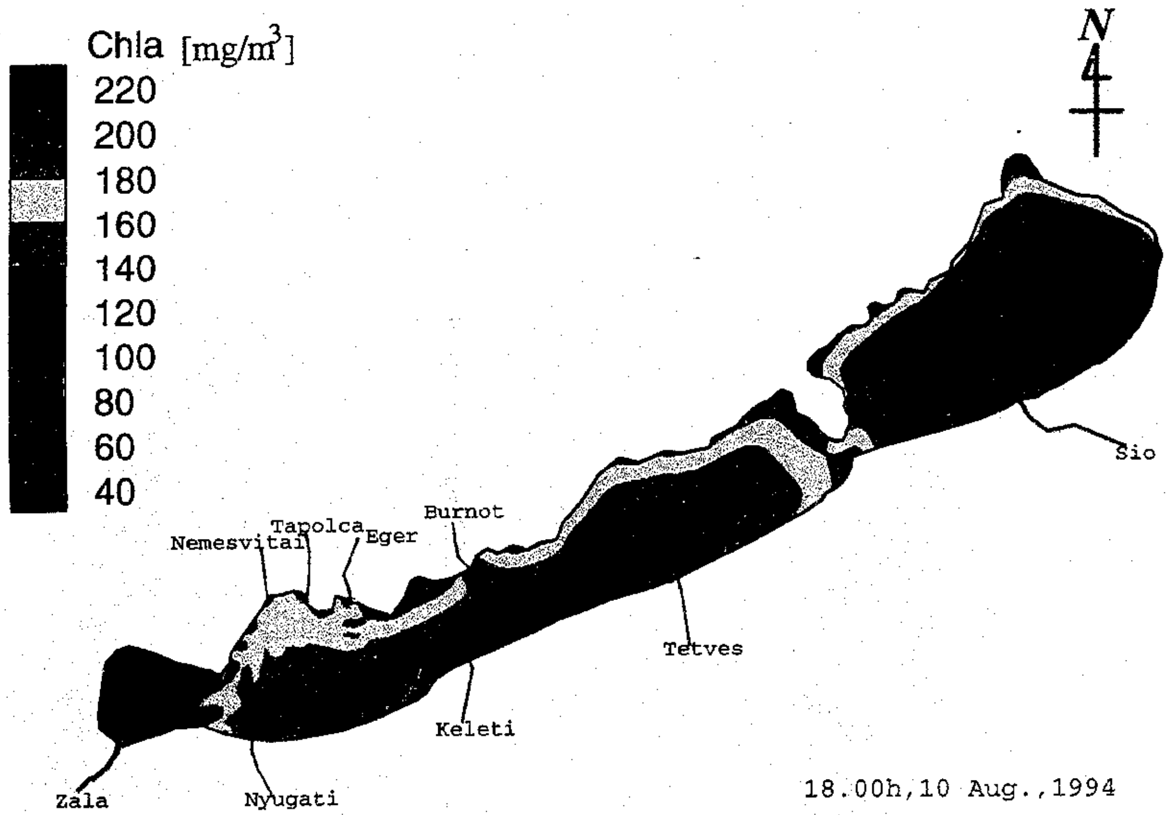


Figure C.76 ***Chla*** **Distribution at the Time of Peak Bloom in Keszthely Bay in 1994**

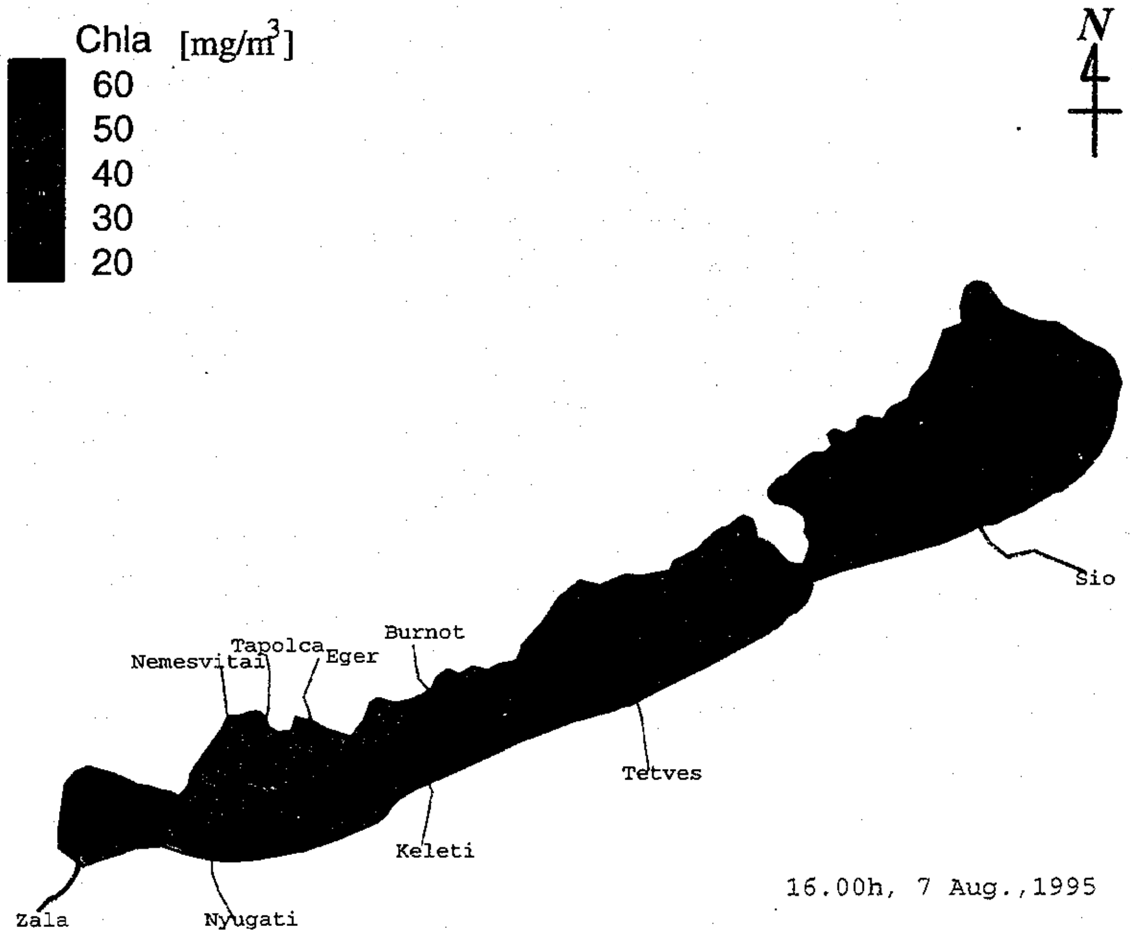


Figure C.77 ***Chla*** **Distribution at the Time of Peak Bloom in Keszthely Bay in 1995**

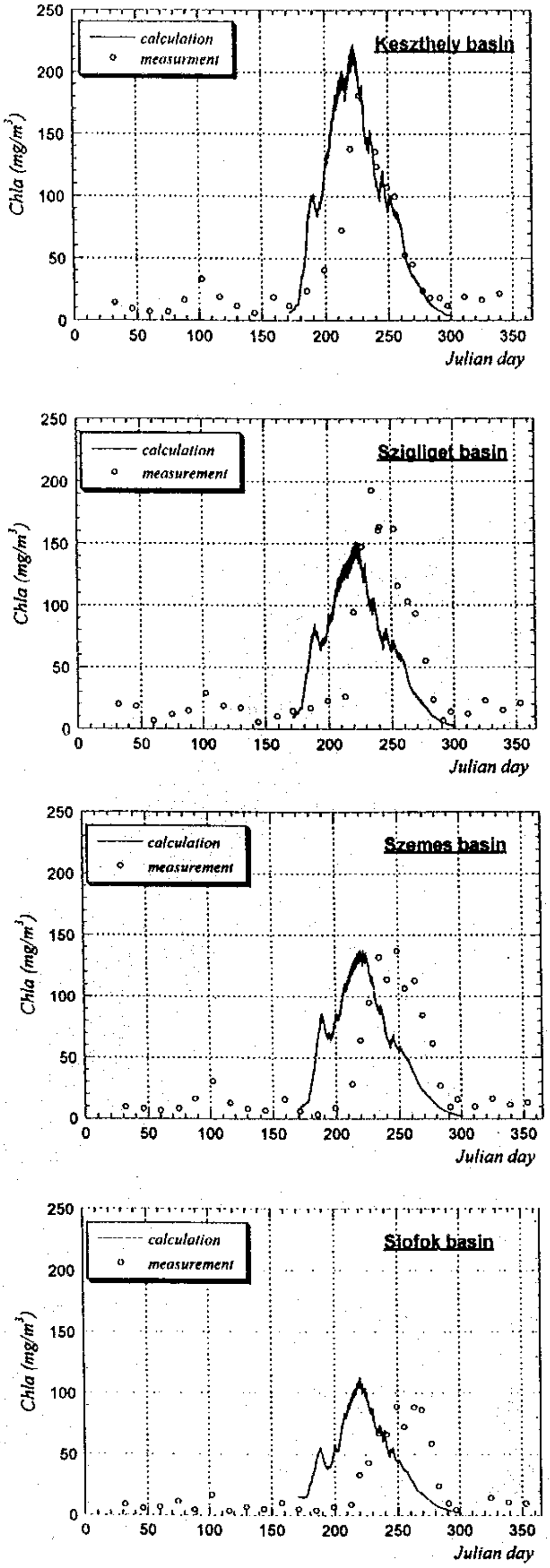


Figure C.78 Computed, by WQSM, and Measured (KDT-KÖFE) Time-series of *Chla* in 1994

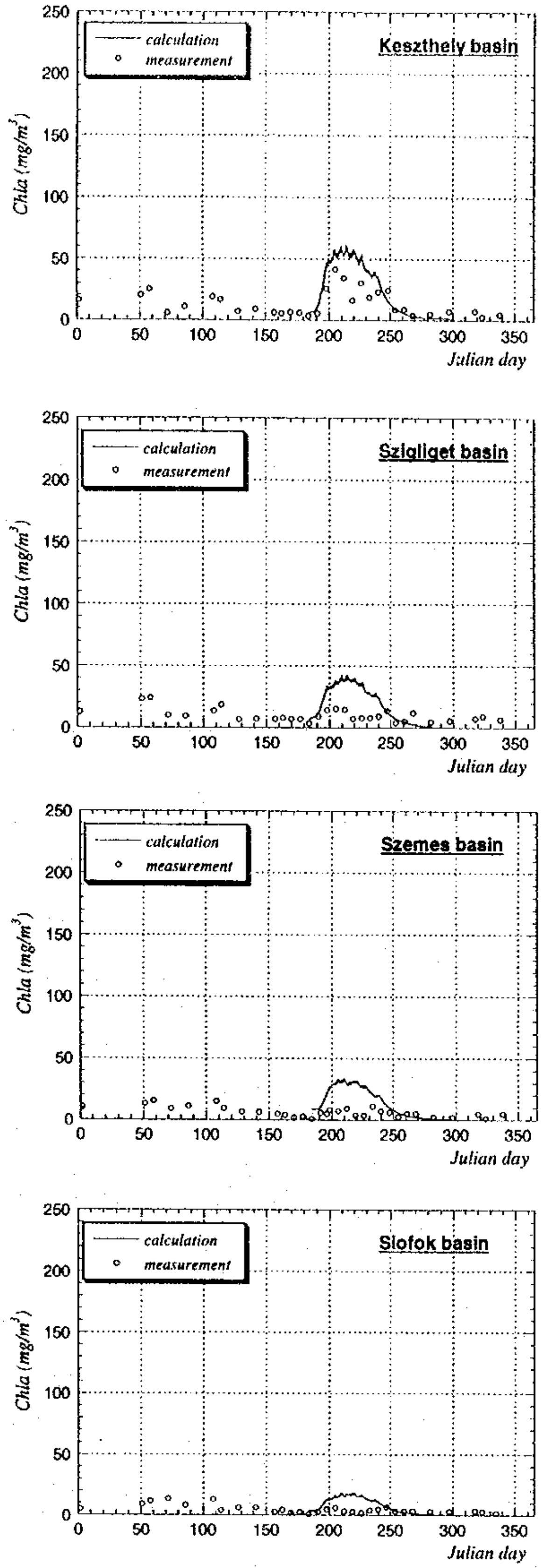


Figure C.79 Computed, by WQSM, and Measured (KDT-KÖFE) Time-series of *Chla* in 1995

APPENDIX - D

FACILITY PLAN (EXTERNAL LOAD)

APPENDIX - D

FACILITY PLAN (EXTERNAL LOAD)

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FACILITY PLAN (EXTERNAL LOAD)

1. SELECTION OF ALTERNATIVES

It is recognized that phosphorous is a limiting factor of algal growth in Lake Balaton. So it is very important to remove phosphorous from non-point sources in the catchment area.

There are various methods to remove phosphorous from water, although it is necessary to well consider people's acceptance, technological applicability, removal efficiency, environmental condition, local condition, and successful examples around Lake Balaton. The followings are selected as conceivable methods.

- Settling reservoir method
- Coagulation sedimentation method
- Anaerobic - aerobic activated sludge method
- Mix a coagulant activated sludge method
- Soil infiltration method
- Crystallization for phosphorus removal method
- Vegetation purification method

Comparative evaluation of these methods is made as shown in *Table D.1*. Although these methods have various characters, applicable methods are selected as follows, considering land use, natural and environmental conditions around Lake Balaton, construction and maintenance costs, applicability to river water.

1.1 SETTLING RESERVOIR METHOD

This method requires a large construction site area and construction costs are higher, but maintenance costs are lower than other methods. There are more than a few rivers which can provide construction sites for this method around Lake Balaton. The system is simple to operate and maintain. Therefore this method is applicable.

1.2 VEGETATION PURIFICATION METHOD

This method does not need a large site. Construction costs are comparatively low. Removal efficiency is almost same. Maintenance costs are high comparing with settling reservoir method.

There are a lot of wetlands around Lake Balaton where natural reeds are growing, and some exanples have been materialized beside rivers which flow into the lake. This method does not appear to affect the environment including scenic view of the surrounding area.

For the reasons, this method is applicable.

1.3 COAGULATION SEDIMENTATION METHOD

This method is popular in treatment of sewage or industrial wastewater. The removal efficiency of phosphorus is higher and necessary site area is smaller, though the costs of construction and maintenance are higher and it needs technique to operate and maintain a machine system.

If a land for construction site is limited but the costs are acceptable , this method is applicable to Lake Balaton.

2. COMPONENTS OF ALTERNATIVES

Components of facilities are examined for selected applicable methods. It is important for planning a river purification system to select a location and a structure which cause no damage by floodwater. The sites for river purification facilities should be constructed outside river courses considering river conditions. Components of applicable purification methods are shown as follows.

2.1 COMMON FACILITIES

Water Intake Gate

To lead river water to the purification facility, it is necessary to set an intake gate in the river course. The gate should be retractable one which falls down at a certain flood water level to lead floodwater to main river course, or not to lead floodwater to the purification facility in order to protect the facility from damages of floodwater.

A rubber-made gate is proposed for easy operation and maintenance, following examples in Japan.

