ACTIVITIES AND RESULTS

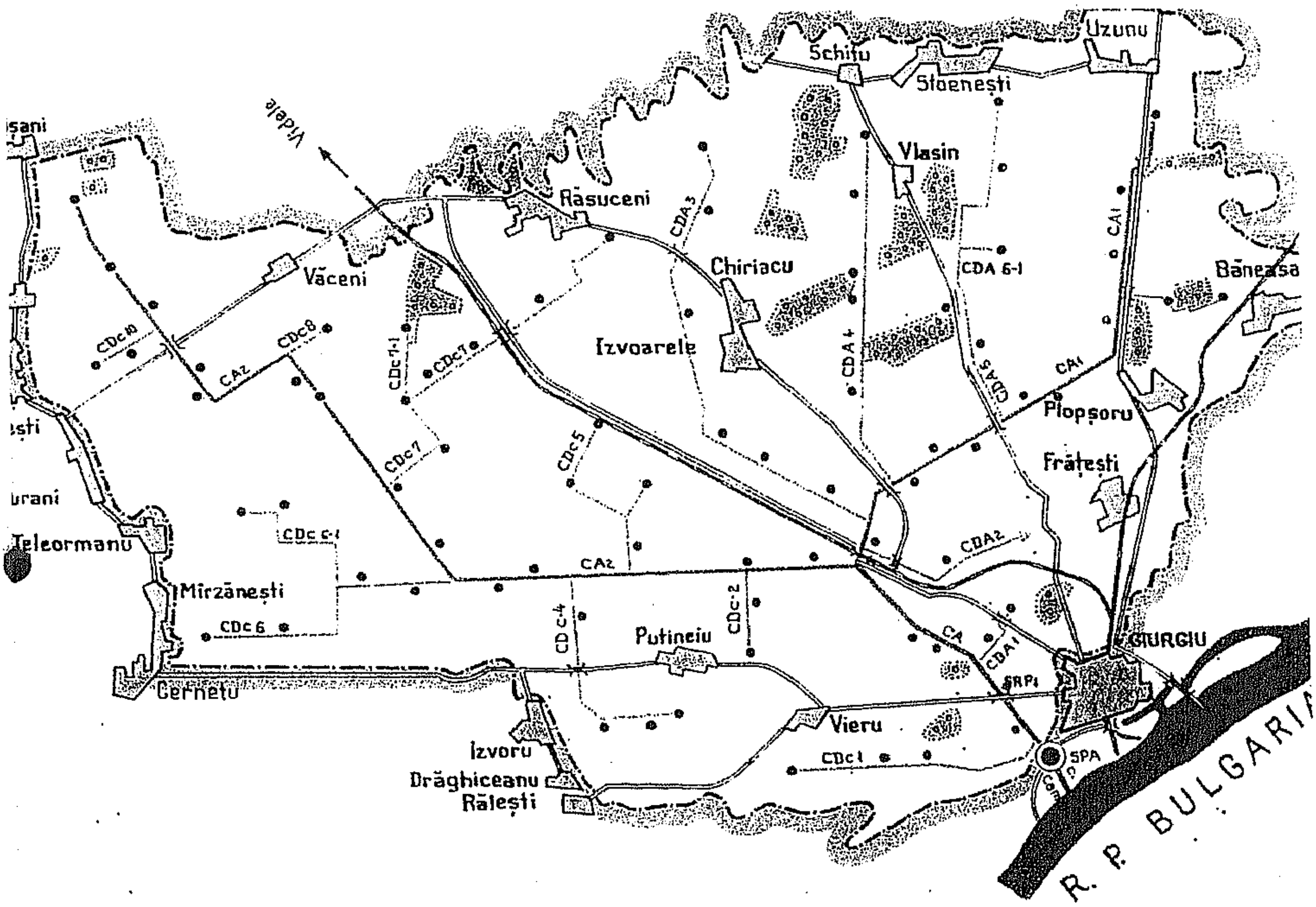
IN THE

IRRIGATION SYSTEM READJUSTMENT PROJECT

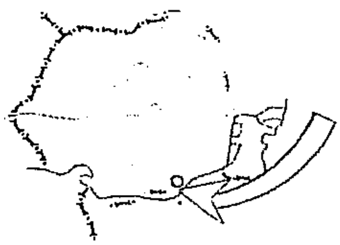
IN ROMANIA

< WATER DELIVERY SYSTEMS >

NOVEMBER 2000



SISTEMUL DE IRIGAȚII GIURGIU-RĂSMIREȘTI (ZONA A + C)
GIURGIU-RĂSMIREȘTI IRRIGATION SYSTEM (ZONE A + C)
LE SYSTÈME D'IRRIGATION GIURGIU RĂSMIREȘTI (A + C ZONE)



LEGENDA, LÉGENDE, LEGEND

Limita sistemului de irigație	Irrigation system limit La limite du système d'irrigati
Canal de aducțiune	Delivery canal Canal d'adduction
Canal de alimentare	Supply canal Canal d'alimentation
Stația de pompare Giurgiu	Giurgiu pumping station Station de pompage Giurgiu
Stație de pompare și repompare	Pumping and repumping stati Station de pompage et repompa
Pod	Bridge Pont
Drum	Road Route

Present problems and the solutions in the Project

The re-pump station (SRP1 GHIZDARU)

Item	Present situation	Problems	Solutions in the Project	Introduced equipment
Pump facilities				
1. Butterfly valves	Butterfly valves do not close in two speeds as designed. The tightening (sealing) in the valve is not good.	Closing in high speed may cause water hammer and cause damages to the valve. Bad sealing cause water losing when the pump is in intermission.	We improved the sealing in the valves, and control devices for closing butterfly valves in two steps of speed, both in extraordinary conditions and when it is necessary to stop pumps.	- Butterfly valves : 4 units - Control devices : 3 units
2. Lubrication water system	Lubrication water for the pump shaft comes from discharge pipe directly.	Soils in the lubrication water are not good for the pump shaft. Pressure and quantity of the lubrication water may not be enough.	We installed lubrication water system with a pressure pump and a cleaner. We installed pressure and flow sensors for lubrication water to monitor them.	- Lubrication water system : 1unit - Pressure sensors - Flow sensors
3. Circuit breakers	Spec: Oil type, 10kV/630A for each motor, 10kV/2500A for main power supply	The oil circuit breakers have low electric and mechanical endurance. The oil has danger of explosion in case of bad starting.	We introduced the vacuum type circuit breakers that has high electric and mechanical endurance, and are safe in operation.	- Circuit breakers (vacuum type) : 1 unit for 1 motor 1 unit for main power supply
4. Synchronizing motor system	Operators adjust the synchronizing motor system manually.	It is difficult to adjust it at all times. Operating the motor out of synchronizing may cause troubles to the motor and higher reactive power consumption.	We introduced the automatic synchronizing motor system, that can always keep the power factor almost cos ϕ=1 (0.9998), and that also has automatic safety functions.	- Synchronizing motor system : 3 units
Pump operation				
1. Operation conditions	The operators measure following operation conditions by watching, and judge it before starting pumps and during operating pumps: - water level of the suction and discharging sump (canal), - oil level in the tank around the shaft of the motor, Following sensors are out of order: - oil temperature sensors in the tank around the shaft of the motor.	It depends on the operators to measure and judge the conditions, therefor it may; - lack correctness from misreading, - take time and hands, - not be timely, especially in sudden troubles, - not be done at all times.	Breakdowns of pump facilities caused by operation mistakes or extraordinary happenings should be prevented to save the maintenance management expenses. Therefore we put following sensors and functions ; 1) Indication of measured values by sensors (as right) 2) Indication of extraordinary conditions 3) Cancellation of starting pumps in extraordinary conditions 4) Stopping pumps in extraordinary conditions	1) Sensors - Water level sensor for the suction and discharging sump (canal) - Oil level sensor for the motor shaft - Oil temperature sensor for the motor shaft - Flow meter for the discharge pipe 2) Local Logical Unit : 1 unit
2. Record of data and Communication with the center office	(same as CAMA)	(same as CAMA)	(same as CAMA)	(same as CAMA)

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Present problems and the solutions in the Project

The pressure pump station (SPPA6)