2.2 WATER PURIFICATION FACILITY

(1) Settling Reservoir Method

So-called pre-reservoir pond is applied to phosphorus removal method for rivers, following some examples of the pre-reservoir pond for water supply or industry reservoir in central European countries. It is said that removal efficiency is over 60% if retention time is over 15 days. According to some examples in Japan, the removal efficiency is 20～60% if retention time is over 8 days. Following those examples, the reservoir pond is designed and design conditions are as follows:

Design water flow	10,000 m^3/day (as a typical design capacity)
Water depth	3 m
Retention time	15 days
Pond capacity	10,000 m^3/day × 15 days = 150,000 m^3

$H = 3.0$ m
$L = 300$ m
$B = 10{,}000\ m^3/day \div (L \times H/15days) = 170$ m
$A = B \times L = 51{,}000\ m^2$

(2) Vegetation Purification Method

According to some examples in Japan, removal efficiency is 40～60%. Following those examples, the reed pond is designed with the following conditions.

Design water flow	10,000 m^3/day (as a typical design capacity)
Water depth	20 cm
Water flow velocity	0.8 cm/sec
Retention time	5 hr
Pond capacity	2,100 m^3

$H = 0.20$ m
$L = (0.008\ m/s \times 5\ hr \times 60\ min \times 60\ s) = 150$ m
$B = 10{,}000\ m^3/day \div (0.2m \times 0.008m/s \times 24hr \times 60min \times 60sec) = 70$ m
$A = 10{,}500\ m^2$

(3) Coagulation Sedimentation Method

Components of this method are shown as follows.

Design water flow — 10,000 m^3/day (as a typical design capacity)

Mixing pond — mixing time : 5 min.

Pond capacity — $(10{,}000 m^3/day \times 5 min.) \div (24 \times 60) = 35\ m^3$

Flocculator

Pond capacity — $(10{,}000 m^3/day \times 20 min.) \div (24 \times 60) = 140\ m^3$

Settling pond — effective water surface area : 20 $m^3/m^2 \cdot day$

Pond capacity — $(10{,}000 m^3/day \times 3\ hr.) \div 24 = 1{,}250\ m^3$

Pond area — $10{,}000 m^3/day \div 20 m^3/m^2 \cdot day = 500\ m^2$

Overflow pond

Necessary site area is same as that of mixing pond.

Coagulant storage tank

Tank capacity — $Q \times D \times 10^{-6} \times 10(day) \div d = 4.3$ m

Q : Inflow volume (10,000 m^3/day)

D : Maximum coagulant injection proportion (30 mg/l)

d : Specific gravity of coagulant (0.7)

Sludge tank

According to examples in Japan, necessary site area is 30 m^2.

Sludge thickener

According to examples in Japan, necessary site area is 50 m^2.

Dehydrator

According to examples in Japan, necessary site area is 20 m^2.

Average water depth is assumed as 2.5 m, thus necessary site area is as follows.

$$(35m^3+140m^3) \div 2.5m + 500m^2 + (35m^3+4.3m^3) \div 2.5m + 30m^2 + 50m^2 + 20m^2$$

$$\fallingdotseq 700\ m^2$$

Necessary site area is 700 m^2 and a maintenance area is also necessary. The total site area is about 1,500 m^2.

3 EVALUATION OF ALTERNATIVES

3.1 COMPARISON OF COSTS

Costs of main structures of purification facilities are compared to evaluate the alternatives. The costs of water intake gate are excluded from the comparison because it is a common structure for all alternatives. For convenience of the comparison, the design inflow of 10,000 m^3/day is used as a typical design capacity.

The construction costs and the operation and maintenance (O/M) costs are based on data of unit costs obtained from PMO/VATI, VIZITERV Kft, examples of Várpalota Region Environmental Improvement Project, examples of the wastewater treatment plant of Tapolca town, and other sources. Unit construction costs include overhead costs which are assumed to be 30 % of the costs of equipment and civil works.

The results are shown in the following tables.

① Construction and O/M costs

Method	Construction Costs (1000HUF)	O/M Costs (1000HUF/year)	Remarks
Settling Reservoir	304,885	355	excluding a removal of sediment sludge
		2,340	including all
Vegetation Purification	29,440	3,400	
Coagulation Sedimentation	123,166	14,796	

② Construction and O/M costs to be needed for 20years

Method	Construction Costs (1000HUF)	O/M Costs (1000HUF/20years)	Total Cost (1000 HUF)
Settling Reservoir	304,885	7,100	311,985
		46,800	351,685
Vegetation Purification	29,440	68,000	97,440
Coagulation Sedimentation	123,166	295,920	418,690

The above results are estimated as follows.

(1) Settling Reservoir Method

L = 300 m, B = 170 m, H = 3 m

1) Construction costs

a. Quantity calculation

Excavation	300m × 170m × 3.5m = 178,500 m^3 ≒	179,000 m^3
	(including a part of open channel)	
Removal of surplus soil		179,000 m^3
Slope protection	(300+170) × 2 × 6.30 = 5,922 m^2 ≒	6,000 m^2
Inflow and outflow channel (0.5m × 0.5m)		L = 200 m
Maintenance gate (0.5m × 0.5m)		2 pieces
Screen (0.5m × 0.5m)		1 piece

b. Cost estimation

Excavation	179,000 m^3 × 1,170 HUF/m^3 =	209,400,000 HUF
Removal of surplus soil (1km)	179,000m^3 × 520HUF/m^3 =	93,000,000 HUF
Slope protection(turfing)	6,000 m^2 × 260HUF/m^2 =	1,560,000 HUF
Inflow/outflow channel(0.5m × 0.5m)	200m × 4,290HUF/m=	860,000HUF
Maintenance gate(0.5m × 0.5m)	2pieces × 26,000HUF =	52,000 HUF
Screen (0.5m × 0.5m)	1 piece × 13,000 HUF =	13,000 HUF

Total Construction Cost 304,885,000 HUF

2) Operation and maintenance (O/M) costs

a. Inspection of facilities

Frequency of inspection is once a week, and it takes 2 hours for one time inspection.

1 time/week × 2 hours × 52 weeks/year = 104 hours/year

Labor unit cost (skilled labor) 60,000 HUF/month/person
= 430 HUF/hour/person

Annual inspection cost 104 hours /year × 430HUF/hour/person × 1 person
= 44,720 HUF/year

b. Removal of sediment sludge

It is necessary to remove sediment sludge regularly. Frequency of the removal should be at least every 10 years.

Assuming that a thickness of sediment sludge is 30 cm;

Sludge volume L × B × 0.3 = 300 × 170 × 0.3 = 15,300 m^3

Excavation 15,300m^3 × 900HUF/m^3 × 1/10years = 1,377,000 HUF/year

Removal of surplus soil (1km) 15,300m^3 × 400HUF/m^3 × 1/10years
= 612,000 HUF/year

Subtotal 1,989,000 HUF/year

c. Water quality monitoring

To monitor nutrients removal efficiency, water quality analysis is necessary once a month. Samples should be taken at the points of inflow/outflow of the facility.

		Unit Cost (HUF)	Unit	Quantity	Amount (HUF)
Sampling and Transportation		1,480		24	35,520
Laboratory Analysis	T-P	3,180	sample	24	76,320
	T-N	3,180	sample	24	76,320
	COD	2,540	sample	24	60,960
	SS	2,540	sample	24	60,960
		Subtotal			310,000 HUF/year

Total O/M Cost 2,343,720 HUF / year

(2) Vegetation Purification Method

L = 150 m, B = 70 m, H = 0.2 m

1) Construction costs

a. Quantity calculation

Excavation 150m × 70m × 0.3m ≒ 3,500 m^3
(including a part of open channel)

Removal of surplus soil 3,500 m^3

Reed lake 150m × 70m = 10,500 m^2

Inflow/outflow channel (0.5m × 0.5m) L = 200 m

Maintenance gate (0.5m × 0.5m) 2 pieces

Screen (0.5m × 0.5m) 1 piece

b. Costs estimation

Excavation 3,500 m^3 × ((1,170+2,860) × 1/2)HUF/m^3 = 7,060,000 HUF
(50% by equipment, 50% by manpower)

Removal of surplus soil (1km) 3,500 m^3 × 520HUF/m^3 =1,820,000 HUF

Make reed lake 10,500 m^2 × 1,870 HUF/m^2 = 19,635,000 HUF

(Planting of emergent plant: 117HUF/piece, Planting pitch: 30cm, Density: 16pieces/m^2, thus 117HUF/piece × 16pieces/m^2 = 1,870 HUF/m^2)

Inflow/outflow channel (0.5m × 0.5m) 200m × 4,290HUF/m = 860,000HUF

Maintenance gate (0.5m × 0.5m) 2 pieces × 26,000HUF = 52,000 HUF

Screen (0.5m × 0.5m) 1 piece × 13,000 HUF = 13,000 HUF

Total Construction Cost 29,440,000 HUF

2) O/M Costs

a. Inspection of Facilities

Frequency of inspection is once a week, and it takes 2 hours for an inspection.

1 time/week × 2 hr × 52 weeks/year = 104 hours/year

Labor unit cost (skilled labor) 60,000 HUF/month/person
= 430 HUF/hour/person

Annual inspection cost 104 hours/ year × 430HUF/hour/person × 1 person
= 44,720 HUF/year

b. Cut and disposal of reeds

Cut of reeds 10,500 m^2 × 80 HUF/m^2 = 840,000 HUF/year

Disposal of reeds 10,500 m^2 × 60 HUF/m^2 = 630,000 HUF/year

Subtotal 1,470,000 HUF/year

c. Recultivation (excavation & backfill) and planting reeds

The sediment sludge and bottom soil in which phosphorous is stored will increase day by day. When it become to full of store capacity, phosphorus will be released to the lake. It is not certain when it become to full, but it is necessary to remove a sediment sludge and bottom soil regularly. Frequency of removal and backfill should be at least every 10 years.

Recultivation 150m × 70m × 60HUF/m^2 × 1/10yrs = 63,000 HUF/year

Planting reeds 150m × 70m × 1,440HUF/m^2 × 1/10yrs =1,512,000 HUF/year

Subtotal 1,575,000 HUF/year

d. Water quality monitoring

Water analysis is necessary same as the settling reservoir method.

310,000 HUF/year

Total O/M Costs 3,400,000 HUF / year

(3) Coagulation Sedimentation Method

Construction costs and operation costs are estimated using a relation (scale factor) between costs and purification capacity of the method in Japan. The total cost of the Keszthely urban runoff control facility which is to be mentioned later, is used in this section.

1) Construction costs

a. Construction of main structure

The total construction cost for the facility with purification capacity of 40,600 m^3/day) is 306,681,000 HUF.

In the case of purification capacity is 10,000 m^3/day, the scale factor of 0.40 should be multiplied.

306,681,000 HUF × 0.40 (scale factor) = 122,672,000 HUF

b. Other works

Inflow/outflow channel(0.5m × 0.5m)

100m × 4,290HUF/m = 429,000 HUF

Maintenance gate (0.5m × 0.5m) 2 pieces × 26,000HUF = 52,000 HUF

Screen (0.5m × 0.5m) 1 piece × 13,000 HUF = 13,000 HUF

Subtotal 494,000 HUF

Total construction cost 123,166,000 HUF

2) O/M Costs

a. Electric, chemicals and sludge disposal costs

10,000m^3/day × 3.03HUF/m^3 × 365days = 11,060,000 HUF/year

b. **Operation costs** (equal to the case of Keszthely urban runoff purification facility) 3,036,000 HUF/year

c. **Water quality monitoring**

To monitor a removal efficiency, water quality analysis is necessary. For an adjustment of coagulant injection volume, water analysis of T-P should be done once a week, and T-N, COD, SS once a month.

Samples should be taken at the points of inflow and outflow of the facility.

		Unit Cost (HUF)	Unit	Quantity	Amount (HUF)
Sampling and Transportation		1,480		108	159,840
Laboratory Analysis	T-P	3,180	sample	108	343,440
	T-N	3,180	sample	24	76,320
	COD	2,540	sample	24	60,960
	SS	2,540	sample	24	60,960
		Subtotal			700,000 HUF/year

Total O/M Costs 14,796,000 HUF/year

3.2 TECHNOLOGICAL ADAPTABILITY

The results of comparative evaluation are summarized in *Table D.2*.

3.3 WATER QUALITY IMPROVEMENT

To compare cost efficiencies of the alternatives, phosphorous load to be reduced by a certain investment is estimated for each alternative. For the estimation, a typical design water flow of 10,000 m^3/day is used to make the discussion easier.

Purification capacity and inflow water quality is supposing that follows.

Q = 10,000 m^3/day

When, inflow phosphorus concentration is 1.0 mg/l,

T-P load (kg/year): $10{,}000 m^3 \times 365 days \times 1.0 mg/l \times 10^{-3} = 3{,}650$ kg/year

The followings are annual total amounts of phosphorus to be reduced by each alternative.

Purification Method	Phosphorous Reduction
Settling Reservoir	3,650 kg/year × 60 % = 2,190 kg/year
Vegetation Purification	3,650 kg/year × 50 % = 1,825 kg/year
Coagulation Sedimentation	3,650 kg/year × 80 % = 2,920 kg/year

Cost efficiency of alternative is defined as annual total amounts of phosphorous to be reduced by one HUF of investment. As the following results show, the vegetation purification seems to be the most cost-effective method among the alternatives.

Purification Method	Cost Efficiency of Phosphorous Reduction
Settling Reservoir	2,190 kg/year÷311,985 thousand HUF/20years = 140 mg/year/HUF
Vegetation Purification	1,825 kg/year÷97,440 thousand HUF/20years = 375 mg/year/HUF
Coagulation Sedimentation	2,920 kg/year÷419,086 thousand HUF/20years = 139 mg/year/HUF

4. OVERALL EVALUATION AND SELECTION OF ALTERNATIVE FOR THE COMPREHENSIVE PLAN

4.1 SELECTION OF THE OPTIMUM PLAN

As an optimum method, the vegetation purification method has been selected, because of the reasons as follows:

- It is an environmental-friendly method, and will be accepted by residents and tourists in the Lake Balaton region. It does not use any chemicals but natural materials, emergent plants, which grow around the lake.

- There are some examples constructed in the 1980's around Lake Balaton.

- It is cost-effective method comparing with other alternatives.

The coagulation sedimentation would be the second option, when it is difficult to acquire sufficiently large area for the construction site. Its phosphorous removal efficiency is high and necessary area for the site is small, though it uses chemicals as coagulant and its cost efficiency is low.

4.2 THE SITES FOR PURIFICATION FACILITIES

The catchment area of Lake Balaton is divided into many small sub-basins. These sub-basins are classified into two categories; river outflow basins and direct runoff basins.

Kis-Balaton system is a typical example of the river purification method and is ongoing project to reduce nutrient loads of Zala river. Therefore this study does not propose water quality improvement measures for Zala river.

(1) River Outflow Basins

There are a lot of wetlands or farmlands around the lower reaches of rivers in the northern catchment area, and there are suitable sites for construction of vegetation purification facilities.

In the southern catchment area, there are many houses built between the coastal road and the lakeshore, therefore it is difficult to find suitable sites for vegetation purification facilities near the lakeshore. On the other hand, in the south of the coastal road, there are a lot of wetlands or farmlands along rivers, those areas would be available for the sites of facilities.

(2) Direct Runoff Basins

There are a lot of small creeks and drains in those basins. Therefore it is inefficient to construct purification facility at each water course. And also it is difficult to find suitable sites for facility construction due to crowded houses in urban areas. A pipeline along the lakeshore is proposed to gather water from those small water courses and lead it to a purification facility at available land.

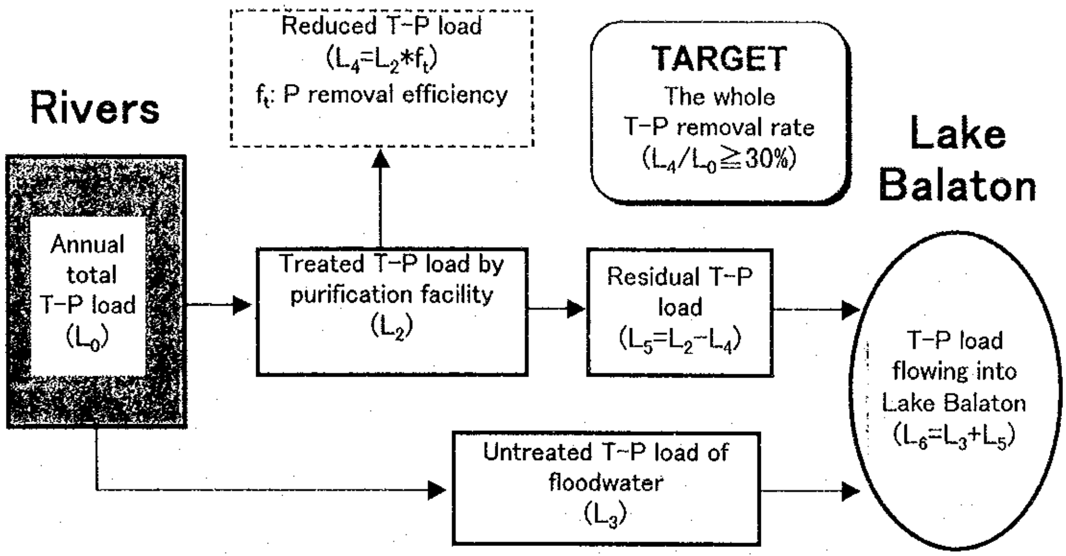
(3) Basins of Pumping Stations

Four pumping stations are located in the southern catchment area of the lake to drain a storm water. There are also many houses built around the downstream of the pumping stations, so suitable sites for facilities should be found in the upstream sides.

5. COMPREHENSIVE PLAN

5.1 DESIGN WATER FLOWS AND PHOSPHOROUS LOADS

Capacities of river purification facilities are designed for all rivers to meet the basic condition, which requires that annual total phosphorous load flowing into the Lake Balaton should be reduced at least by 30 % even if a certain level of floodwaters can not be treated to protect the facilities from damages.



Design water flows and phosphorous loads for all rivers are shown in *Table D.3*.

5.2 STRUCTURAL COMPONENTS OF THE COMPREHENSIVE PLAN

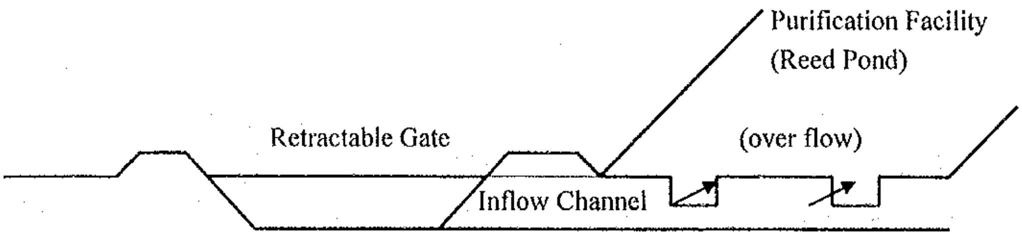
A typical layout and cross sections of the vegetation purification facility are shown in *Figure D.1*. Dimensions of all facilities are designed as shown in *Table D.4*.

(1) Part of Water Intake

To lead river water to a purification facility, it is necessary to set an intake gate inside of the river course. When floodwater comes, the gate falls down at a certain water level to lead the floodwater to main river course, and protect the purification facility from damages by the floodwater. The certain water level is set over 10 cm higher than the top of the gate. According to examples in Japan, a rubber-made gate is proposed.

From the intake gate to the purification facility, water flows into an open channel made by reinforced concrete, but a box culvert is used where intake water crosses the embankment of the river.

A set of screen and gate (flush board) is set at the entrance of the channel to shut the river water out when the purification facility is under maintenance. Water flowrate in channel is assumed as 0.3 m/sec. To make a uniform water flow, overflow system is proposed at the entrance of the reed pond as shown in the following conceptual figure.



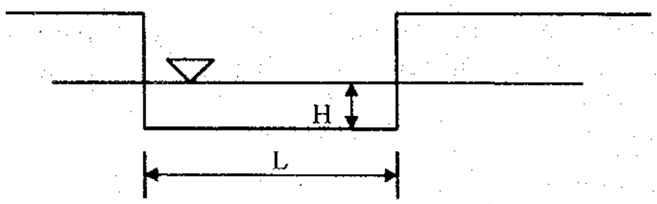
Facility design capacity of the inflow channel

$$Q = (150\ m \times 10\ m \times 0.2\ m) \div 5\ hr = 60\ m^3/hr = 0.017\ m^3/sec$$

Over flow volume of each weir is calculated by the following formula.

$$Q = C1 \times L \times H^{3/2}$$

Q : over flow volume (m3/sec)
C1 : flow coefficient (=1.2)
L : length of over flow weir (m)
H : water depth of over flow (m)



When,

$L = 0.50\ m$, $H = 0.10\ m$

$$Q = 1.2 \times 0.50 \times 0.10^{3/2} = 0.019\ m^3/sec$$

$$\fallingdotseq 0.017\ m^3/sec\ (Q_d : \text{design flow})$$

These over flow weirs are set at intervals of 10 m of the inflow channel.

(2) Retractable Gate

As the gate does not fall down until the water level rises up to 10 cm higher than the top of the gate, the water level of the inflow channel (H) rises up to a maximum height of 0.20 m.

When,

$H = 0.20\ m$

$$Q = 1.2 \times 0.50 \times (0.20)^{3/2} = 0.054\ m^3/sec = 2.84\ Q_d$$

Thus, the facility can treat a maximum water flow of about three times of design inflow (Q_d), even if the river water flow exceeds the design inflow of the facility.

However, the purification efficiency does not meet the designed level under such condition.

When the retractable gate falls down, the river water flow is calculated as follows.

$$Q = 2.84Q_d + Q_{overflow}$$

Where,

Q: river flow rate when the gate is retracted (m^3/sec)

Q_d: design inflow of the facility (m^3/sec)

$Q_{overflow}$: over flow rate of the retractable gate (m^3/sec)

$$Q_{overflow} = C_{gate} \times W_{gate} \times H_{gate}^{3/2}$$

C_{gate} : flow coefficient ($= 1.77\, h/H_{gate} + 1.05$)
W_{gate} : top width of the gate (m)
H_{gate} : height of the gate (m)
h: water depth of over flow (m)

(3) Purification Facility (Reed Pond)

Design conditions are follows.

Water depth = 0.20 m, Purification length = 150m,

Design water velocity = 0.8 cm/sec

Necessary width of the pond

Settling time = $((150 \times 10^2) \div 0.8) \div (60 \times 60) = 5.2$ hr

$Q (m^3/day) \times 5.2 / 24 = 0.20 \times 150 \times B$

$B = (5.2 \times Q) \div (24 \times 0.20 \times 150) = (5.2 \times Q) \div 720$

(4) Outflow Channel

A part of outflow system is same as that of inflow channel. Water from the facility flows into the outflow channel by overflow system, and flows into a river course by open channel. The channel is made by reinforced concrete, and a small gate is set at the exit of a channel to shut the river water out when the facility is under maintenance.

5.3 Implementation Program

In Lake Balaton, water quality is getting worse when going up to the westward. The catchment area of Keszthely basin is undoubtedly the first priority to reduce the phosphorous load from its catchment area. Therefore the proposed river purification facilities should be implemented from the west toward the east. The rivers with large amount of flowrate and T-P load should be given higher priority.

Based on these conditions, the implementation schedule is proposed as shown in *Table D.5*. The implementation schedule is made based on the following ideas.

- The construction schedule is starting from year 2001 until year 2010.
- The engineering cost is divided into first three years.
- The construction cost is divided into each year from 2002 to 2010.
- The facilities for the rivers flowing into Keszthely basin or Szigliget basin, have higher priority.
- Each construction period of vegetation purification facility is one (1) year, except facilities with the width of over 500m, which construction period is two (2) years.

5.4 PROJECT COSTS

The project costs consist of the following items.

- Construction cost
- Land acquisition cost
- Engineering service cost
- Physical contingency
- Operation and maintenance (O/M) cost

Construction costs are based on data of unit costs obtained from PMO/VATI, VIZITERV Kft, examples of Várpalota Region Environmental Improvement Project, and other sources. Unit construction costs include overhead costs which are assumed to be 30 % of the costs of equipment and civil works.

Facilities would be constructed on the agricultural land or public-owned land, thus an average agricultural land price of 500 HUF/m^2 is used for estimation of land acquisition cost.

The cost of engineering services is estimated at 5% of the construction cost and land acquisition cost, and survey cost.

The physical contingency is provided to cope with the unforeseen conditions, such as change in site condition, etc. The physical contingency is assumed to be 5% of the construction cost, land acquisition, and engineering services.

Operation and maintenance (O/M) costs are based on data of unit costs obtained from PMO/VATI, VIZITERV Kft, examples of Várpalota Region Environmental Improvement Project, and other sources.

Project costs are summarized as below.

Total construction cost	:	3,915,588,000 HUF
Total operation and maintenance cost	:	256,933,000 HUF/year

Breakdown of the project costs by cost item, facility component and year are shown in *Table D.6*, *Table D.7* and *Table D.8*.

Construction costs estimation of facility components are shown in *Table D.9* (reed pond), *Table D.10* (maintenance gate and screen), *Table D.11* (retractable gate), and *Table D.12* (inflow/outflow channel).

Operation and maintenance (O/M) cost estimation is shown in *Table D.13*, land acquisition cost estimation in *Table D.14*, and survey cost estimation in *Table D.15*.

6. FEASIBILITY STUDY

6.1 SELECTION OF PROJECTS FOR FEASIBILITY STUDY

By the following reasons, two rivers among 33 rivers and pumping stations studied in the comprehensive plan have been selected.

- The river which flow volume is comparatively big and phosphorous load flowing into the lake is also big.
- The river flowing into the Keszthely basin or Szigliget basin which receives a large volume of nutrient loads from both external and internal sources and is suffering from eutrophication.
- The river where suitable land for facility site is easily found and acquired.
- The river which can be a model case to develop the river purification systems for other rivers.

Additionally, one (1) small river which is a storm water drainage of Keszthely town rather than a river has been selected. Because it is necessary to show a typical plan for urban runoff purification which should be a model case for further development of nutrient control in the direct runoff sub-catchment.

Selected project areas are shown as follows and their locations are shown in *Figure D.2*.

① River purification facility (vegetation purification method)

Nyugati-övcsatorna river

Keleti-bozot river

② Urban runoff purification facility (coagulation sedimentation method)

Keszthely urban runoff area (Szent Imre/Bödös river)

6.2 DESIGN OF FACILITIES

(1) Nyugati-övcsatorna Facility

The location of the project site is shown in *Figure D.3*.

1) Method

Vegetation purification Method

General layout and profiles of the vegetation purification facilities are shown in *Figure D.4* and *Figure D.5*.

2) Design of facility

Water Flow (Q) = 1.01 m^3/sec (87,264 m^3/day)

Water Velocity = 0.8 cm/sec

Facility Length = 150 m

Water Depth = 0.20 m

Necessary Width

Retention Time = $((150 \times 10^2) \div 0.8\text{cm/sec}) \div (60 \times 60) = 5.2$ hr

$Q \times (5.2/24) = 0.20 \times 150 \times B$

$\therefore$ B = 630 m

3) Intake gate

Retractable Gate (Rubber made)

B = 15.0 m (bottom width), H = 2.0m

General layout and profiles of the intake gate are shown in *Figure D.6* and *Figure D.7*.

4) Inflow-outflow channel

Water Velocity 0.3 m/sec (assumed)

$B \times H \times 0.3 = 1.01\ m^3/sec$

$\therefore\ B = H = 1.84 \fallingdotseq 1.90\ m$

(2) Keleti-bozot Facility

The location of the project site is shown in *Figure D.8.*

1) Method

Vegetation purification Method

General layout and profiles of the vegetation purification facilities are shown in *Figure D.9* and *Figure D.10.*

2) Designing of facility

Water Flow (Q)	= 1.13 m^3/sec (97,632 m^3/day)
Water Velocity	= 0.8 cm/sec
Facility Length	= 150 m
Water Depth	= 0.20 m

Necessary Width

$\text{Settling Time} = ((150 \times 10^2) \div 0.8\text{cm/sec}) \div (60 \times 60) = 5.2\ hr$

$Q \times (5.2/24) = 0.20 \times 150 \times B$

$\therefore\ B = 705\ m$

3) Intake gate

Retractable Gate (Rubber made)

B = 8.0 m (bottom width), H = 2.5m

General layout and profiles of the intake gate are shown in *Figure D.11* and *Figure D.12.*

4) Inflow-outflow channel

Water Velocity 0.3 m/sec (assumed)

$B \times H \times 0.3 = 1.13\ m^3/sec$

$\therefore\ B = H = 1.94 \fallingdotseq 2.00\ m$

(3) Keszthely Urban Runoff Purification Facility

The location of the project site is shown in *Figure D.13*.

1) Method

Coagulation sedimentation method

General system flow and layout of the vegetation purification facilities are shown in *Figure D.14* and *Figure D.15*.