Item	Present situation	Problems	Solutions in the Project	Introduced equipment
Pump facilities				
1. Pumps	The rotation of the motor is constant. To adjust the quantity of supply water to demand, operators adjust the pressure of discharging water with adjusting the surplus flow through the bypass pipe back to the canal.	It is not possible to adjust the quantity of supply water to demand continuously by adjusting the number of pumps. The surplus flow through the bypass pipe is discharged back to the canal, that results in increasing the cost of water.	To adjust the quantity of supply water to any demand, we installed a frequency converter device to adjust the rotation of motor with a set value of pressure. We installed the adjustable valves with control device on the bypass pipe for small water demand, because the motor has proper minimum rotation.	- Frequency converter device : 1 unit - Circuit breaker : 1 unit - Pressure sensor : 1 uint - Adjustable valve with control device : 2 units - Electric butterfly valve : 1 unit
Pump operation				
1. Operation conditions	The operators measure following operation conditions by watching, and judge it before starting pumps and during operating pumps ; - water level of the suction sump (canal), Following sensors are out of order ; - water level meter of the pressure tank, - water level sensor for the suction sump (canal).	It depends on the operators to measure and judge the conditions, therefor it may; - lack correctness from misreading, - take time and hands, - not be timely, especially in sudden troubles, - not be done at all times.	Breakdowns of pump facilities caused by operation mistakes or extraordinary happenings should be prevented to save the maintenance management expenses. Therefore we put following sensors and functions ; 1) Indication of measured values by sensors (as right) 2) Indication of extraordinary conditions 3) Cancellation of starting pumps in extraordinary conditions 4) Stopping pumps in extraordinary conditions	1) Sensors - Water level sensor for the suction sump (canal) - Water level sensor (pressure sensor) for the pressure tank - Flow meter for the discharge pipe 2) Local Logical Unit : 1 unit
2. Record of data and Communication with the center office	(same as CAMA)	(same as CAMA)	(same as CAMA)	(same as CAMA)

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SPA CAMA

Main Supply Pumping Station

Improvement of Pumps in SPA Cama main supply pumping station

1. The existing "DV2-87 pump"

1-1. Present situations and problems

The existing pumping equipments in SPA Cama station are already in service for about 20-25 years, and it presents the following features now:

1) When the operation at low water level in the suction basin (Cama - Danube River supplying canal) is performed, the following states appear:

- the flow rate has been low (Q=1.5 m3/sec) comparing to the nominal flow rate (Q=3 m3/sec) in some pumps;
- the electric power consumption has increased (active power 650 – 700 kW) comparing to the nominal electric power consumption (500 kW) in some pumps;
- cavitation phenomena with abnormal noise and vibrations, causing the destruction of impeller chamber, impeller blades and bearing etc.

2) Caused by frequent repairing works, a disarrangement of the blade's angle of the pump impeller has appeared, that has resulted in a flow rate decreasing, cavitation phenomena, and high power consumption.

1-2. Technical features and problems

1) Constructive Features and problems

From constructive point of view, the followings are to be mentioned:

- the complete impeller assembly has axial supporting by the motor thrust bearing;
- the rigid coupling can not isolate the effect of shortcomings propagation from the motor to the pump and vice versa;
- the impeller chamber is in the shape of a truncated cone;
- the impeller is dynamically unbalanced.

2) Materials used for manufacturing:

- impeller chamber made of Fc-200 grey cast iron;
- wearing sleeves made of OL 38 ordinary steel;
- impeller unit (blades / hub) made of OX 39 / OT 450 steel;
- shaft made of OL 38 ordinary steel;
- rubber bushing bearing.

2. The introduced "AV 902 pump"

2-1. The introduced solutions and features

The upgrading of DV2-87 pumping units can be done by their transformation into pumping units of AV 902 type, by replacement of some sub-assemblies and components, providing functional parameters reaching performances, same as provided by the best external market offers.

1) General constructive solution:
- self axial supporting;
- cylindrical impeller chamber (provided with wearing sleeve);
- assembled impeller provided with wedged cylindrical shaft;
- sleeve for the shaft protection made of heavy duty materials, with high wearing resistance:
- impeller blades manufactured by duplicate work under high accuracy conditions;
- dynamically balanced impeller;
- robust mechanical constructive type, more reliable than previous constructive types.

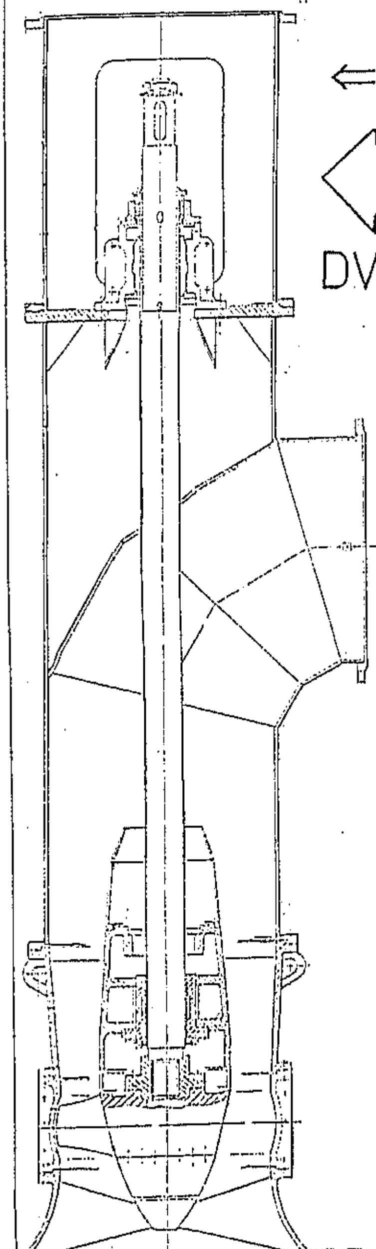
2) Materials used for manufacturing:
- impeller chamber made of Fc200 grey cast iron;
- wearing sleeve made of OX39 steel
- impeller (blades / hub) made of OX39 / OT450 steel;
- shaft wearing sleeves made of 20Cr130 steel;
- shaft made of stainless steel.

2-2. Advantages of the introduced pumps

1) Advantages comparing with the existing constructive type:
- the more reliability of the complete pump-motor assembly (the operation period between two successive repairing interventions is improved, practically it is doubled.);
- flexible coupling between the electric motor and pump, that can isolate the effect of shortcomings propagation from motor to the pump and vice versa;
- simplifies significantly the alignment works of the pump shaft and electric motor;
- the motor axial bearing is not any more subdued to the axial effort, due to both impeller assembly weight and axial hydraulic head, having as result the increment of the driving electric motor ball bearings service time;
- utilization of the shaft wearing sleeves, in the present constructive solution, provides a 3-4 times longer service period than the ordinary constructive solution (sleeves are made of 20Cr130).

Upgrading of DV2-87 pumps into pumping units of AV 902 type

APPLICATION - RAIF Giurgiu
SP Cama Main Supply Pumping Station



⇐**Existing**

DV 2-87

AV 902

Constructive type:
- vertical, axial, immersed

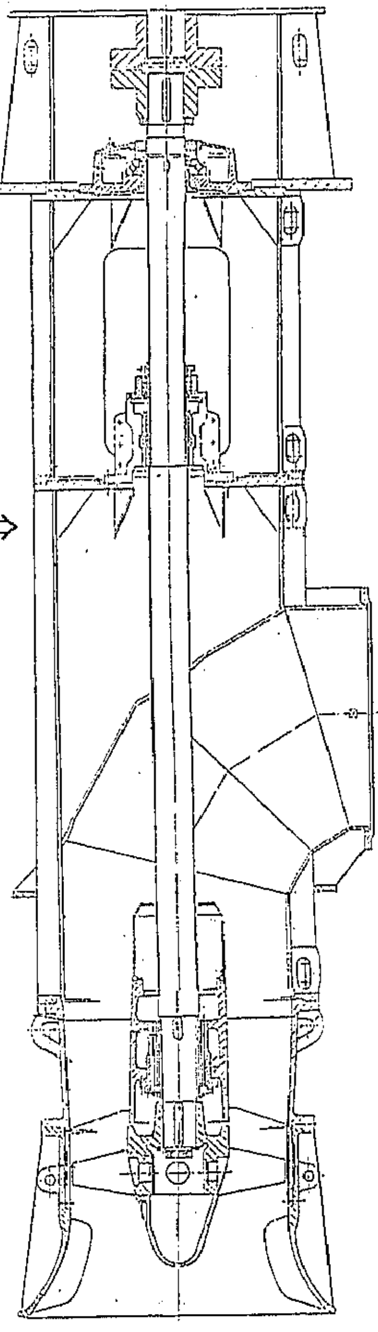
Nominal operating characteristics:
- Q_n=3cu.m./sec.; - H_n=11.5 m.W.C.
- n = 585rpm; - Efficiency=84%

Characteristic operating range:
- Q = 2.7 - 3.5 cu.m./sec.
- H = 7.5 - 13.5 m.W.C.
- Efficiency = 73% - 84%

Made of materials:
- impeller case - Fc200
- wearing sleeve - Ox 39
- impeller - Ox 39 / OT 450
- shaft wearing sleeve - 20 Cr 130

After⇒

Advantages of AV 902 type in comparison with DV 2 - 87:
- increased liability due to the constructive solution and made of materials;
- wedged impeller;
- wearing sleeve in the impeller case;
- shaft wearing sleeve;
- impeller - blades OX 39
  - hub OT 450



Constructive type:
- vertical, axial, immersed

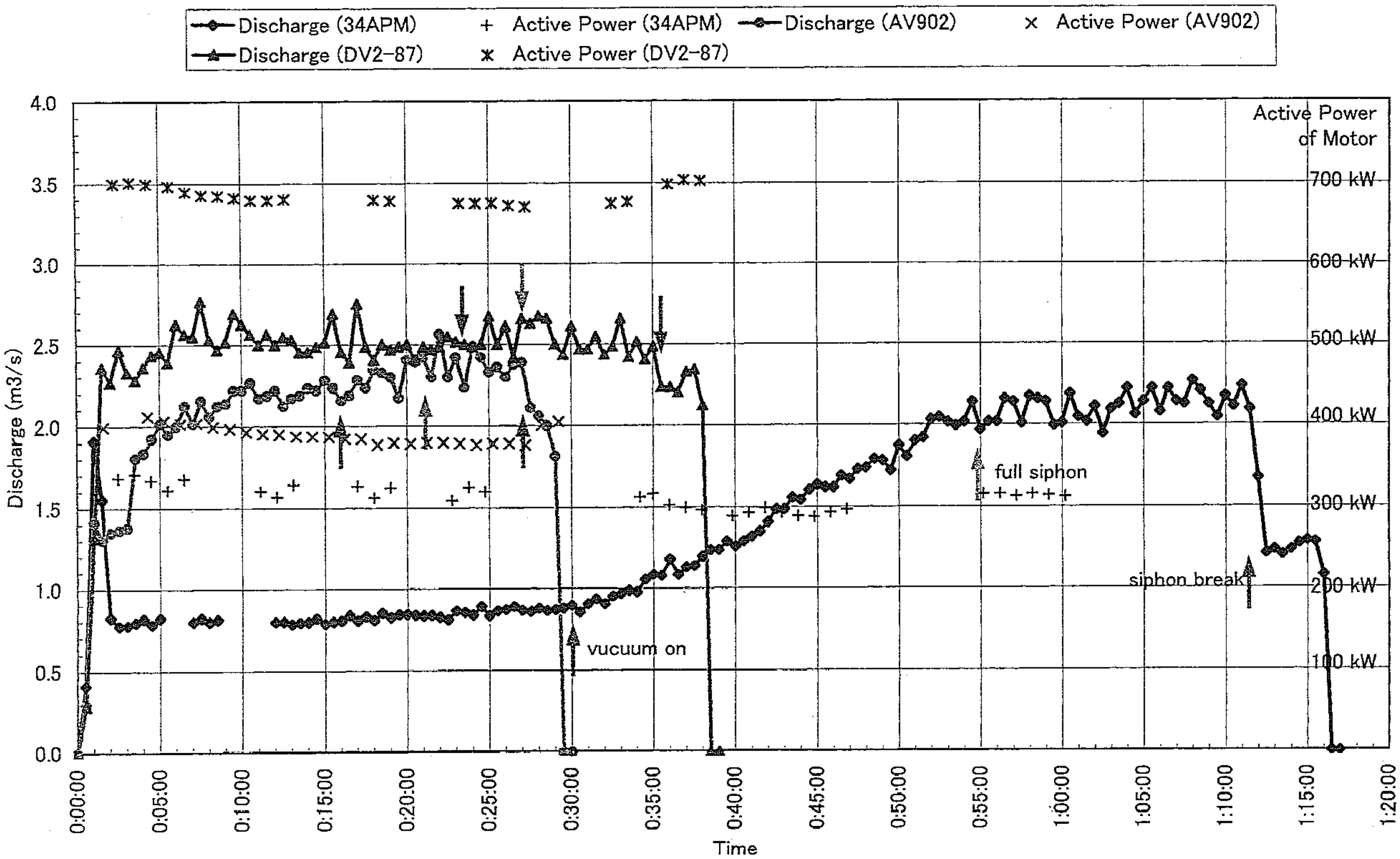
Nominal operating characteristics:
- Q_n = 3 cu.m./sec.
- H_n = 11.5 m.W.C.
- n = 84%

Made of materials:
- impeller case - Fc 200
- impeller - Ox 39 / OT 450

Discharge and Active Power of Motor at SPA CAMA main supply pumping station

Measurement date	Difference of height between the suction canal and the discharge canal	Difference of height between the suction canal and the top of siphon	Condition of siphon	Original pump from 1975 DV2-87		Introduced pump in 1994 34APM		Introduced pump on this project in 1999 AV902	
				Discharge	Active Power	Discharge	Active Power	Discharge	Active Power
	m	m		m3/s	kW	m3/s	kW	m3/s	kW
28-Sep-00	9.22	12.39	Out of siphon	2.23	702	0.80	334	1.81	412
			In full siphon	2.66	672	2.12	315	2.38	379
6-Oct-00	8.30	11.83	Out of siphon	2.16	683	0.85	324	2.17	404
			In full siphon	(2.66)	656	2.05	312	2.92	(379)
Average	8.76	12.11	Out of siphon	2.19	693	0.82	329	1.99	408
			In full siphon	2.66	664	2.08	314	2.65	379

Change of Discharge and Active Power of Motor at SPA CAMA on 28 SEP 2000



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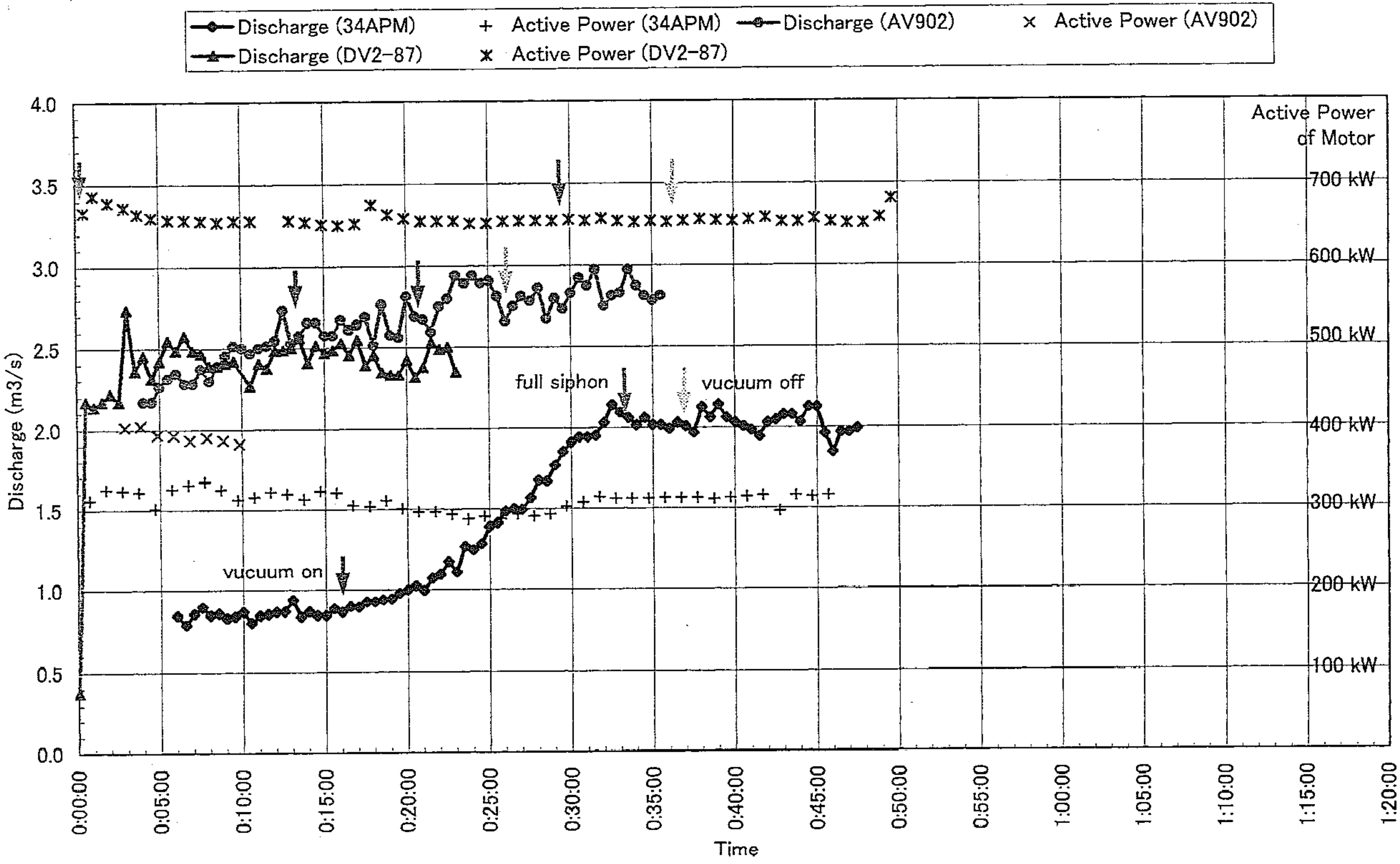
Change of Discharge and Active Power of Motor at SPA CAMA on 6 OCT 2000