2) Designing of facility

a. Design condition

Water flow (Q) = $0.47 m^3/sec = 40,600 m^3/day$

Inflow water quality T-P = 1.1 mg/l

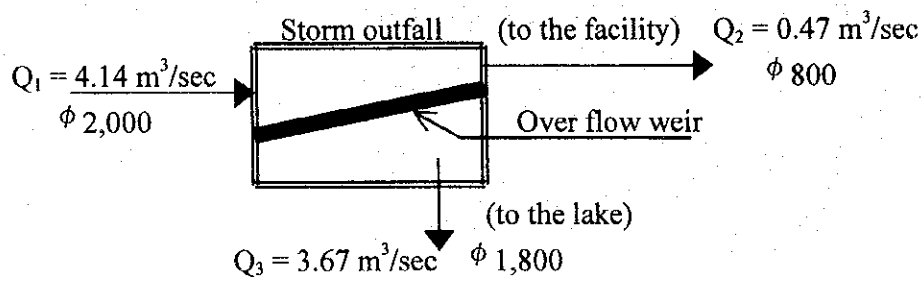
SS = 6.0 mg/l

b. Storm outfall

Annual max flow $Q_1 = 4.14 m^3/sec$ (Φ 2,000, water depth 1.46 m)

Facility design inflow $Q_2 = 0.47 m^3/sec$ (Φ 800 , water depth 0.52 m)

Storm outfall volume $Q_3 = Q_1 - Q_2 = 3.67 m^3/sec$ (Φ 1,800)



Design of storm outfall

Over flow water depth = 0.50 m (assumed)

Over flow weir length (L)

$L = Q_3 \div (1.8 \times H^{3/2}) = 3.67 \div (1.8 \times 0.50^{3/2}) = 5.76 m \fallingdotseq 6.0 m$

(General layout and profile are shown in *Figure D.16*.)

c. Intake gate

Size of the gate	:	1.0 m high × 1.0 m wide
Type of control	:	manual operation
Unit	:	1

d. Coarse screen

Size of the screen	:	3.50 m length × 1.0 m wide
Mesh of the screen	:	50 mm
Type of control	:	automatic operation
Unit	:	2

e. Sand basin

Load of water surface area	:	a = 1.800 m^3/m^2/day
Water velocity	:	V = 0.1 m/sec
Settling time	:	T ≧ 1 min
Useful depth	:	H = 2.0 m
Unit	:	2
Necessary water surface area	:	A = Q/a = 40,600 / 1,800 = 23 m^2
Width of sand basin	:	W = Q / H × V = 23 / 2 × 0.1 = 2.35 → 3.0 m
Length of sand basin	:	L = A / W = 23 / 2.5 = 9.2 m → 10 m

Plan of sand basin : 1.5m (W) ×10m (L) × 3.0m (H) × 2 units

∴ Settling time T = (W× L ×H) / Q = (3 ×10 ×2) / 0.47 = 128 sec

f. Screen

Size of the screen	:	3.50 m length × 0.8 m wide
Mesh of the screen	:	5 mm
Type of control	:	automatic operation
Unit	:	2

g. Mixing basin

Mixing time	:	T = 5 min
Unit	:	2
Plan of the pond	:	3.0m (W) × 6.0m (L) × 4.0m (H) (useful volume = 72m^3/ 1pond)

∴ Mixing time T = 72 / (28.2 / 2) = 5.1 min

h. Flocculator

Flocculation time	:	T = 20 min
Unit	:	4
Plan of the pond	:	7.0 m (W) × 7.0 m (L) ×3.0 m (H) (useful volume = 147.0m^3/ 1pond)

∴ Flocculation time T = 147.0 / (28.2 / 4) = 20.9 min

i. Settling pond

Settling time : 3 hours
Unit : 4
Plan of the pond : 7.0 m (W) × 41.0 m (L) × 4.5 m (H)
(useful volume = 1,291.5m^3/ 1pond)

∴ Settling time T = 1,291.5 / (1,691.7 / 4) = 5.05 hr

j. Coagulant storage tank

Chemicals : Ferric chloride ($FeCl_3$, 37%)
Volume of pouring :
Ferric chloride = 40,600 m^3/day×12~18 mg/l × (100/37) ×(1/1.2) × 10^{-3}
= 950 ~ 1,426 (l / day)
Volume of tank
Ferric chloride 10m^3×2units (max pouring volume×10 days)

k. Sludge tank

Design of water quality

	Inflow		Outflow
SS	60 mg/l	→	5 mg/l
T−P	1.1 mg/l	→	0.33 mg/l

Outbreak sludge concentration : 5 kg/m^3 (5,000 mg/l)

Outbreak sludge volume

Sludge volume from SS : 40,600 × (60 - 5) ×10^{-3} = 2,233 kg(DS)/day

Sludge volume from $FePO_4$: 40,600 ×151 ×(1.1 - 0.33)/31 × 10^{-3}
= 152 kg(DS)/day

Sludge volume from $Fe(OH)_3$: 40,600 ×107 ×(1.1 - 0.33) × (2 - 1) / 31×10^{-3} = 108 kg(DS)/day

Total volume = 2,493 kg(DS)/day

Sludge volume : 2,493 kg(DS)/day / 5 kg / m^3 = 499 m^3

Storage time : 1 day

Plan of the sludge tank : 10 m (W) × 20 m (L) × 2.5 m (H)
(useful volume = 500 m^3)

l. Sludge thickener

Outbreak sludge volume : 2,493 kg(DS)/day

Solid load : 10 kg(DS)/m^2·day

Necessary surface area : 2,493 kg(DS)/day/10 kg(DS)/m^2·day = 249.3 m^2

Diameter of sludge thickener : $(249.3)^{1/2}$ / 0.785 = 17.8m ϕ → 18m ϕ

Sludge depth : 3.0m (useful depth)

Plan of the sludge thickener : 18m (ϕ) × 3.5 m (H)

Concentration of the sludge thickener : 2.5 %

Outbreak sludge volume from the sludge thickener :
2,493 kg(DS)/day × (100/2.5) × 10^{-3} = 100 m^3

m. Sludge storage tank

Sludge volume : 100 m^3
Storage time : 1 day
Plan of the storage tank : 4.0 m (W) × 9.0 m (L) × 3.0 m (H)
(useful volume 108 m^3)

n. Coagulation basin

Operation time of dehydrator : 10 hr
Inflow sludge volume : 100 m^3/10 hr = 10 m^3/hr
Storage time : 3 min
Necessary tank volume : 10 m^3/hr × (3/60) = 0.5 m^3
Plan of the coagulation basin : 0.8 m (W) ×0.8 m (L) × 0.8 m (H)

0. Dehydrator

Operation time of dehydrator : 10 hr/day

Outbreak sludge volume : 2,493 kg(DS)/day

Volume for treatment: 2,493 kg(DS)/day / 10 = 249.3 kg(DS)/hr

Dehydrate sludge:

water content < 70 %
volume of dehydrate sludge
2,493 kg(DS)/day × 1/(1−(70/100)) = 8,310 kg(WS)/day
density = 0.9 kg /l
8,310(kg(WS)/day) ÷ 0.9(kg/l) = 9,233 l/day = 9.23 m^3 / day

6.3 COST ESTIMATION

(1) Nyugati-övcsatorna Facility

1) Construction costs

a. Quantity calculation

Excavation

Case1 (H=0.3m, L= 150m)
V1=(3.30+(3.30+0.30×2)) ×1/2×0.30×150×2=324m^3

Case2 (H=0.3～1.3m, L=380m)
A1=(3.30+(3.30+0.30×2)) ×1/2×0.30=1.08m^2
A2=(3.30+(3.30+1.30×2)) ×1/2×1.30=5.98m^2

V2=(1.08+5.98) ×1/2×380 × 2=2,683m^3

Case3 (H=1.30～2.30m, L=20m)
A1=(3.30+(3.30+1.30×2)) ×1/2×1.30=5.98m^2
A2=(3.30+(3.30+2.30×2)) ×1/2×2.30=12.88m^2
V3=(5.98+12.88) ×1/2×20×2=377m^3

Case4 (H=2.30m, L= 80m)
V4=12.88m^2×80×2=2,061m^3

Case5 (H=2.30～3.90m, L=20m)
A1=(3.30+(3.30+2.30×2)) ×1/2×2.30=12.88m^2
A2=(3.30+(3.30+3.90 × 2)) ×1/2×3.90=28.08m^2
V5=(12.88+28.08) ×1/2×20×2=819m^3

Case6 (H=3.90m, L= 4.0m)
V6=28.08m^2×4.0×2=225m^3

Case7 (H=3.90～2.30m, L=3.20m)
V7=(28.08+12.88) ×1/2×3.20×2=131m^3

Case8 (H=2.30m, L= 6.50m)
V8=12.88m^2×6.50×2=167m^3

Total excavation = 6,787 m^3

Removal of surplus soil 6,787m^3

Backfill

Case1	324 - (2.30×0.30×150×2) = 117m^3
Case2	2,683 - (2.30×(0.30+1.30) ×1/2×380×2) = 1,285m^3
Case3	377 - (2.30×(1.30+2.30) ×1/2×20×2) = 211m^3
Case4	2,061 - (2.30×2.30×80×2) = 1,215m^3
Case5	819 - (2.30×(2.30+3.90) ×1/2×20×2) = 534m^3
Case6	225 - (2.30×3.90×4.0×2) = 153m^3
Case7	131 - (2.30×(2.30+3.90) ×1/2×3.20×2) = 85m^3
Case8	167 - (2.30×2.30×6.50×2) = 98m^3

Total backfill = 3,698 m^3

Fill(banking)

1.70 × 150 × 150 = 38,250 m^3
1.70× 400 × 1/2 ×150 = 51,000 m^3
(0.80+2.90) × 1/2 × 2.10 × 153 = 594 m^3
(0.80+2.90) × 1/2 × 2.10 × 550 × 1/2 × 2 = 2,137m^3
Total fill(banking) = 91,981 m^3

Reed pond 150 × 630 = 94,500 m^2

Inflow and outflow channel (1.9m × 2.1m) L= 1,300 m

Maintenance gate (flush board , 1.9m × 1.9m) = 2 pieces

Screen (1.9m × 1.9m) = 1 piece

Retractable gate (rubber made) B = 15.0m(bottom width), H = 2.0m

b. Costs estimation

Purification Facility

Excavation	$6{,}787\ m^3 \times 1{,}170$ HUF/m^3 =	7,940,000 HUF
Removal of surplus soil	$6{,}787\ m^3 \times 520$ HUF/m^3 =	3,529,000 HUF
Backfill	$3{,}698\ m^3 \times 1{,}430$ HUF/m^3 =	5,288,000 HUF
Fill(banking)	$91{,}981\ m^3 \times 1{,}170$ HUF/m^3 =	107,617,000 HUF
Make reed pond	$94{,}500\ m^2 \times 1{,}870$ HUF/m^2 =	176,715,000 HUF
Inflow/outflow channel	1,300m×33,020HUF/m =	42,926,000HUF
Maintenance gate (flush board)	2 × 130,000 HUF =	260,000 HUF
Screen	1 × 65,000 HUF =	65,000 HUF
	(Sub Total	344,340,000 HUF)

Retractable Gate

Materials	=	30,280,000 HUF
Concrete(reinforced)	480m3×50,700HUF/m^3 =	24,300,000 HUF
Concrete	$26\ m^3 \times 18{,}000$ HUF/m^3 =	468,000 HUF
Excavation	$720\ m^3 \times 1{,}170$ HUF/m^3 =	842,000 HUF
Removal of surplus soil	$720\ m^3 \times 520$ HUF/m^3 =	374,000 HUF
Backfill	$240\ m^3 \times 1{,}430$ HUF/m^3 =	343,000 HUF
Cost of employees	4,550 HUF/day/man×220 days =	1,001,000 HUF
Machine operation cost	130,000HUF/day×10days =	1,300,000 HUF
Control house	=	260,000 HUF
Cost of temporary facilities	=	390,000 HUF
	(Sub Total	59,558,000 HUF)

Total Construction Cost

344,340,000 + 59,558,000 = 403,898,000 HUF

2) Operation costs

a. Maintenance cost

Frequency of inspection is once a week, and it takes 2 hours for an inspection.

1 time/week × 2 hr× 52 weeks/year = 104 hours/year

Labor unit cost (skilled) 60,000 HUF/month/person = 430HUF/hr./person

Annual inspection cost 104 hrs/yr. ×430HUF/hr/person×1 person

= 44,720 HUF/year

b. Cut and disposal of reeds

Cut of reeds	94,500 $m^2 \times 80$ HUF/m^2 =	7,560,000 HUF/year
Disposal of reeds	94,500 $m^2 \times 60$ HUF/m^2 =	5,670,000 HUF/year
	Subtotal	13,230,000 HUF/year

c. Remove and backfill of sediment sludge and bottom soil (once a decade)

Recultivation	94,500$m^2 \times$ 60HUF/$m^2 \times$ 1/10yrs =	567,000 HUF/yr.
Planting reeds	94,500$m^2 \times$ 1,440HUF/$m^2 \times$ 1/10yrs =	13,608,000 HUF/yr.
	Subtotal	14,175,000 HUF/year

d. Water quality monitoring

To examine a removal efficiency, water analysis is necessary once in a month, about T-P, T-N, COD,SS. Sampling spot is inflow and outflow spot of facility.

	Unit Rate(HUF)	Unit	Quantity	Amount(HUF)
Sampling & transportation	1,480		24	35,520
T-P	3,180	sample	24	76,320
T-N	3,180	sample	24	76,320
COD	2,540	sample	24	60,960
SS	2,540	sample	24	60,960
		Subtotal	≒	310,000 HUF

Total operation costs = 27,760,000 HUF/year

(2) Keleti-bozot Facility

1) Construction cost

a. Quantity calculation

Excavation

Case1 (H=1.40m, L= 705m)
$V1=(3.40+(3.40+1.40\times2))\times1/2\times1.40\times705\times2=9{,}475m^3$

Case2 (H=1.40～2.80m, L=7.0m)
$A1=(3.40+(3.40+1.40\times2))\times1/2\times1.40=6.72m^2$
$A2=(3.40+(3.40+2.80\times2))\times1/2\times2.80=17.36m^2$
$V2=(6.72+17.36)\times1/2\times7.0\times2=169m^3$

Case3 (H=2.80m, L=3m)
$V3=17.36\times3.0\times2=104m^3$

Case4 (H=2.80~0.30m, L=5.0m)

A1=17.36m^2

A2=(3.40+(3.40+0.30×2)) ×1/2×0.30=1.11m^2

V4=(17.36+1.11) ×1/2×5.0×2=92m^3

Total excavation = 9,840 m^3

Removal of surplus soil 9,840m^3

Backfill

Case1	9,475 - (2.40×1.40×705×2) = 4,737m^3
Case2	169 - (2.40×(1.40+2.80) ×1/2×7.0×2) = 98m^3
Case3	104 - (2.40×2.80×3.0×2) = 64m^3
Case4	92 - (2.40×(2.80+0.30) ×1/2 ×5.0 ×2) = 55m^3

Total backfill = 4,954 m^3

Fll(banking)

0.70 × 705 × 150 = 74,025 m^3

(0.80+1.90) ×1/2× 1.10 ×153 = 223 m^3

(0.80+1.90) × 1/2 × 1.10 × 705 × 2 = 2,094 m^3

Total fill(banking) = 76,342 m^3

Reed pond 150 × 705 = 105,750 m^2

Inflow and outflow channel (2.0m×2.2m) L= 1,440 m

Maintenance gate (flush board , 2.0m × 2.0m) = 2 pieces

Screen (2.0m × 2.0m) = 1 piece

Retractable gate (rubber made) B = 8.0m(bottom width), H = 2.5m

b. Costs estimation

Purification Facility

Excavation	9,840 m^3 × 1,170 HUF/m^3 = 11,512,000 HUF
Removal of surplus soil	9,840 m^3×520 HUF/m^3 = 5,116,000 HUF
Backfill	4,954 m^3×1,430 HUF/m^3 = 7,084,000 HUF
Fill(banking)	76,342 m^3 × 1,170 HUF/m^3 = 89,320,000 HUF
Make reed lake	105,750 m^2 ×1,870 HUF/m^2 = 197,752,000 HUF
Inflow/outflow channel	1,440m ×35,100HUF/m=50,544,000 HUF
Maintenance gate (flush board)	2 ×130,000 HUF = 260,000 HUF
screen	1 × 65,000 HUF = 65,000 HUF
(Sub Total	361,653,000 HUF)

Retractable Gate

Materials	= 24,260,000 HUF
Concrete(reinforced)	420m^3 × 50,700HUF/m^3 = 21,294,000 HUF

Concrete	$25m^3 \times 18,000HUF/m^3$	= 450,000 HUF
Excavation	$630\ m^3 \times 1,170\ HUF/m^3$ =	737,000 HUF
Removal of surplus soil	$630\ m^3 \times 520\ HUF/m^3$ =	327,000 HUF
Backfill	$210\ m^3 \times 1,430\ HUF/m^3$ =	300,000 HUF
Cost of employees	4,550 HUF/day/man × 220 days =	1,001,000 HUF
Machine operation cost	130,000HUF/day ×10days=	1,300,000 HUF
Control house	=	260,000 HUF
Cost of temporary facilities	=	390,000 HUF
(Sub Total		50,319,000 HUF)

Total Construction Cost

361,653,000 + 50,319,000 = 411,972,000 HUF

2) Operation costs

a. Maintenance cost

Frequency of inspection is once a week, and it takes 2 hours for an inspection.