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Comparison of Electric Power Consumption between DV2-87 and AV902
at SPA CAMA main supply pumping station

Condition of siphon	Item	Original pump from 1975 DV2-87	Introduced pump in this project in 1999 AV902	Difference (saved power)	Difference (saved charge) (0.055USD/kWh)
Out of siphon	Measured value				
	Discharge	2.19 m3/s	1.99 m3/s		
	Active Power	693 kW	408 kW		
	Electric Power	kWh	kWh	kWh	USD
	for 10,000 m3	880	570	310	17
	for 150,000 m3	13,200	8,500	4,700	260
	for 500,000 m3	43,900	28,500	15,400	850
	for 13,500,000 m3	1,187,000	769,000	418,000	23,000
	for 50,000,000 m3	4,395,000	2,848,000	1,547,000	85,100
In full siphon	Measured value				
	Discharge	2.66 m3/s	2.65 m3/s		
	Active Power	664 kW	379 kW		
	Electric Power	kWh	kWh	kWh	USD
	for 10,000 m3	690	400	290	16
	for 150,000 m3	10,400	6,000	4,400	240
	for 500,000 m3	34,700	19,900	14,800	810
	for 13,500,000 m3	936,000	536,000	400,000	22,000
	for 50,000,000 m3	3,467,000	1,986,000	1,481,000	81,500

[Remark]

150,000m3 : approximate average quantity of irrigation in a day (in 2000)
500,000m3 : approximate average quantity of irrigation in a day (expectancy in the future)

13,500,000m3 : total quantity of irrigation in a year (in 2000)
50,000,000m3 : total quantity of irrigation in a year (expectancy in the future)

Electric energy charge : 1,345Lei/kWh = 0.055USD/kWh (as of October 2000)

Comparison of Electric Power Consumption between 34APM and AV902
at SPA CAMA main supply pumping station

Condition of siphon	Item	Introduced pump in 1994 34APM	Introduced pump in this project in 1999 AV902	Difference (saved power)	Difference (saved charge) (0.055USD/kWh)
Out of siphon	Measured value				
	Discharge	0.82 m3/s	1.99 m3/s		
	Active Power	329 kW	408 kW		
	Electric Power	kWh	kWh	kWh	USD
	for 10,000 m3	1,110	570	540	30
	for 150,000 m3	16,700	8,500	8,200	450
	for 500,000 m3	55,700	28,500	27,200	1,500
	for 13,500,000 m3	1,505,000	769,000	736,000	40,500
	for 50,000,000 m3	5,572,000	2,848,000	2,724,000	149,800
In full siphon	Measured value				
	Discharge	2.08 m3/s	2.65 m3/s		
	Active Power	314 kW	379 kW		
	Electric Power	kWh	kWh	kWh	USD
	for 10,000 m3	420	400	20	1
	for 150,000 m3	6,300	6,000	300	20
	for 500,000 m3	21,000	19,900	1,100	60
	for 13,500,000 m3	566,000	536,000	30,000	1,700
	for 50,000,000 m3	2,097,000	1,986,000	111,000	6,100

[Remark]

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Electric energy charge : 1,345Lei/kWh = 0.055USD/kWh (as of October 2000)

Comparison of Electric Power Consumption between DV2-87 and 34APM
at SPA CAMA main supply pumping station

Condition of siphon	Item	Original pump from 1975 DV2-87	Introduced pump in 1994 34APM	Difference (saved power)	Difference (saved charge) (0.055USD/kWh)
Out of siphon	Measured value				
	Discharge	2.19 m3/s	0.82 m3/s		
	Active Power	693 kW	329 kW		
	Electric Power	kWh	kWh	kWh	USD
	for 10,000 m3	880	1,110	-230	-13
	for 150,000 m3	13,200	16,700	-3,500	-190
	for 500,000 m3	43,900	55,700	-11,800	-650
	for 13,500,000 m3	1,187,000	1,505,000	-318,000	-17,500
	for 50,000,000 m3	4,395,000	5,572,000	-1,177,000	-64,700
In full siphon	Measured value				
	Discharge	2.66 m3/s	2.08 m3/s		
	Active Power	664 kW	314 kW		
	Electric Power	kWh	kWh	kWh	USD
	for 10,000 m3	690	420	270	15
	for 150,000 m3	10,400	6,300	4,100	230
	for 500,000 m3	34,700	21,000	13,700	750
	for 13,500,000 m3	936,000	566,000	370,000	20,400
	for 50,000,000 m3	3,467,000	2,097,000	1,370,000	75,400

[Remark]

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Electric energy charge : 1,345Lei/kWh = 0.055USD/kWh (as of October 2000)

Comparison of Electric Power Consumption between two siphon conditions
at SPA CAMA main supply pumping station

Condition of siphon	Item	Unit	Original pump from 1975 DV2-87	Introduced pump in 1994 34APM	Introduced pump on this project in 1999 AV902
Out of siphon	Measured value				
	Discharge	m3/s	2.19	0.82	1.99
	Active Power	kW	693	329	408
	Electric Power				
	for 10,000 m3	kWh	880	1,110	570
	for 150,000 m3	kWh	13,200	16,700	8,500
	for 500,000 m3	kWh	43,900	55,700	28,500
	for 13,500,000 m3	kWh	1,187,000	1,505,000	769,000
	for 50,000,000 m3	kWh	4,395,000	5,572,000	2,848,000
In full siphon	Measured value				
	Discharge	m3/s	2.66	2.08	2.65
	Active Power	kW	664	314	379
	Electric Power				
	for 10,000 m3	kWh	690	420	400
	for 150,000 m3	kWh	10,400	6,300	6,000
	for 500,000 m3	kWh	34,700	21,000	19,900
	for 13,500,000 m3	kWh	936,000	566,000	536,000
	for 50,000,000 m3	kWh	3,467,000	2,097,000	1,986,000
Difference (saved power) between the two conditions of siphon	Electric Power				
	for 10,000 m3	kWh	190	690	170
	for 150,000 m3	kWh	2,800	10,400	2,500
	for 500,000 m3	kWh	9,200	34,700	8,600
	for 13,500,000 m3	kWh	251,000	939,000	233,000
	for 50,000,000 m3	kWh	928,000	3,475,000	862,000
Difference (saved charge) between the two conditions of siphon (0.055USD/kWh)	Electric energy charge				
	for 10,000 m3	USD	10	38	9
	for 150,000 m3	USD	150	570	140
	for 500,000 m3	USD	510	1,910	470
	for 13,500,000 m3	USD	13,800	51,600	12,800
	for 50,000,000 m3	USD	51,000	191,100	47,400

[Remark]

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50,000,000m3 : total quantity of irrigation in a year (expectancy in the future)

Electric energy charge : 1,345Lei/kWh = 0.055USD/kWh (as of October 2000)

Improvement of Power Circuit-Breakers for Motors

and General Power Circuit-Breakers for Main power supply

in SPA Cama main supply pumping station and SRP1 Ghizdaru re-pumping station

1. The existing "Power circuit-breaker with Oil"

There are Power Circuit-Breakers for Motor to connect each electric motors to the supply power network (General Power Circuit-Breakers), and General Power Circuit-Breakers for Main Power Supply to connect each sections to the supply power network.

[SPA Cama]

- Power Circuit-Breakers (7.2kV / 400A) for Motor (6kV / 500kW)
- General Power Circuit-Breakers (10 kV / 2500A) for Main Power Supply

[SRP1 Ghizdaru]

- Power Circuit-Breakers (10kV / 630A) for Motor (10kV / 5000kW)
- General Power Circuit-Breakers (10 kV / 2500A) for Main Power Supply

1-1. Present situations and problems

- the equipment is already in service for over 25 years (therefore apparatus having an advanced wearing out stage);
- requires overhauling and a more attentive maintenance, and a high number of spare parts, very difficult to be found, for replacing the worn out ones.

(Such a relay switch operating under required parameters has not been manufactured now.)

1-2. Technical features and problems

Such power circuit-breaker has the following technical drawbacks:

- the extinction electric arc environment is the transformer oil (high dielectric characteristics);
- its operation is performed by a complicated mechanism of MRI type, requiring a low voltage (Direct Current) supply source (electric rechargeable batteries), in case of power line shortcoming (for disconnecting);
- frequent disarrangement of the MRI starting mechanism (frequent shutting off);
- danger of explosion in case of bad starting (the electric arch extinction environment is the transformer oil;
- low electric and mechanical endurance (low number (500 cycles) of connecting-breaking cycles under nominal current, and a number of 3 - 6 cycles for shortcoming current (short circuit));

2. The introduced "Power circuit-breaker with Vacuum relay switch"

2-1. Technical features and advantages

1) Technical features:

- the vacuum relay switch is an electric device;
- having the extinction chambers with high vacuum;
- interrupting the overloading electric current up to 8,000 A (the short circuit electric current being limited by medium voltage fuses);
- having high breaking power (FIN 7.2 kV / 160 A) and t = 0.5 – 1 ms.

2) Advantages:

- since it is an electromagnetic relay switch, it does not require a mechanical operating device (but an electromagnetic one), being not required any more a Direct Current supply source (electric rechargeable batteries) for starting in case of power line shortcoming;
- the extinction chamber has a long life (for a 25 years servicing period);
- increased electric and mechanical endurance (30,000 – 1,000,000 connecting-breaking cycles under nominal current, and 100 breakings under shortcoming conditions (short circuit));
- practically, they do not require maintenance works;
- safe disconnecting (circuit breaking) in case of short circuit, caused by burning of the medium voltage fuse;
- it is installed jointly with discharging rods (DRV) for limitation of breaking overload voltage and being equipped with digital electrical protection system;
- operating mechanism is improved (with separating switch for earthing protection);
- decreased size and weight, silent functioning.

Improvement of electric power consumption by the introduced Static Condenser for Motors

(SPA Cama, Ship Nr.4)

Item	Existing Static Condenser	Introduced Static Condenser (2,000USD/unit)	Difference (saved power)	Difference (saved charge) (0.055USD/kWh)
Power factor (cos ϕ)	0.72	0.95		
Active power	400 kW	400 kW		
Apparent power	556 kW	421 kW	135 kW	
Discharge	3.00 m3/s	3.00 m3/s		
Discharge per hour	10,800 m3/hr	10,800 m3/hr		
Electric Power	kWh	kWh	kWh	USD
for 10,000 m3	514	390	125	7
for 150,000 m3	7,716	5,848	1,868	103
for 500,000 m3	25,720	19,493	6,227	342
for 13,500,000 m3	694,444	526,316	168,129	9,247
for 50,000,000 m3	2,572,016	1,949,318	622,699	34,248

[Remark]

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500,000m3 : approximate average quantity of irrigation in a day (expectancy in the future)

13,500,000m3 : total quantity of irrigation in a year (in 2000)
50,000,000m3 : total quantity of irrigation in a year (expectancy in the future)

Electric energy charge : 1,345Lei/kWh = 0.055USD/kWh (as of October 2000)

Improvement of electric power consumption by the introduced Static Condenser for Motors

(SPA Cama, Ship Nr.3)

Item	Existing Static Condenser	Introduced Static Condenser (2,000USD/unit)	Difference (saved power)	Difference (saved charge) (0.055USD/kWh)
Power factor (cos ϕ)	0.85	0.95		
Active power	300 kW	300 kW		
Apparent power	353 kW	316 kW	37 kW	
Discharge	3.00 m3/s	3.00 m3/s		
Discharge per hour	10,800 m3/hr	10,800 m3/hr		
Electric Power	kWh	kWh	kWh	USD
for 10,000 m3	327	292	34	2
for 150,000 m3	4,902	4,386	516	28
for 500,000 m3	16,340	14,620	1,720	95
for 13,500,000 m3	441,176	394,737	46,440	2,554
for 50,000,000 m3	1,633,987	1,461,988	171,999	9,460

[Remark]

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50,000,000m3 : total quantity of irrigation in a year (expectancy in the future)

Electric energy charge : 1,345Lei/kWh = 0.055USD/kWh (as of October 2000)

SRP1 GHIZDARU

Re-Pumping Station

Improvement of Synchronizing motor system

in SRP1 Ghizdaru re-pumping station

1. The existing Synchronizing motor system

1-1. Present situations and problems

- Operators adjust the synchronizing motor system manually to achieve $\cos\phi = 1$, but it is difficult to adjust it just on $\cos\phi = 1$ or to keep it at all times;
(usually $\cos\phi = 0.90 - 0.95$)

- Operating the motor out of synchronizing may cause low power and high current, that results in troubles to the motor and higher electric power consumption.

2. The introduced solutions (Automatic synchronizing motor system)

2-1. Technical features and advantages

- In automatic mode, the electric control unit of this device keeps the motor state in synchronizing, with controlling motor current automatically.
(measured value: $\phi = 0.3 - 1.4$ degree $\rightarrow$ $\cos\phi = 0.99999 - 0.9997$)

- In extraordinary conditions, it sends a command to the Power circuit breaker to cut the supply power, and sends a command to the Butterfly valve controller to release the oil pressure to close the valve, linked with the Local logical unit.

2-2. Effects

- increase of safety
- improvement of electric power consumption (cf. See annex)

Improvement of electric power consumption by the introduced Synchronizing system

Item	Existing Synchronizing system	Introduced Synchronizing system (17,700USD/unit)	Difference (saved power)	Difference (saved charge) (0.055USD/kWh)
Power factor (cos ϕ)	0.95	0.9998		
Active power	5,000 kW	5,000 kW		
Apparent power	5,263 kW	5,001 kW	262 kW	
Discharge	6.00 m3/s	6.00 m3/s		
Discharge per hour	21,600 m3/hr	21,600 m3/hr		
Electric Power	kWh	kWh	kWh	USD
for 10,000 m3	2,437	2,315	121	7
for 150,000 m3	36,550	34,729	1,821	100
for 500,000 m3	121,832	115,764	6,068	334
for 13,500,000 m3	3,289,474	3,125,625	163,849	9,012
for 50,000,000 m3	12,183,236	11,576,389	606,847	33,377

[Remark]

150,000m3 : approximate average quantity of irrigation in a day (in 2000)
500,000m3 : approximate average quantity of irrigation in a day (expectancy in the future)

13,500,000m3 : total quantity of irrigation in a year (in 2000)
50,000,000m3 : total quantity of irrigation in a year (expectancy in the future)

Electric energy charge : 1,345Lei/kWh = 0.055USD/kWh (as of October 2000)

Improvement of Butterfly Valves and Control units

in SRP1 Ghizdaru re-pumping station

1. The existing Butterfly Valve and Control unit

This valve (ND1400mm) is installed on the discharging pipe after the pump (57V-11 type, Q= 6 m3/sec, H= 80 m w.c.) in SRP1 Ghizdaru re-pumping station, for closing-opening of the discharging pipe with counterweight and hydraulic control unit, and has been in service for over 20 years.

1-1. Present situations and problems

a) The tightening (sealing) system

The present tightening (sealing) system, consisted with the rubber gasket on the valve clack (clapper) and the stainless steel ring (mirror) on the pipe (or on valve body), has been damaged by rust, wear and tear, and in addition by the hydraulic control unit out of function.

That results in the following situations:
- when the pumping unit is in intermission, the valve clack should be closed, but the bad tightening (sealing) between the valve body (pipe) and the valve clack results in high water losses during the operation of the other pumping units, because seven pumping units are connected to the same main discharging pipe;

- during pumping unit operation, the valve is open, but the damaged valve clack can not tolerate the vibrations which are brought about by different operating conditions of the pumping unit (pipe filled up with water at starting), and that results in the rubber gasket detachment from the valve clack and worse tightening (sealing).

b) The hydraulic control unit for valve operation

The hydraulic control unit for valve operation has many shortcomings, as follows:
- the hydraulic control unit (cylinder) can not control the speed of closing of the valve in two speeds stages (close fast then slowly) as designed, that may cause water hammer in the discharge pipe and cause damages to the body of valve.
- pipes, valves and other devices of the hydraulic unit have wear and tear.