1 time/week × 2 hr× 52 weeks/year = 104 hours/year

Labor unit cost (skilled) 60,000HUF/month/person= 430 HUF/hr/person

Annual inspection cost 104 hrs/yr×430HUF/hr./person×1 person

= 44,720 HUF/year

b. Cut and disposal of reeds

Cut of reeds	$105,750\ m^2 \times 80\ HUF/m^2$ =	8,460,000 HUF/year
Disposal of reeds	$105,750\ m^2 \times 60\ HUF/m^2$ =	6,345,000 HUF/year
	Subtotal	14,805,000 HUF/year

c. Remove and backfill of sediment sludge and bottom soil.(once a decade)

Recultivation	$105,750m \times 60HUF/m^2 \times 1/10yrs$ =	634,500 HUF/year
Planting reeds	$105,750m \times 1,440HUF/m^2 \times 1/10yrs$ =	15,228,000 HUF/year
	Subtotal	15,863,000 HUF/year

d. Water analysis

Water analysis is same as Nyugati-övcsatorna.

310,000 HUF

Total operation costs = 31,022,000 HUF/year

(3) Keszthely Urban Runoff Purification Facility

1) Construction costs

a. Building works quantity calculation

Concrete

(storm outfall)

$7.0 \times 6.0 \times (0.50 + 0.60) - 1.20^2 \times \pi/4 = 45.1\ m^3$

$((7.0 \times 6.0) - (6.0 \times 5.0)) \times 3.50 = 42.0\ m^3$

$\triangle\ (2.20^2 + 2.00^2 + 0.90^2) \times \pi/4 \times 0.50 = \triangle\ 3.8\ m^3$

$(3.0 + 2.0) \times 1/2 \times 6.0 \times 0.50 = 7.5\ m^3$

(sand basin)

$1.0 \times 0.3 \times 3.5 \times 2 = 2.1\ m^3$

$1.6 \times 0.3 \times 3.5 = 1.7\ m^3$

$(1.3 + 3.4) \times 1/2 \times 0.3 \times 3.0 \times 2 = 4.2\ m^3$

$(1.6 + 4.2) \times 1/2 \times 0.4 \times 3.0 \times 2 = 7.0\ m^3$

$3.3 \times 2.5 \times 0.3 \times 2 = 5.0\ m^3$

$0.4 \times 3.0 \times 10.0 \times 3 = 36.0\ m^3$

$4.2 \times 0.4 \times 10.0 = 16.8\ m^3$

$1.0 \times 0.3 \times 3.5 \times 2 = 2.1\ m^3$

$1.6 \times 0.3 \times 3.5 = 1.7\ m^3$

$(1.3 + 3.4) \times 1/2 \times 0.3 \times 3.0 \times 2 = 4.2\ m^3$

$(1.6 + 4.2) \times 1/2 \times 0.4 \times 3.0 \times 2 = 7.0\ m^3$

(mixing basin)

$((13.2 \times 3.4) - (12.0 \times 3.0)) \times 4.0 = 35.5\ m^3$

$13.2 \times 3.4 \times 0.5 = 22.4\ m^3$

(flocculator)

$((9.5 \times 32.0) - (9.0 \times 29.5)) \times 3.2 = 123.2\ m^3$

$1.0 \times 0.3 \times (8.5 \times 2 + 32.0) = 14.7 m^3$

$2.0 \times 0.3 \times (7.0 \times 3 + 30.0) = 30.6 m^3$

$9.5 \times 32.0 \times 0.5 = 152.0\ m^3$

$((41.0 \times 32.0) - (41.0 \times 29.5)) \times 4.2 = 430.5\ m^3$

$1.0 \times 0.3 \times 41.0 \times 2 = 24.6\ m^3$

$2.0 \times 0.3 \times 41.0 \times 3 = 73.8\ m^3$

$41.0 \times 32.0 \times 0.5 = 656.0\ m^3$

$((6.0 \times 32.0) - (5.5 \times 29.5)) \times 3.2 = 95.2\ m^3$

$1.0 \times 0.3 \times (5.0 \times 2 + 32.0) = 12.6 m^3$

$2.0 \times 0.3 \times 5.0 \times 3 = 9.0 m^3$

6.0 × 32.0 × 0.5 = 96.0 m^3

(sludge tank)

((19.6 × 10.6) - (18.6 × 9.6)) × 3.0 = 87.6 m^3

9.6 × 0.5 × 3.0 = 14.4 m^3

19.6 × 10.6 × 0.7 = 145.4 m^3

(sludge thickener)

((19.0×19.0×π/4) - (18.0×18.0×π/4)) ×4.0 = 116.2m^3

(19.0×19.0×π/4) × 0.70 = 198.4 m^3

5.0 × 5.0 × π/4 × 2.0 = 39.3 m^3

(sludge storage tank)

((9.6 × 4.6) - (8.8 × 3.8)) × 3.5 = 37.5 m^3

3.8 × 0.4 × 3.5 = 5.3 m^3

9.6 × 4.6 × 0.5 = 22.1 m^3

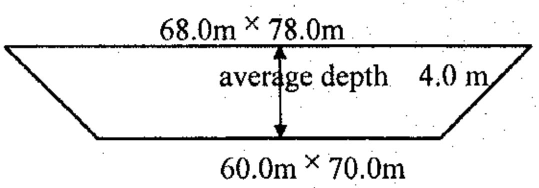
(coagulant storage tank)

((15.0 × 10.3) - (14.4 × 9.7)) × 2.0 = 29.6 m^3

15.0 × 10.3 × 0.5 = 77.3 m^3

Total concrete volume = <u>2,727.8 m^3</u>

<u>Excavation</u>



A1 = 60.0 × 70.0 = 4,200 m^2

A2 = 68.0 × 78.0 = 5,304 m^2

Total excavation volume = (4,200 + 5,304) ×1/2×4.0 = <u>19,000 m^3</u>

<u>Removal of surplus soil</u> <u>19,000 m^3</u>

<u>Backfill</u>

(storm outfall)

△ 7.0 × 6.0 × 4.6 = 193.2 m^3

△ 0.90^2 × π/4 × 10.0 = 6.4 m^3

(sand basin)

△ 1.3 × 1.6 × 3.50 × 2 = 14.6 m^3

△ (1.6+4.2) ×1/2×(1.3+3.4) ×1/2×3.0×2 = 40.9 m^3

△ 3.4 × 4.2 × 10.0 = 142.8 m^3

(mixing basin)

$\triangle$ $13.2 \times 3.4 \times 4.5 = 202.0\ m^3$

(flocculator)

$\triangle$ $9.5 \times 32.0 \times 4.0 = 1{,}216.0\ m^3$

$\triangle$ $41.0 \times 32.0 \times 5.0 = 6{,}560.0\ m^3$

$\triangle$ $6.0 \times 32.0 \times 4.0 = 768.0\ m^3$

(sludge tank)

$\triangle$ $19.6 \times 10.6 \times 3.7 = 768.7\ m^3$

(sludge thickener)

$\triangle$ $19.0 \times 19.0 \times \pi/4 \times 4.7 = 1{,}331.9\ m^3$

(sludge storage tank)

$\triangle$ $9.6 \times 4.6 \times 4.0 = 176.6\ m^3$

(coagulant storage tank)

$\triangle$ $15.0 \times 10.3 \times 2.5 = 386.3\ m^3$

(base gravel)

$\triangle$ $7.0 \times 6.0 \times 0.1 = 4.2\ m^3$

$\triangle$ $1.6 \times 3.5 \times 0.1 \times 2 = 1.1\ m^3$

$\triangle$ $(1.6 + 4.2) \times 1/2 \times 0.1 \times 2 = 0.6\ m^3$

$\triangle$ $3.4 \times 4.2 \times 0.1 = 1.4\ m^3$

$\triangle$ $13.2 \times 3.4 \times 0.1 = 4.5\ m^3$

$\triangle$ $9.5 \times 32.0 \times 0.1 = 30.4\ m^3$

$\triangle$ $41.0 \times 32.0 \times 0.1 = 131.2\ m^3$

$\triangle$ $6.0 \times 32.0 \times 0.1 = 19.2\ m^3$

$\triangle$ $19.6 \times 10.6 \times 0.1 = 20.8\ m^3$

$\triangle$ $19.0 \times 19.0 \times \pi/4 \times 0.1 = 28.3\ m^3$

$\triangle$ $9.6 \times 4.6 \times 0.1 = 4.4\ m^3$

$\triangle$ $15.0 \times 10.3 \times 0.1 = 15.5\ m^3$ (base gravel total $261.6\ m^3$)

(base concrete)

$\triangle$ $261.6 \times 1/2 = 130.8\ m^3$

Subtotal $\triangle = 12{,}200\ m^3$

Total backfill = $19{,}000 - 12{,}200 = \underline{6{,}800\ m^3}$

Building work

$6.5 \times 5.6 = 36.4\ m^2$

$10.6 \times 8.0 = 84.8\ m^2$

$10.3 \times 15.0 = 154.5\ m^2$

$4.3 \times 4.6 = 19.8\ m^2$

Total building work = 295.5 m^2

Timbering

$(7.0 + 6.0) \times 4.6 \times 2 = 119.6\ m^2$

$(6.0 + 5.0) \times 3.5 \times 2 = 77.0\ m^2$

$(1.4+3.5) \times 1/2 \times 3.0 \times 2 \times 2 = 29.4\ m^2$

$(1.0+3.0) \times 1/2 \times 3.0 \times 2 \times 2 = 24.0\ m^2$

$3.5 \times 10.0 \times 2 = 70.0\ m^2$

$3.0 \times 10.0 \times 4 = 120.0\ m^2$

$(9.5 \times 2 + 32.0) \times 4.1 = 209.1\ m^2$

$41.0 \times 5.1 \times 2 = 418.2\ m^2$

$(9.0 \times 8 + 31.0) \times 3.5 = 360.5\ m^2$

$41.0 \times 8 \times 4.5 = 1{,}476.0\ m^2$

$(19.6 + 10.6) \times 2 \times 3.8 = 229.5\ m^2$

$(18.6 + 9.6) \times 2 \times 3.0 = 169.2\ m^2$

$19.0 \times 19.0 \times \pi/4 \times 4.8 = 1{,}360.2\ m^2$

$18.0 \times 18.0 \times \pi/4 \times 4.0 = 1{,}017.4\ m^2$

$(9.6 + 4.6) \times 2 \times 4.1 = 116.4\ m^2$

$(8.6 + 3.6) \times 2 \times 3.5 = 85.4\ m^2$

$(15.0 + 10.3) \times 2 \times 2.6 = 131.6\ m^2$

Total timbering = 6,013.5 m^2

b. Costs estimation

① Coagulation Sedimentation Facility

Machinery costs

912,600,000 YEN

Electric works costs

168,900,000 YEN

Building works costs

Excavation : 19,000 m^3 × 650 YEN/m^3 = 12,350,000 YEN

Removal of surplus soil: 19,000m^3 × 910YEN/m^3 = 17,290,000YEN

Backfil : 6,800 m^3 × 4,550 YEN/m^3 = 30,9400,000 YEN

Concrete(reinforced): 2,728 m^3 × 65,000 YEN/m^3
= 177,320,000 YEN

Base concrete: 131 m^3 × 26,000 YEN/m^3 = 3,406,000 YEN

Base gravel : 262 m^3 × 5,850 YEN/m^3 = 1,533,000 YEN

Building: $296\ m^2 \times 260{,}000\ YEN/m^2 = 76{,}960{,}000$ YEN

Timbering: $6{,}014\ m^2 \times 1{,}560\ YEN/m^2 = 9{,}382{,}000$ YEN

Subtotal 329,180,000 YEN

Total Construction Cost in Japan 1,410,680,000 YEN

Convert for the cost in Hungary

To convert for the cost in Hungary, the construction cost ratio of oxidation ditch method in Japan to that in Hungary is used.

Construction Costs (purification capacity: 6,000m^3/day)

- average cost in Japan 2,760,000,000 YEN (cost J)
- average cost in Hungarian 600,000,000 HUF (Cost H)
  (source: Várpalota region environmental improvement project)

Construction cost ratio (cost B : cost A) 0.2174

Convert for HUF (purification capacity: 40,600m^3/day)

1,410,680,000 YEN × 0.2174 = 306,681,000 HUF

Total Construction Cost in Hungary 306,681,000 HUF

② Inflow Pipes

φ 2,000	L = 20 m
φ 1,800	L = 20 m
φ 800	L = 10 m

Pipe construction cost

φ 2,000	20 m × 126,000 HUF/m	=	2,520,000 HUF
φ 1,800	20 m × 109,000 HUF/m	=	2,180,000 HUF
φ 800	10 m × 39,000 HUF/m	=	390,000 HUF
Total	5,090,000 HUF		

③ Outflow Channel

Water flow Q = 0.47 m^3/sec,

Water velocity V = 0.50 m/sec (assumed)

A = 0.47 m^3/sec / 0.50 m/sec = 0.94 m^2

→ 1.00 m(B) × 1.20m(H)

L = 50m

Construction cost = 16,900 HUF/m × 50m = 850,000 HUF

Grand Total Construction Cost

306,681 + 5,090,000 + 850,000 = 312,621,000 HUF

2) Operation costs

a. Electric costs

Electric power of machines is shown as follows.

No	Name of machine	Power (kw)	Unit	Operation time (hr)	Total output (kw/day)
1	Coarse screen	0.1	2	24	4.8
2	Screen	0.1	2	24	4.8
3	Sand pump	2.0	1	0.1	0.2
4	Water service pump	22	3	24	1,584
5	Ferric chloride pouring pump	0.2	2	24	9.6
6	Rapid mechanical aeration	5.5	3	24	396
7	Slow mechanical aeration①	1.5	8	24	288
8	Slow mechanical aeration②	0.2	4	24	19.2
9	Sludge discharge pump①	7.5	1	24	180
10	Aeration blower①	5.5	1	24	132
11	Sludge pump	7.5	1	24	180
12	Sludge scraper	1.5	1	24	35
13	Sludge discharge pump②	7.5	1	24	180
14	Aeration blower②	5.5	1	24	132
15	Sludge mechanical aeration	0.1	1	10	1
16	Macromolecule pouring pump	0.2	1	10	2
17	Mechanical aeration machine for macromolecule tank	1.5	1	10	15
18	Dehydrator	8	1	10	80
19	Water supply pump	1.1	1	10	11
	Total				3,254.6

Electric costs = 3,254.6kw/day × 15.7 HUF/kw × 0.8 = 40,877 HUF/day

b. Chemicals costs

Ferric chloride

Volume : 40,600m^3 × 15g/m^3 × 10^{-3} = 609 kg/day

Costs : 609 kg/day × 55 HUF/kg = 33,495 HUF/day

Macromolecule coagulant

Volume : 2,493 kg(DS)/day × (0.5/100) = 12.5 kg/day

Costs : 12.5 kg/day × 480 HUF/kg = 6,000 HUF/day

Total chemicals costs 33,495 + 6,000 = 39,495 HUF/day

c. Sludge dispose costs

Sludge discharge volume = 9.23 m^3/day

Cost = 9.23 m^3/day × 4,600 HUF/m^3 = 42,458 HUF/day

d. Operation cost

This method is a mechanical system and sludge outbreak everyday, therefor manpower is required for the operation everyday.