2. The introduced solutions

2-1. Technical features and advantages

a) The tightening (sealing) system

- replacement of the old tightening system with the new one, which has the high reliable and flexible rubber gasket on the valve body (pipe) and the stainless steel mirror on the clack;
- a gasket position adjustment system is provided, so that the tightening during operation has to be easily remade, as long as the gasket is still usable;
- the valve clack axle is provided with an anticorrosive protection.

b) The hydraulic control unit for valve operation

b-1) The hydraulic control cylinder

- the hydraulic control unit (cylinder) can control the speed of closing of the valve in two speeds stages (close fast then slowly) in order to mitigate the water hammer effect when pumping unit stops;

b-2) The electric devices of hydraulic control unit

- the electric devices of hydraulic control unit can control the angle of the valve, and close the valve automatically in extraordinary conditions, linked with other electric devices (Synchronizing motor system, Local logical unit);

Caluculation of water loss from the Butterfly valve in SRP1 Ghizdaru re-pumping station

Item	Code	Unit	The existing valve	The improved valve 1	2	3	average
[Data]							
Pressure at T1	P1	bar	6.00	6.00	2.55	2.40	
Pressure at T2	P2	bar	0.20	2.55	2.40	2.20	
Water level at T1	h1	m	60.0	60.0	25.5	24.0	
Water level at T1	h2	m	2.0	25.5	24.0	22.0	
Time of start	T1			1:45	13:05	14:00	
Time of finish	T2			13:05	14:00	15:00	
Time interval	T			11:20	0:55	1:00	
Time interval	T	hr	1	11.33	0.92	1.00	
Time interval	T	sec	3,600	40,800	3,300	3,600	
Length of main discharge	L	m	400	400	400	400	
Slope of main discharge pipe	θ	degree	9	9	9	9	
Diameter of main discharge pipe	D	m	3.5	3.5	3.5	3.5	
Area of main discharge pipe	A'	m2	9.62	9.62	9.62	9.62	
Horizontal area of main discharge pipe	A	m2	64.14	64.14	64.14	64.14	
[Calculation]							
Area of water flow from the gap in the valve (7 valves)	C*a	cm2	509.63	19.15	13.24	16.79	16.39
Area of water flow from the gap in the valve (1 valve)	C*a	cm2	72.80	2.74	1.89	2.40	2.34
Coefficient of flow	C		0.6	0.6	0.6	0.6	0.6
Area of gap in the valve (1valve)	a	cm2	121.34	4.56	3.15	4.00	3.90
Diameter of valve	Dv	cm	140	140	140	140	140
Distance of the gap d=a/(π*Dv)	d	mm	2.76	0.10	0.07	0.09	0.09
Loss from the gap (1valve) when the main discharge pipe is full (pumping)	Q	m3/s	0.2497				0.0080
Q=C*a*(2*g*h)^0.5		m3/hr	898.8				28.9

*) Calculate the flow from the gap of the valve as a flow from a orifice.
Q=C*a*(2*g*h), T=2*A/(C*a*(2*g)^0.5)*((h1)^0.5-(h2)^0.5)

Improvement of electric power consumption by the introduced Butterfly Valve (body)

Item	Existing Butterfly valve	Introduced Butterfly valve (5,958USD/unit)	Difference (saved power)	Difference (saved charge) (0.055USD/kWh)
Loss from the gap (1valve) when the main discharge pipe is full (pumping)	0.2497 m3/s	0.0080 m3/s		
	898.8 m3/hr	28.9 m3/hr		
Power of motor	5,000 kW	5,000 kW		
Discharge of pump	6 m3/s	6 m3/s		
Loss of elecric power	208.1 kWh/hr	6.7 kWh/hr		
Loss of Electric Power	kWh	kWh	kWh	USD
for 10,000 m3	96.32	3.10	93	5
for 150,000 m3	1,445	46	1,398	77
for 500,000 m3	4,816	155	4,661	256
for 13,500,000 m3	130,036	4,182	125,853	6,922
for 50,000,000 m3	481,614	15,490	466,123	25,637

[Remark]

150,000m3 : approximate average quantity of irrigation in a day (in 2000)
500,000m3 : approximate average quantity of irrigation in a day (expectancy in the future)

13,500,000m3 : total quantity of irrigation in a year (in 2000)
50,000,000m3 : total quantity of irrigation in a year (expectancy in the future)

Electric energy charge : 1,345Lei/kWh = 0.055USD/kWh (as of October 2000)

SPPA6

Pressure Pumping Station

Improvement of Pump and Motor units (Introduce of Frequency converter)

in SPPA6 pressure pumping station

1. The existing pump and motor units

1-1. Present situations and problems

- The rotation of the motor is constant, therefore it is not possible to adjust the quantity of supply water at the quantity of demand continuously by adjusting the number of pumps.

- To adjust the quantity of supply water to demand, operators adjust the flow through the bypass pipe to avoid high pressure in the discharging pipe. The flow through the bypass pipe is discharged back to the canal uselessly.

2. The introduced solutions (Frequency converter)

2-1. Technical features and advantages

1) The Frequency converter device gets the data of pressure in the pressure tank, and adjusts the frequency and the voltage of electricity to adjust rotation of motor to achieve the set value of pressure.
When the water demand increases or decreases, the pressure in the pressure tank will decrease or increase respectively.
Therefore, to adjust the quantity of supply water to any demand, the Frequency converter can adjust the frequency and the voltage of electricity to adjust rotation of motor.

2) It is no necessary to discharge the useless water from the bypass pipe in vain.
(Except in case of quite small water demand, because the motor has proper minimum rotation. To avoid this case, the adjustable valves with control device were installed on the bypass pipe.)

3) The Frequency converter device will keep the pressure in the pressure tank at the set value of pressure, therefore there are following benefits:
- the pressure in the discharging pipes will be stabilized, so it is good for pouring water;
- the accidents caused by high pressure will be avoided;

Improvement of electric power consumption by the introduced solution (Frequency converter)

(SPPA6)

Item	Existing Pump and Morter units	Introduced solution (Frequency converter) (32,400USD/unit)	Difference (saved power)	Difference (saved charge) (0.055USD/kWh)
All discharge from 1 pump (smaller pump)	0.100 m3/s			
Useless discharge from the bypass pipe (average= Q/2)	0.050 m3/s 180 m3/hr			
Power of motor	110 kW			
Loss of elecric power	55 kWh/hr	0 kWh/hr		
Loss of Electric Power	kWh	kWh	kWh	USD
for 12 hr	660	0	660	36
for 24 hr	1,320	0	1,320	73
for 240 hr	13,200	0	13,200	726
for 480 hr	26,400	0	26,400	1,452
for 960 hr	52,800	0	52,800	2,904
for 1,920 hr	105,600	0	105,600	5,808

[Remark]

240 hr : approximate average hours of irrigation in a month (in 2000)
480 hr : approximate average hours of irrigation in a month (expectancy in the future)

960 hr : total hours of irrigation in a year (in 2000)
1,920 hr : total hours of irrigation in a year (expectancy in the future)

Electric energy charge : 1,345Lei/kWh = 0.055USD/kWh (as of October 2000)

The Management Way for Operating

SPA CAMA

The management way for operating SPA CAMA

1. The existing management way for operating SPA CAMA

1) The control staff in the Giurgiu branch center office gathers data of the water level in CA at SRP1 GHIZDARU by asking the operator through radio voice communications.

2) If the water level in CA at SRP1 GHIZDARU is near the minimum height for water level management, EL=18.80m, that is hydrodynamic water level at SRP1 GHIZDARU at the maximum flow, and if it is necessary to start SRP1 GHIZDARU soon, or if SRP1 GHIZDARU has been already started, the control staff orders the operator in SPA CAMA to start several pumps.

3) The control staff decides the number of pumps to be started according to the number of pumps to be started at SRP1 GHIZDARU and the water level in CA, and orders to start.

4) Several hours later the control staff asks the water level in CA at SRP1 GHIZDARU again to decide to keep or change the number of running pumps.

*) Two or three pumps at SPA CAMA (2.0 – 3.0 m3/s per a pump) should be usually running when one pump is running at SRP1 GHIZDARU (6.0m3/s per a pump).

2. Problems on the existing management way for operating SPA CAMA

1) Communications for operation are done through radio voice communications.
Therefore the control staff in the center office sometimes can not know the necessary data timely when operators in each pumping station are not near the radio voice communication device.