Manpower is proposed to be as follows.

Chief	1
Workers	2

The eligibility of the chief will be engineer.

Chief	1	×	100,000 HUF/month	=	100,000 HUF/month
Workers	2	×	60,000 HUF/month	=	120,000 HUF/month

Total cost 220,000 HUF / month

e. Administration cost

Administration cost is proposed to be 15 % of the operation costs.

220,000 HUF/month × 0.15 = 33,000 HUF/month

f. Water quality analysis

To examine a removal efficiency, water analysis is necessary. For an adjustment of coagulant injection volume, water analysis of T-P is once in a week, and T-N,COD,SS are once in a month..

Sampling points are inflow and outflow points of the facility.

	Unit Rate(HUF)	Unit	Quantity(/yr.)	Amount(HUF)
Sampling and transportation	1,480		108	159,840
T-P	3,180	sample	108	343,440
T-N	3,180	sample	24	76,320
COD	2,540	sample	24	60,960
SS	2,540	sample	24	60,960

Total cost ≒ 700,000 HUF

g. Total operation costs in a year

Electric, chemicals and sludge dispose costs

Subtotal 40,877 + 39,495 + 42,458 = 122,830 HUF/day

122,830 HUF/day ÷ 40,600 m^3/day = 3.03 HUF/m^3

3,010,106 m^3/year × 3.03 HUF/m^3 = 9,121,000 HUF/year

Operation cost

Operation : 220,000HUF/month × 12months = 2,640,000 HUF/year

Administration: 33,000HUF/month × 12months = 396,000 HUF/year

Subtotal 3,036,000 HUF/year

Water quality analysis 700,000 HUF/year

Total operation cost

9,121,000 + 3,036,000 + 700,000 = 12,857,000 HUF/year

6.4 PROJECT COSTS

(1) Basis of Project Cost Estimate

The project costs consist of the following items.

- Construction cost
- Engineering service cost
- Physical contingency
- Operation and maintenance (O/M) cost

All sites estimated based on the following conditions.

- The estimation is made on the assumption that all construction works will be contracted to general contractors by Hungary.
- Most of costs are expressed under the economic conditions that prevailed in 1998.
- The exchange rates of currencies are as follows.

US $	1.00
Hungarian Forint (HUF)	211.945

Japanese Yen (J.Yen) 132.80

- All these project sites are belonging to governmental authorities, therefore land acquisition costs are neglected.
- Engineering cost is estimated at 5% of the total construction cost, and survey cost.
- Physical contingency is assumed to be 5% of the total construction and engineering service costs.
- Price escalation is not counted.

(2) Total Project Cost

The construction cost is based on the data of unit costs obtained from PMO/VATI, VIZITERV Kft, Várpalota region environmental improvement project, Tapolca town, and other sources.

Project costs are summarized as below.

Total construction cost : 1,247,644,000 HUF

Total operation and maintenance cost : 75,221,000 HUF/year

Breakdown of the project costs by cost item is shown in *Table D.16*, and annual construction costs or operation and maintenance costs of the facilities are given in *Table D.17*.

6.5 IMPLEMENTATION PROGRAM

(1) General

The construction works for Feasibility study consist on earth works, vegetation purification works, retractable gate works, concrete works, mechanical/electrical works for coagulation sedimentation facility, and other miscellaneous works.

Major works are planned to be carried out by mechanical power.

(2) Construction Plan

1) Construction plan

Construction plan of major works is expected as follows.

- Detail design and tendering process
- River purification facility

Reed lake/pond
Retractable gate
Inflow and outflow channels

- Urban runoff purification facility

Coagulant sedimentation facility
Inflow and outflow channels

2) Required construction period

Required construction period for each work is estimated as follows.

- Detail design period and tendering process are 12 months.
- River purification facility (Nyugati-övcsatorna and Keleti-bozot facilities)

Reed lake	15 months
Retractable gate	6 months
Channels and others	3 months

- Urban runoff purification facility (Keszthely urban runoff purification facility)

Earth works	3 months
Coagulant sedimentation facility (including channels)	9 months

Implementation Schedule is shown in *Table D.18.*

6.6 MANAGEMENT OF THE PROJECT

After completion of construction of the facilities, following system is proposed for operation and maintenance.

(1) River Purification Facility

This method use the natural ability of the marsh reed, and mechanical system is only retractable gate.

So ordinary management is proposed as follows.

- Frequency of inspection is once a week by labor (skilled), and inspect a condition of the facility on the site, dispose a trash of screen, etc.

- The retractable gate falls down at a certain floodwater level to lead the floodwater to main course of the river, and protect the purification facility from damages by the floodwater.

- A water level monitoring system is necessary to send a signal of river water level to the office which is responsible for the operation and maintenance of the facility. When river water level exceeds a certain level, a worker has to go to the facility site and close the flush board of inflow and outflow channels.

- When the river water go down less than a certain level, a worker has to get up a retractable (rubber-made) gate by air power and take off the flush board of the inflow and outflow channels.

- It is necessary to cut and dispose reed plant once a year when reeds died, and it is convenient to do the work in winter season.

- To keep the phosphorous removal efficiency of the facility, it is necessary to replace sediment sludge and bottom soil with fresh soil, and plant a reed again at least once in a decade.

- For operation and maintenance, a working yard should be provided around the facility.

- To check the removal efficiency, a water quality monitoring is necessary at least once a month. Parameters to be analyzed are COD,SS, T-P and T-N.

(2) Urban Runoff Purification Facility

This method is a mechanical system and sludge is always generated, therefore manpower is required foe the operation and maintenance everyday.

Manpower necessary for this work is as follows:

- One (1) chief and two (2) workers are required.

- The eligibility of the chief is an engineer and can manage a all of the facility.

- Two (2) workers operate and maintain the mechanical/electrical systems and sludge disposal system..

- To check the phosphorous removal efficiency, water quality monitoring is necessary.

- For an adjustment of coagulant injection volume, T-P should be monitored once a week, and other parameters such as T-N, COD, or SS should be once a month.

Table D.1 Comparative Evaluation of River Water Purification Methods

Method	Settling Reservoir Method	Coagulation Sedimentation Method	Anaerobic - aerobic Activated Sludge Method	Mixure of Coagulant and Activated Sludge Method	Soil Infiltration Method	Crystallization for Phosphorous Removal Method	Vegetation Purification Method
Principle of Purification	Lead river water to the settling reservoir and settle suspended solids by making very slow flow.	Remove phosphorous by chemical sedimentation; Mix a coagulant to river water and settle phosphorus.	Use nature of activated sludge activated sludge; in aerobic condition, activated sludge wants a lot of phosphorous in the cells.	To increase phosphorous removal efficiency, mix a coagulant to the aeration-tanl of activated sludge method.	Infiltrate water through a soil to remove phosphorous by filtration and adsorption function of soil	Use a crystallization of hydro-oxi-apatite,which made from a reaction of phosphoric acid ion, calcium ion, and hydroxid ion.	Run water through reed pond to remove phosphorous by natural purification ability of emergent plants
Design Conditions	It is familiar in Europe as pre-settling reservoir of water purification plant, retention time is over 15 days.	Main system is composed of mixing coagulant pond, churning pond, settling pond, and sterilizer pond.	System is same as the activated sludge method.	System is same as the activated sludge method.	Example in Japan; infiltration velocity 3m/m2/day	Its need a pre-treatment system such as carbonic acid eliminati pond or sand infiltration pond. System is complex.	Example in Japan; water depth 0.1-0.2m velocity 0.5-1.0cm/sec lake length over 100m retention time 4-5hr
Removal Efficiency (%)	max 60 %	70-80%	60 -80%	90%	50%	60-80%	40-50%
Necessary Site Area	Large	Small	Small	Small	Smaller than vegetation purification method. but not so small as chemical method.	Small	Smaller than settling reservoir method. but not so small as chemical method.
Merits and Demerits	Simple system. Little impact to the environme Removal efficiency is lower than a chemical method. Regular removal of sediment sludge is necessary.	High removal efficiency. A lot of sludge is generated. Necessary site area is small.	It is difficult to make a good activated sludge by using river water.	Removal efficiency is high. It is rather difficult to make a good activated sludge by using river water. A lot of sludge is generated.	Efficiency strongly depends on a character of soil. It is necessary to experiment by using a soil around Lake Balaton.	Removal efficiency is not so high like a chemical method. There is no example to river water. Using no chemicals.	Simple system. No environmental impact Removal efficiency is not so high like a chemical method. It is necessary to cut and dispose a reed every year. It is necessary to remove sediment sludge regularly.
Construction Costs	Low	High	High	High	High	High	Low
O/M Costs	Low	High	High	High	Not so high like a chemical method. Almost same as vegetation purification method.	High	Medium
Applicability to Lake Balaton	Applicable because of using no chemicals and simple O/M, though a large site area is necessary.	Applicable because of higher removal efficiency and smaller site area though costs are higher and chemicals are used.	Not applicable because of higher costs and very few example applied to natural water bodies.	Not applicable because of higher costs and very few example applied to natural water bodies.	Probably Applicable But it is necessary to examine the efficiency by using soil around Lake Balaton.	Not applicable because of higher costs and very few example.	Applicable because of some examples around Lake Balaton Environmentally-friendly meth
Evaluation	○	○	×	×	△	×	○

Table D.2 Adaptability Evaluation of Alternatives

Criteria	Settling Reservoir Method	Vegetation Purification Method	Coagulation Sedimentation Method
Applicability to river water	some examples applied to river water in Europe.	some examples in the catchment area of Lake Balaton.	a example applied to river water in Japan.
	○	◎	○
Phosphorous removal efficiency	Max 60%	40～50%	70～80%
	△	△	○
Reliability or stability	not so high due to utilization of of natural purification effect	higher than the settling reservoir method due to utilizing of vegetation-purification effect	high due to controlled dosing of coagiulant
	△	△	○
Environmnetal impact	little impact because no chemicals are used	environmentally-friendly method no use of chemicals	a little impact due to chemicals use
	○	◎	△
Operation and Maintenance	simple, not so often inspection and sludge removal	simple, not so often inspection, but cut and disposal of reeds are necessary every year	Manpower and technique are required for an operation of machine system every day.
	○	○	△
Possibility of land acquisition	necessary a large area, limited available lands	necessary a little large area Wetlands or farmlands are available.	necessary small area In urbanized area, available land is limited and expensive.
	△	○	○

Table D.3 Design Water Flow and Design T-P Load of River Purification Facilities

Catchment Area	KOFE Code	River Name	Average Flow Rate (m^3/sec)	Design Flow (m^3/sec)	Design T-P load (mg/sec)	T-P load to be treated (kg/year)
North	E-1	Cinege patak	0.024	0.017	12.3	286.5
	E-2	Fuzfoi sed	0.018	0.070	4.3	100.4
	E-3	Vorosberenyi sed	0.052	0.370	21.2	476.7
		Lovasi sed	0.014	0.016	6.4	141.6
	E-4	Csopaki sed	0.006	0.007	3.7	89.2
		Aracsi sed	0.008	0.009	4.3	99.1
		Keki patak	0.032	0.170	7.4	161.2
		Szolosi sed	0.086	0.540	39.2	865.3
		Tavi(Aszofoi sed)	0.024	0.020	2.4	55.0
	E-5	Orvenyesi sed	0.056	0.060	4.4	97.7
	E-6	Csorszai patak	0.051	0.045	8.5	195.2
		Horogi sed	0.020	0.016	8.2	184.3
	E-7	Burnot patak	0.198	0.500	22.1	492.5
	E-8	Eger patak	0.156	0.350	23.6	548.8
	E-9	Tapolca patak	0.246	0.240	107.8	2,532.3
	E-10	Ketoles patak	0.018	0.016	7.3	162.8
		Vilagos patak	0.009	0.009	6.6	148.5
		Lesence patak	0.038	0.040	8.6	191.5
		Nemesvital ovarok	0.114	0.300	22.2	489.3
South	D-1	Endredi patak	0.054	0.070	8.7	203.3
	D-2	Koroshegyi sed	0.061	0.110	9.3	205.4
	D-3	Nagymetszes patak	0.188	0.500	95.8	1,954.0
	D-4	Tetves patak	0.171	0.720	84.2	1,817.5
		A-B-Ccsatorna	0.025	0.020	10.6	250.9
	D-5	Forro arok	0.014	0.012	13.1	300.2
		Jamai patak	0.080	0.135	6.6	148.4
	D-6	Keleti-Nyugati-Focsato	0.066	0.130	10.1	208.3
		Keleti bozot	0.482	1.130	836.3	17,447.9
	D-7	Nyugati ovcsatorna	0.428	1.010	643.6	13,222.0
	Pumping Station	Balatonfenyves	0.433	0.850	619.8	13,313.2
		Balatonlelle	0.100	0.263	14.6	423.1
		Ordacsehi	0.161	0.360	19.2	731.8
		Beletelep	0.037	0.230	32.8	219.6

Table D.4 Dimensions of River Purification Facility

KOFE Code	Name of River	Design Flow (m^3/sec)	Reed Pond (B x L)	Retractable Gate (B x H)	Inflow/Outflow Channel (B x H x L)
E-1	Cinege patak	0.017	11 x 150	2 x 0.5	0.3 x 0.3 x 60
E-2	Fuzfoi sed	0.070	44 x 150	2 x 0.5	0.5 x 0.5 x 120
E-3	Vorosberenyi sed	0.370	231 x 15	2 x 0.5	1.1 x 1.1 x 500
	Lovasi sed	0.016	10 x 150	3 x 0.5	0.3 x 0.3 x 60
E-4	Csopaki sed	0.007	4.5 x 150	2 x 0.5	0.2 x 0.2 x 40
	Aracsi sed	0.009	5.7 x 150	2 x 0.5	0.2 x 0.2 x 40
	Keki patak	0.170	107 x 15	3 x 1.0	0.7 x 0.7 x 250
	Szolosi sed	0.540	337 x 15	5 x 1.0	1.3 x 1.3 x 700
	Tavi(Aszofoi sed)	0.020	2.5 x 15	5 x 1.0	0.3 x 0.3 x 60
E-5	Orvenyesi sed	0.060	38 x 150	2 x 0.5	0.5 x 0.5 x 100
E-6	Csorszai patak	0.045	28 x 150	4 x 1.5	0.4 x 0.4 x 80
	Horogi sed	0.016	10 x 150	3 x 1.0	0.3 x 0.3 x 60
E-7	Burnot patak	0.500	312 x 15	2 x 0.5	1.3 x 1.3 x 660
E-8	Eger patak	0.350	219 x 15	5 x 1.0	1.1 x 1.1 x 500
E-9	Tapolca patak	0.240	150 x 15	5 x 1.0	0.8 x 0.8 x 260
E-10	Ketoles patak	0.016	10 x 150	3 x 0.5	0.3 x 0.3 x 60
	Vilagos patak	0.009	5.7 x 150	3 x 0.5	0.2 x 0.2 x 40
	Lesence patak	0.040	25 x 150	5 x 0.5	0.4 x 0.4 x 80
	Nemesvital ovarok	0.300	188 x 15	5 x 0.5	1.0 x 1.0 x 400
D-1	Endredi patak	0.070	44 x 150	5 x 0.5	0.5 x 0.5 x 120
D-2	Koroshegyi sed	0.110	69 x 150	3 x 1.0	0.6 x 0.6 x 170
D-3	Nagymetszes patak	0.500	312 x 15	3 x 1.0	1.3 x 1.3 x 660
D-4	Tetves patak	0.720	450 x 15	2 x 1.6	1.6 x 1.6 x 930
	A-B-Ccsatorna	0.020	2.5 x 15	2 x 0.5	0.3 x 0.3 x 60
D-5	Forro arok	0.012	7.5 x 150	2 x 0.5	0.2 x 0.2 x 40
	Jamai patak	0.135	85 x 150	7 x 1.0	0.7 x 0.7 x 200
D-6	Keleti-Nyugati-Focsato	0.130	82 x 150	3 x 1.0	0.7 x 0.7 x 200
	Keleti bozot	1.130	705 x 15	8 x 2.0	2.0 x 2.0 x 1450
D-7	Nyugati ovcsatorna	1.010	630 x 15	15 x 2.0	1.9 x 1.9 x 1300
Pumping Station	Balatonfenyves	0.850	531 x 15	15 x 2.0	1.7 x 1.7 x 1100
	Balatonlelle	0.263	165 x 15	8 x 2.0	1.0 x 1.0 x 360
	Ordacsehi	0.360	225 x 15	10 x 2.0	1.1 x 1.1 x 480
	Beletelep	0.230	144 x 15	10 x 2.0	0.9 x 0.9 x 320

Table D.5 Implementation Schedule for Comprehensive Plan

KOFE Code	Name of River \ Year	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Survey, Design, Contract Process		- -	- -	- -								
E-1	Cinege patak									▬		
E-2	Fuzfoi sed								▬			
E-3	Vorosberenyi sed			▬								
	Lovasi sed				▬							
E-4	Csopaki sed						▬					
	Aracsi sed					▬						
	Keki patak						▬					
	Szolosi sed					▬						
	Tavi(Aszofoi sed)				▬							
E-5	Orvenyesi sed							▬				
E-6	Csorszai patak						▬					
	Horogi sed							▬				
E-7	Burnot patak							▬				
E-8	Eger patak		▬									
E-9	Tapolca patak		▬									
E-10	Ketoles patak		▬									
	Vilagos patak			▬								
	Lesence patak			▬								
	Nemesvital ovarok			▬								
D-1	Endredi patak									▬		
D-2	Koroshegyi sed									▬		
D-3	Nagymetszes patak				▬							
D-4	Tetves patak						▬					
	A-B-Ccsatorna			▬								
D-5	Forro arok			▬								
	Jamai patak								▬			
D-6	Keleti-Nyugati-Focsatorna		▬									
	Keleti bozot			▬	▬							
	(Pogany volgyiviz)											
D-7	Nyugati ovcsatorna		▬	▬								
Pumping Station	Balatonfenyves							▬	▬			
	Balatonlelle				▬							
	Ordacsehi								▬			
	Beletelep						▬					

Table D.6 Breakdown of Project Cost

(× 1,000 HUF)

KOFE Code	Name of River	Land cquisitio Costs	Construction Costs			Operation Costs (/year)
			L/C portion		F/C portion	
			(1st year)	(2nd year)	(1st year)	
E-1	Cinege patak	1,440	8,484	0	2,550	805
E-2	Fuzfoi sed	4,320	22,306	0	2,550	2,290
E-3	Vorosberenyi sed	19,280	106,062	0	2,550	10,705
	Lovasi sed	1,360	9,358	0	3,400	760
E-4	Csopaki sed	920	5,795	0	2,550	513
	Aracsi sed	1,016	6,283	0	2,550	567
	Keki patak	9,360	58,473	0	8,500	5,125
	Szolosi sed	27,760	169,666	0	11,900	15,475
	Tavi(Aszofoi sed)	1,560	23,174	0	11,900	873
E-5	Orvenyesi sed	3,840	19,781	0	2,550	2,020
E-6	Csorszai patak	3,040	36,876	0	16,835	1,570
	Horogi sed	1,360	17,038	0	8,500	760
E-7	Burnot patak	25,760	144,591	0	2,550	14,350
E-8	Eger patak	18,320	115,264	0	11,900	10,165
E-9	Tapolca patak	12,800	81,729	0	11,900	7,060
E-10	Ketoles patak	1,360	9,358	0	3,400	760
	Vilagos patak	1,016	7,563	0	3,400	567
	Lesence patak	2,800	18,178	0	5,100	1,435
	Nemesvital ovarok	15,840	89,952	0	5,100	8,770
D-1	Endredi patak	4,320	26,146	0	5,100	2,290
D-2	Koroshegyi sed	6,320	42,051	0	8,500	3,415
D-3	Nagymetszes patak	25,760	153,551	0	8,500	14,350
D-4	Tetves patak	36,800	229,390	0	14,144	20,560
	A-B-Ccsatorna	1,560	9,094	0	2,550	873
D-5	Forro arok	1,160	7,015	0	2,550	648
	Jamai patak	7,600	58,885	0	15,023	4,135
D-6	Keleti-Nyugati-Focsator	7,360	47,895	0	8,500	4,000
	Keleti bozot	0	185,581	185,581	24,240	32,035
D-7	Nyugati ovcsatorna	0	168,773	168,773	30,400	28,660
Pumping Station	Balatonfenyves	43,280	142,918	142,918	30,400	24,205
	Balatonlelle	14,000	105,711	0	24,240	7,735
	Ordacsehi	18,800	135,300	0	26,600	10,435
	Beletelep	12,320	98,460	0	26,600	6,790
Subtotal		332,432	2,360,698	497,272	347,032	244,698
Engineering Service Cost		191,698				0
Contingency		186,457				12,235
Totoal Cost		3,915,588				256,933

Table D.7 Construction Costs of Vegetation Purification Facility

KOFE Code	Name of River	Direct Construction Costs (1000 HUF)				
		Reed Pond	Gate and Screen	Retractable Gate	Inflow/Outflo Channel	Total
E-1	Cinege patak	4,472	33	6,390	140	11,034
E-2	Fuzfoi sed	17,886	65	6,390	515	24,856
E-3	Vorosberenyi sed	93,902	195	6,390	8,125	108,612
	Lovasi sed	4,065	33	8,520	140	12,758
E-4	Csopaki sed	1,829	33	6,390	94	8,345
	Aracsi sed	2,317	33	6,390	94	8,833
	Keki patak	43,496	98	21,300	2,080	66,973
	Szolosi sed	136,991	195	29,820	14,560	181,566
	Tavi(Aszofoi sed)	5,081	33	29,820	140	35,074
E-5	Orvenyesi sed	15,447	65	6,390	429	22,331
E-6	Csorszai patak	11,382	65	41,993	270	53,711
	Horogi sed	4,065	33	21,300	140	25,538
E-7	Burnot patak	126,828	195	6,390	13,728	147,141
E-8	Eger patak	89,024	195	29,820	8,125	127,164
E-9	Tapolca patak	60,975	130	29,820	2,704	93,629
E-10	Ketoles patak	4,065	33	8,520	140	12,758
	Vilagos patak	2,317	33	8,520	94	10,963
	Lesence patak	10,163	65	12,780	270	23,278
	Nemesvital ovarok	76,422	130	12,780	5,720	95,052
D-1	Endredi patak	17,886	65	12,780	515	31,246
D-2	Koroshegyi sed	28,049	98	21,300	1,105	50,551
D-3	Nagymetszes patak	126,828	195	21,300	13,728	162,051
D-4	Tetves patak	182,925	260	35,443	24,905	243,534
	A-B-Ccsatorna	5,081	33	6,390	140	11,644
D-5	Forro arok	3,049	33	6,390	94	9,565
	Jamai patak	34,553	98	37,594	1,664	73,908
D-6	Keleti-Nyugati-Focsator	33,333	98	21,300	1,664	56,395
	Keleti bozot	286,583	325	57,600	50,895	395,403
D-7	Nyugati ovcsatorna	256,095	325	68,600	42,926	367,946
Pumping Station	Balatonfenyves	215,852	325	68,600	31,460	316,236
	Balatonlelle	67,073	130	57,600	5,148	129,951
	Ordacsehi	91,463	195	62,442	7,800	161,900
	Beletelep	58,536	130	62,442	3,952	125,060
TOTAL		2,118,028	3,965	839,504	243,506	3,205,002

Table D.8 Construction and Operation/Maintenance Costs by Year

(× 1,000 HUF)

KOFE Code	Name of River	2001			2002			2003			2004			2005			2006			2007			2008			2009			2010			2011			Total Project Cost		
		Construction Cost L/C	Construction Cost F/C	O/M Cost	Construction Cost L/C	Construction Cost F/C	O/M Cost	Construction Cost L/C	Construction Cost F/C	O/M Cost	Construction Cost L/C	Construction Cost F/C	O/M Cost	Construction Cost L/C	Construction Cost F/C	O/M Cost	Construction Cost L/C	Construction Cost F/C	O/M Cost	Construction Cost L/C	Construction Cost F/C	O/M Cost	Construction Cost L/C	Construction Cost F/C	O/M Cost	Construction Cost L/C	Construction Cost F/C	O/M Cost	Construction Cost L/C	Construction Cost F/C	O/M Cost	Construction Cost L/C	Construction Cost F/C	O/M Cost	Construction (L/C portion)	Construction (F/C portion)	O/M (per year)
E-1	Cinege patak																									9,924	2,550				805			805	9,924	2,550	805
E-2	Fuzfoi sed																						26,626	2,550				2,290			2,290			2,290	26,626	2,550	2,290
E-3	Vorosberenyi sed							125,342	2,550				10,705			10,705			10,705			10,705			10,705			10,705			10,705			10,705	125,342	2,550	10,705
	Lovasi sed										10,718	3,400				760			760			760			760			760			760			760	10,718	3,400	760
E-4	Csopaki sed																6,715	2,550				513			513			513			513			513	6,715	2,550	513
	Aracsi sed													7,299	2,550				567			567			567			567			567			567	7,299	2,550	567
	Keki patak																67,833	8,500				5,125			5,125			5,125			5,125			5,125	67,833	8,500	5,125
	Szolosi sed													197,426	11,900				15,475			15,475			15,475			15,475			15,475			15,475	197,426	11,900	15,475
	Tavi(Aszofoi sed)										24,734	11,900				873			873			873			873			873			873			873	24,734	11,900	873
E-5	Orvenyesi sed																			23,621	2,550				2,020			2,020			2,020			2,020	23,621	2,550	2,020
E-6	Csorszai patak																39,916	16,835				1,570			1,570			1,570			1,570			1,570	39,916	16,835	1,570
	Horogi sed																			18,398	8,500				760			760			760			760	18,398	8,500	760
E-7	Burnot patak																			170,351	2,550				14,350			14,350			14,350			14,350	170,351	2,550	14,350
E-8	Eger patak				133,584	11,900				10,165			10,165			10,165			10,165			10,165			10,165			10,165			10,165			10,165	133,584	11,900	10,165
E-9	Tapolca patak				94,529	11,900				7,060			7,060			7,060			7,060			7,060			7,060			7,060			7,060			7,060	94,529	11,900	7,060
E-10	Keteles patak				10,718	3,400				760			760			760			760			760			760			760			760			760	10,718	3,400	760
	Vilagos patak							8,579	3,400				567			567			567			567			567			567			567			567	8,579	3,400	567
	Lesence patak							20,978	5,100				1,435			1,435			1,435			1,435			1,435			1,435			1,435			1,435	20,978	5,100	1,435
	Nemesvital ovarok							105,792	5,100				8,770			8,770			8,770			8,770			8,770			8,770			8,770			8,770	105,792	5,100	8,770
D-1	Endredi patak																									30,466	5,100				2,290			2,290	30,466	5,100	2,290
D-2	Koroshegyi sed																									48,371	8,500				3,415			3,415	48,371	8,500	3,415
D-3	Nagymetszes patak										179,311	8,500				14,350			14,350			14,350			14,350			14,350			14,350			14,350	179,311	8,500	14,350
D-4	Terves patak																266,190	14,144				20,560			20,560			20,560			20,560			20,560	266,190	14,144	20,560
	A-B-Csatorna							10,654	2,550				873			873			873			873			873			873			873			873	10,654	2,550	873
D-5	Forro arok							8,175	2,550				648			648			648			648			648			648			648			648	8,175	2,550	648
	Jamai patak																						66,485	15,023				4,135			4,135			4,135	66,485	15,023	4,135
D-6	Keleti-Nyugati-Focsatorna				55,255	8,500				4,000			4,000			4,000			4,000			4,000			4,000			4,000			4,000			4,000	55,255	8,500	4,000
	Keleti bozot							185,581			185,581	24,240				32,035			32,035			32,035			32,035			32,035			32,035			32,035	371,163	24,240	32,035
D-7	Nyugati ovcsatorna				168,773			168,773	30,400				28,660			28,660			28,660			28,660			28,660			28,660			28,660			28,660	337,546	30,400	28,660
Pumping Station	Balatonfenyves																			186,198			142,918	30,400				24,205			24,205			24,205	329,116	30,400	24,205
	Balatonlelle										119,711	24,240				7,735			7,735			7,735			7,735			7,735			7,735			7,735	119,711	24,240	7,735
	Ordacsehi																						154,100	26,600				10,435			10,435			10,435	154,100	26,600	10,435
	Beletelep																110,780	26,600				6,790			6,790			6,790			6,790			6,790	110,780	26,600	6,790
Sub total		0	0	0	462,858	35,700	0	633,874	51,650	21,985	520,055	72,280	73,642	204,725	14,450	129,394	491,434	68,629	145,436	398,568	13,600	179,993	390,128	74,573	197,123	88,761	16,150	238,188	0	0	244,698	0	0	244,698	3,191,402	347,032	244,698
Engineering service cost (5% of Construction Cost + Survey Cost)		95,665	7,982	0	54,736	4,834	0	23,944	4,536																							0	0		174,346	17,352	0
Contingency (5%)		4,783	399	0	25,880	2,027	0	32,891	2,809	1,099	26,003	3,614	3,682	10,236	723	6,470	24,572	3,431	7,272	19,928	680	9,000	19,506	3,729	9,856	4,438	808	11,909	0		12,235	0	0	12,235	168,237	18,219	12,235
Total		100,448	8,381	0	543,474	42,561	0	690,709	58,995	23,084	546,058	75,894	77,324	214,961	15,173	135,864	516,006	72,060	152,707	418,496	14,280	188,993	409,634	78,302	206,979	93,199	16,958	250,097	0	0	256,933	0	0	256,933	3,532,986	382,603	256,933

Table D.9 Construction Costs of Purification Facility (Reed Pond)