2) The data through radio voice communications are sometimes not exact because of misreadings from the gauges or miscommunications.

3) The decision about the time and the number of pumps for operation by the control staff is sometimes rough, because the discharges of SPA CAMA and SRP1 GHIZDARU that he used are approximate values.

3. The improved management way for operating SPA CAMA

1) Basically the improved management way is same as the existing one, but the necessary data are measured exactly by devices, and sent to the center office timely by data transmission system through new owned radio wave 149.6875MHz or GSM telephone networks.

2) The decision about the time and the number of pumps for operation is done more exactly with using computer analysis as follows.

3) This improved management way and the computer analysis can be applied for the management for operating SRP1 GHIZDARU with CA1 and CA2.

4. Effects of the improved management way

1) We can reduce the running time of pumps as much as possible to save electric consumption.

2) We can reduce the frequency of starting pumps as much as possible to save electric consumption.
It is better to reduce the frequency of starting pumps, because the motor needs much electric consumption for starting, and it takes time after starting pump to make the discharge pipe as a siphon. The condition out of a siphon takes much electric power and makes the discharge less.

3) We can properly keep the water level lower as much as possible, therefore the loss of water by filtration to the ground should be reduced.

The computer analysis for the management for operating SPA CAMA

[Step 1] Calculate the balance of water flow in CA

1) Collect the plan of discharge at each pressure pumping station.

2) Set the number of pump at SRP1 GHIZDARU. (approx. 6.09m3/s per a pump)

3) Calculate the balance of water flow in CA with using above data in two cases, that are a minus balance case and a plus balance case according to the discharge at SPA CAMA.

*) The supply from SPA CAMA should be calculated according to the type of pump and the water levels at the suction canal and the discharge canal.

*) The discharge from SRP1 GHIZDARU should be verified with the flow meter.

*) The loss of water by filtration to the ground and evaporation to the air should be added for more exact analysis.

[Step 2] Calculate the first state in CA

1) Calculate the water level as steady flow with using the water level at SRP1 GHIZDARU and the flows calculated in the above Step 1.

2) Calculate the average width of surface of water in CA and total volume of water in CA by this steady flow calculation.

*) Actually the flow should be unsteady flow, and the water level should change according to the time and the point, but it is enough to use this method to calculate the average state (depth, width of water surface and volume) of CA.

*) The water level around the middle point in CA can be almost no changed in the beginning of flow because the water is supplied to CA at SPA CAMA and discharged from CA at SRP1 GHIZDARU. Therefore the calculation can be started from the middle point of CA (L= 6 km) with setting the same water level as the first water level at SRP1 GHIZDARU.

[Step 3] Calculate the water level at SRP1 GHIZDARU from now

and select the number of pumps in SPA CAMA

1) The minus balance flow causes decrease of water level from the first state in CA calculated in Step 2, and also the plus balance flow causes increase.

2) The average change rate of water level should be linear.

3) The number of pumps in SPA CAMA should be selected from this calculation.
(In this example "2 pumps" should be selected.)

*) Actually the flow should be unsteady flow, and the water level should change according to the time, but the average water level at each points should be change linearly soon (cf. see actual measured data).

[Step 4] Calculate the water levels of later by new actual data

and make a plan to change the operation

1) The water level near SRP1 GHIZDARU will change like a wave in the beginning of starting pumps, therefore it is difficult in the beginning to make sure that the water level increase or decrease.

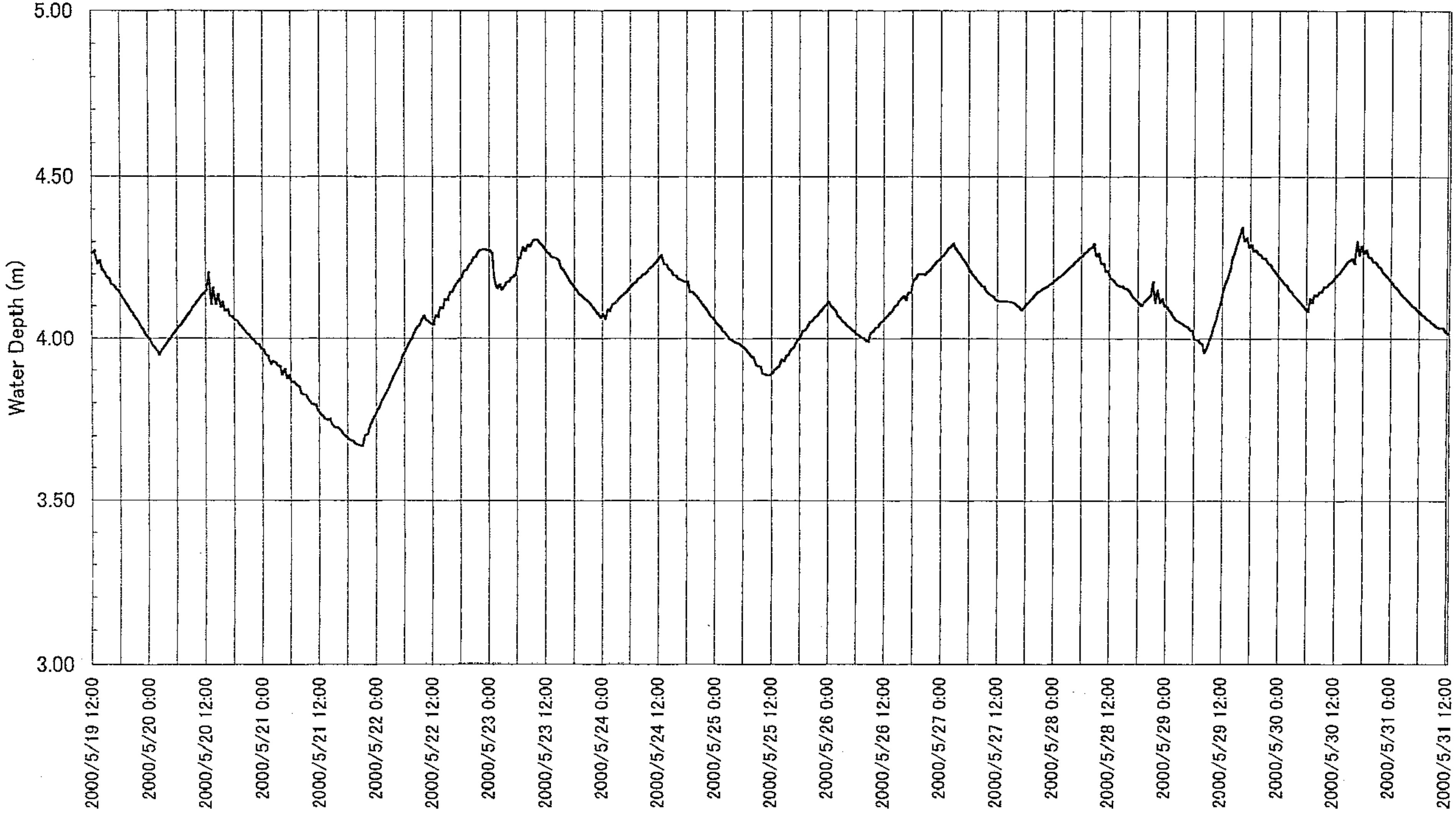
2) With some new exact data measured by water level sensor in the beginning of starting pumps, it is possible to calculate the water levels of later.

3) It has enough accuracy to use the data during 2:30 hr after starting pumps in this example.