KOFE Code	Name of River	Design Flow (m3/sec)	Dimensions of Purification Facilit B (m)	L (m)	Unit Cost (1000HUF/m2)	Construction Cost (1000HUF)
E-1	Cinege patak	0.017	11	150	2,710	4,472
E-2	Fuzfoi sed	0.07	44	150	2,710	17,886
E-3	Vorosberenyi sed	0.37	231	150	2,710	93,902
	Lovasi sed	0.016	10	150	2,710	4,065
E-4	Csopaki sed	0.007	4.5	150	2,710	1,829
	Aracsi sed	0.009	5.7	150	2,710	2,317
	Keki patak	0.17	107	150	2,710	43,496
	Szolosi sed	0.54	337	150	2,710	136,991
	Tavi(Aszofoi sed)	0.02	12.5	150	2,710	5,081
E-5	Orvenyesi sed	0.06	38	150	2,710	15,447
E-6	Csorszai patak	0.045	28	150	2,710	11,382
	Horogi sed	0.016	10	150	2,710	4,065
E-7	Burnot patak	0.50	312	150	2,710	126,828
E-8	Eger patak	0.35	219	150	2,710	89,024
E-9	Tapolca patak	0.24	150	150	2,710	60,975
E-10	Ketoles patak	0.016	10	150	2,710	4,065
	Vilagos patak	0.009	5.7	150	2,710	2,317
	Lesence patak	0.04	25	150	2,710	10,163
	Nemesvital ovarok	0.30	188	150	2,710	76,422
D-1	Endredi patak	0.07	44	150	2,710	17,886
D-2	Koroshegyi sed	0.11	69	150	2,710	28,049
D-3	Nagymetszes patak	0.50	312	150	2,710	126,828
D-4	Tetves patak	0.72	450	150	2,710	182,925
	A-B-Ccsatorna	0.02	12.5	150	2,710	5,081
D-5	Forro arok	0.012	7.5	150	2,710	3,049
	Jamai patak	0.135	85	150	2,710	34,553
D-6	Keleti-Nyugati-Focsator	0.13	82	150	2,710	33,333
	Keleti bozot	1.13	705	150	2,710	286,583
D-7	Nyugati ovcsatorna	1.01	630	150	2,710	256,095
Pumping Station	Balatonfenyves	0.85	531	150	2,710	215,852
	Balatonlelle	0.263	165	150	2,710	67,073
	Ordacsehi	0.36	225	150	2,710	91,463
	Beletelep	0.23	144	150	2,710	58,536
TOTAL						2,118,028

Table D.10 Construction Costs of Maintenance Gate and Screen

KOFE Code	Name of River	Maintenance Gate and Screen			Unit Cost (1000HUF/piece)		Construction Cost (total)
		Dimensions	Number (piece)				
		L(m)×B(m)	Gate	Screen	Gate	Screen	(1000HUF)
E-1	Cinege patak	0.3×0.3	2	1	13	7	33
E-2	Fuzfoi sed	0.5×0.5	2	1	26	13	65
E-3	Vorosberenyi sed	1.1×1.1	2	1	78	39	195
	Lovasi sed	0.3×0.3	2	1	13	7	33
E-4	Csopaki sed	0.2×0.2	2	1	13	7	33
	Aracsi sed	0.2×0.2	2	1	13	7	33
	Keki patak	0.7×0.7	2	1	39	20	98
	Szolosi sed	1.3×1.3	2	1	78	39	195
	Tavi(Aszofoi sed)	0.3×0.3	2	1	13	7	33
E-5	Orvenyesi sed	0.5×0.5	2	1	26	13	65
E-6	Csorszai patak	0.4×0.4	2	1	26	13	65
	Horogi sed	0.3×0.3	2	1	13	7	33
E-7	Burnot patak	1.3×1.3	2	1	78	39	195
E-8	Eger patak	1.1×1.1	2	1	78	39	195
E-9	Tapolca patak	0.8×0.8	2	1	52	26	130
E-10	Ketoles patak	0.3×0.3	2	1	13	7	33
	Vilagos patak	0.2×0.2	2	1	13	7	33
	Lesence patak	0.4×0.4	2	1	26	13	65
	Nemesvital ovarok	1.0×1.0	2	1	52	26	130
D-1	Endredi patak	0.5×0.5	2	1	26	13	65
D-2	Koroshegyi sed	0.6×0.6	2	1	39	20	98
D-3	Nagymetszes patak	1.3×1.3	2	1	78	39	195
D-4	Tetves patak	1.6×1.6	2	1	104	52	260
	A-B-Ccsatorna	0.3×0.3	2	1	13	7	33
D-5	Forro arok	0.2×0.2	2	1	13	7	33
	Jamai patak	0.7×0.7	2	1	39	20	98
D-6	Keleti-Nyugati-Focsatorna	0.7×0.7	2	1	39	20	98
	Keleti bozot	2.0×2.0	2	1	130	65	325
D-7	Nyugati ovcsatorna	1.9×1.9	2	1	130	65	325
Pumping Station	Balatonfenyves	1.7×1.7	2	1	130	65	325
	Balatonlelle	1.0×1.0	2	1	52	26	130
	Ordacsehi	1.1×1.1	2	1	78	39	195
	Beletelep	0.9×0.9	2	1	52	26	130
TOTAL							3,965

Table D.11 Construction Costs of Retractable Gate

KOFE Code	Name of River	Design Flowrate (m^3/sec)		Dimensions of Gat			Construction Cost		Material Cost	
		Purification Facility (Qd)	Retractable Gate (Qmax)	B (m)	H (m)	A (m^2)	Unit Cost (1000HUF/m^2)	Cost (total) (1000HUF)	Unit Cost (HUF/m^2)	Cost (total) (1000HUF)
E-1	Cinege patak	0.017	0.226	2	0.5	1.5	4,260	6,390	1,700,000	2,550
E-2	Fuzfoi sed	0.07	0.376	2	0.5	1.5	4,260	6,390	1,700,000	2,550
E-3	Vorosberenyi sed	0.37	1.228	2	0.5	1.5	4,260	6,390	1,700,000	2,550
	Lovasi sed	0.016	0.267	3	0.5	2	4,260	8,520	1,700,000	3,400
E-4	Csopaki sed	0.007	0.197	2	0.5	1.5	4,260	6,390	1,700,000	2,550
	Aracsi sed	0.009	0.203	2	0.5	1.5	4,260	6,390	1,700,000	2,550
	Keki patak	0.17	0.754	3	1.0	5	4,260	21,300	1,700,000	8,500
	Szolosi sed	0.54	1.883	5	1.0	7	4,260	29,820	1,700,000	11,900
	Tavi(Aszofoi sed)	0.02	0.406	5	1.0	7	4,260	29,820	1,700,000	11,900
E-5	Orvenyesi sed	0.06	0.348	2	0.5	1.5	4,260	6,390	1,700,000	2,550
E-6	Csorszai patak	0.045	0.497	4	1.5	10.5	3,999	41,993	1,603,312	16,835
	Horogi sed	0.016	0.317	3	1.0	5	4,260	21,300	1,700,000	8,500
E-7	Burnot patak	0.50	1.598	2	0.5	1.5	4,260	6,390	1,700,000	2,550
E-8	Eger patak	0.35	1.343	5	1.0	7	4,260	29,820	1,700,000	11,900
E-9	Tapolca patak	0.24	1.031	5	1.0	7	4,260	29,820	1,700,000	11,900
E-10	Ketoles patak	0.016	0.267	3	0.5	2	4,260	8,520	1,700,000	3,400
	Vilagos patak	0.009	0.248	3	0.5	2	4,260	8,520	1,700,000	3,400
	Lesence patak	0.04	0.424	5	0.5	3	4,260	12,780	1,700,000	5,100
	Nemesvital ovarok	0.30	1.163	5	0.5	3	4,260	12,780	1,700,000	5,100
D-1	Endredi patak	0.07	0.510	5	0.5	3	4,260	12,780	1,700,000	5,100
D-2	Koroshegyi sed	0.11	0.584	3	1.0	5	4,260	21,300	1,700,000	8,500
D-3	Nagymetszes patak	0.50	1.692	3	1.0	5	4,260	21,300	1,700,000	8,500
D-4	Tetves patak	0.72	2.353	2	1.6	8.32	4,260	35,443	1,700,000	14,144
	A-B-Ccsatorna	0.02	0.234	2	0.5	1.5	4,260	6,390	1,700,000	2,550
D-5	Forro arok	0.012	0.212	2	0.5	1.5	4,260	6,390	1,700,000	2,550
	Jamai patak	0.135	0.810	7	1.0	9	4,177	37,594	1,669,236	15,023
D-6	Keleti-Nyugati-Focsatorna	0.13	0.641	3	1.0	5	4,260	21,300	1,700,000	8,500
	Keleti bozot	1.13	3.785	8	2.0	24	2,400	57,600	1,010,000	24,240
D-7	Nyugati ovcsatorna	1.01	3.408	15	2.0	38	1,805	68,600	800,000	30,400
Pumping Station	Balatonfenyves	0.85	2.954	15	2.0	38	1,805	68,600	800,000	30,400
	Balatonlelle	0.263	1.323	8	2.0	24	2,400	57,600	1,010,000	24,240
	Ordacsehi	0.36	1.670	10	2.0	28	2,230	62,442	950,000	26,600
	Beletelep	0.23	1.301	10	2.0	28	2,230	62,442	950,000	26,600
TOTAL								839,504		347,032

Table D.12 Construction Costs of Inflow/Outflow Channels

KOFE Code	Name of River	Dimensions of Channel B (m)	H (m)	L (m)	Unit Cost (1000HUF/m^2	Construction Cost (1000HUF)
E-1	Cinege patak	0.3	0.3	60	2	140
E-2	Fuzfoi sed	0.5	0.5	120	4	515
E-3	Vorosberenyi sed	1.1	1.1	500	16	8,125
	Lovasi sed	0.3	0.3	60	2	140
E-4	Csopaki sed	0.2	0.2	40	2	94
	Aracsi sed	0.2	0.2	40	2	94
	Keki patak	0.7	0.7	250	8	2,080
	Szolosi sed	1.3	1.3	700	21	14,560
	Tavi(Aszofoi sed)	0.3	0.3	60	2	140
E-5	Orvenyesi sed	0.5	0.5	100	4	429
E-6	Csorszai patak	0.4	0.4	80	3	270
	Horogi sed	0.3	0.3	60	2	140
E-7	Burnot patak	1.3	1.3	660	21	13,728
E-8	Eger patak	1.1	1.1	500	16	8,125
E-9	Tapolca patak	0.8	0.8	260	10	2,704
E-10	Ketoles patak	0.3	0.3	60	2	140
	Vilagos patak	0.2	0.2	40	2	94
	Lesence patak	0.4	0.4	80	3	270
	Nemesvital ovarok	1	1	400	14	5,720
D-1	Endredi patak	0.5	0.5	120	4	515
D-2	Koroshegyi sed	0.6	0.6	170	7	1,105
D-3	Nagymetszes patak	1.3	1.3	660	21	13,728
D-4	Tetves patak	1.6	1.6	930	27	24,905
	A-B-Ccsatorna	0.3	0.3	60	2	140
D-5	Forro arok	0.2	0.2	40	2	94
	Jamai patak	0.7	0.7	200	8	1,664
D-6	Keleti-Nyugati-Focsatorna	0.7	0.7	200	8	1,664
	Keleti bozot	2	2	1,450	35	50,895
D-7	Nyugati ovcsatorna	1.9	1.9	1,300	33	42,926
Pumping Station	Balatonfenyves	1.7	1.7	1,100	29	31,460
	Balatonlelle	1	1	360	14	5,148
	Ordacsehi	1.1	1.1	480	16	7,800
	Beletelep	0.9	0.9	320	12	3,952
TOTAL						243,506

Table D.13 Operation and Maintenance (O/M) Costs

KOFE Code	Name of River	Dimensions of Reed Pond		O/M Cost		
				Unit Cost	WQ Monitoring	Total
		B (m)	L (m)	(HUF/year/m^2)	(1000HUF/year)	(1000HUF/year)
E-1	Cinege patak	11	150	300	310	805
E-2	Fuzfoi sed	44	150	300	310	2,290
E-3	Vorosberenyi sed	231	150	300	310	10,705
	Lovasi sed	10	150	300	310	760
E-4	Csopaki sed	4.5	150	300	310	513
	Aracsi sed	5.7	150	300	310	567
	Keki patak	107	150	300	310	5,125
	Szolosi sed	337	150	300	310	15,475
	Tavi(Aszofoi sed)	12.5	150	300	310	873
E-5	Orvenyesi sed	38	150	300	310	2,020
E-6	Csorszai patak	28	150	300	310	1,570
	Horogi sed	10	150	300	310	760
E-7	Burnot patak	312	150	300	310	14,350
E-8	Eger patak	219	150	300	310	10,165
E-9	Tapolca patak	150	150	300	310	7,060
E-10	Ketoles patak	10	150	300	310	760
	Vilagos patak	5.7	150	300	310	567
	Lesence patak	25	150	300	310	1,435
	Nemesvital ovarok	188	150	300	310	8,770
D-1	Endredi patak	44	150	300	310	2,290
D-2	Koroshegyi sed	69	150	300	310	3,415
D-3	Nagymetszes patak	312	150	300	310	14,350
D-4	Tetves patak	450	150	300	310	20,560
	A-B-Ccsatorna	12.5	150	300	310	873
D-5	Forro arok	7.5	150	300	310	648
	Jamai patak	85	150	300	310	4,135
D-6	Keleti-Nyugati-Focsatorna	82	150	300	310	4,000
	Keleti bozot	705	150	300	310	32,035
D-7	Nyugati ovcsatorna	630	150	300	310	28,660
Pumping Station	Balatonfenyves	531	150	300	310	24,205
	Balatonlelle	165	150	300	310	7,735
	Ordacsehi	225	150	300	310	10,435
	Beletelep	144	150	300	310	6,790
TOTAL						244,698

Table D.14 Land Acquisition Costs

KOFE Code	Name of River	Dimensions of Facility Site		Land Price	
		B (m)	L (m)	Unit Cost (HUF/m^2)	Total (1000HUF/year)
E-1	Cinege patak	18	160	500	1,440
E-2	Fuzfoi sed	54	160	500	4,320
E-3	Vorosberenyi sed	241	160	500	19,280
	Lovasi sed	17	160	500	1,360
E-4	Csopaki sed	11.5	160	500	920
	Aracsi sed	12.7	160	500	1,016
	Keki patak	117	160	500	9,360
	Szolosi sed	347	160	500	27,760
	Tavi(Aszofoi sed)	19.5	160	500	1,560
E-5	Orvenyesi sed	48	160	500	3,840
E-6	Csorszai patak	38	160	500	3,040
	Horogi sed	17	160	500	1,360
E-7	Burnot patak	322	160	500	25,760
E-8	Eger patak	229	160	500	18,320
E-9	Tapolca patak	160	160	500	12,800
E-10	Ketoles patak	17	160	500	1,360
	Vilagos patak	12.7	160	500	1,016
	Lesence patak	35	160	500	2,800
	Nemesvital ovarok	198	160	500	15,840
D-1	Endredi patak	54	160	500	4,320
D-2	Koroshegyi sed	79	160	500	6,320
D-3	Nagymetszes patak	322	160	500	25,760
D-4	Tetves patak	460	160	500	36,800
	A-B-Ccsatorna	19.5	160	500	1,560
D-5	Forro arok	14.5	160	500	1,160
	Jamai patak	95	160	500	7,600
D-6	Keleti-Nyugati-Focsatorna	92	160	500	7,360
	Keleti bozot	715	160	0	0
D-7	Nyugati ovcsatorna	640	160	0	0
Pumping Station	Balatonfenyves	541	160	500	43,280
	Balatonlelle	175	160	500	14,000
	Ordacsehi	235	160	500	18,800
	Beletelep	154	160	500	12,320
TOTAL					332,432