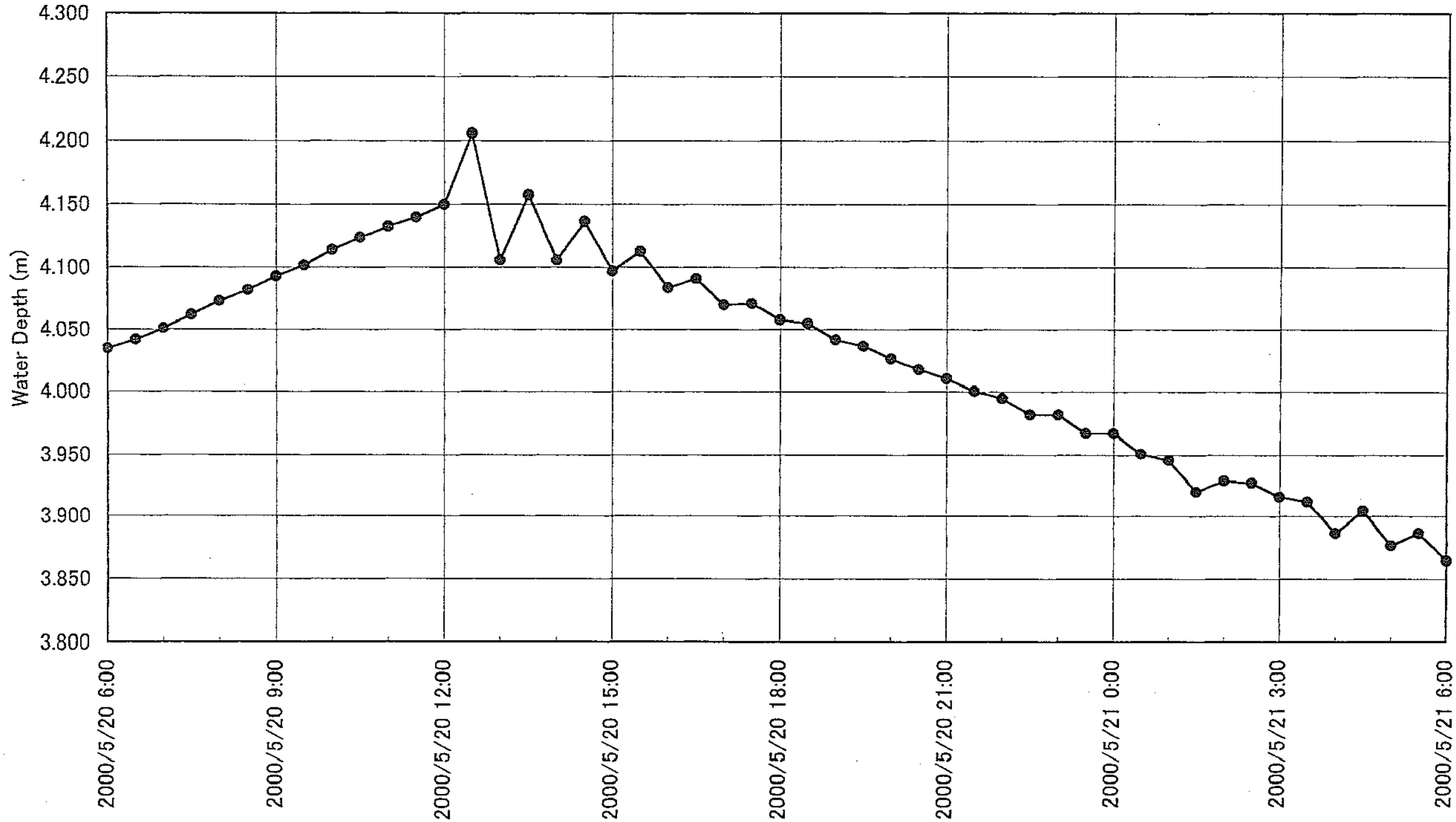
4) Make a plan to change the operation with using this analysis again if necessary.

*) You should use the same number of higher data and lower data to make the accuracy higher. (In the example 3 higher data and 3 lower data were used.)

Change of Water Depth in Canal CA at SRP1 Ghizdaru



Change of Water Depth in Canal CA at SRP1 GHIZDARU



Balance of water flow in CA

point	flow in	supply	demand	flow out (balance)	total pump up from canal
	m3/s	m3/s	m3/s	m3/s	m3/s

[Case 1]　2 pumps running at SPA CAMA

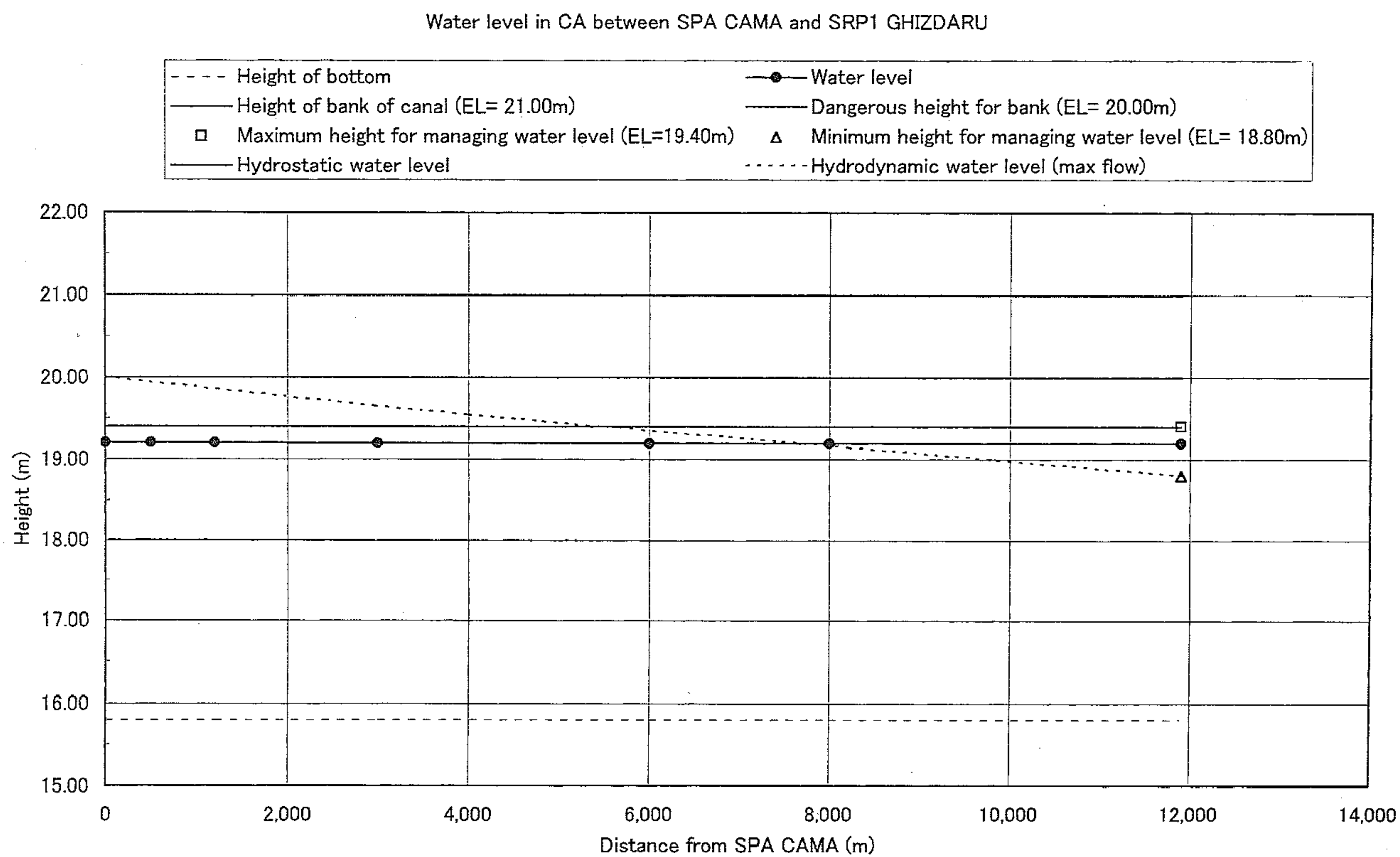
point	flow in	supply	demand	flow out (balance)	total pump up from canal
SPA CAMA	0.00	6.00	0.00	6.00	0.00
Branch 1	6.00		0.27	5.74	0.27
Pump 1	5.74		0.17	5.57	0.17
Pump 2	5.57		0.17	5.40	0.17
Branch 2	5.40		0.27	5.13	0.27
Pump 3	5.13		0.17	4.96	0.17
SRP1 GHIZDARU	4.96		6.00	−1.04	0.00

Balance of flow at the end of canal (SRP1 GHIZDARU)　−1.04 m3/s

[Case 2]　3 pumps running at SPA CAMA

point	flow in	supply	demand	flow out (balance)	total pump up from canal
SPA CAMA	0.00	9.00	0.00	9.00	0.00
Branch 1	9.00		0.27	8.74	0.27
Pump 1	8.74		0.17	8.57	0.17
Pump 2	8.57		0.17	8.40	0.17
Branch 2	8.40		0.27	8.13	0.27
Pump 3	8.13		0.17	7.96	0.17
SRP1 GHIZDARU	7.96		6.00	1.96	0.00

Balance of flow at the end of canal (SRP1 GHIZDARU)　1.96 m3/s


Water level in CA between SPA CAMA and SRP1 GHIZDARU
Height of bottom
Water level
Height of bank of canal (EL= 21.00m)
Dangerous height for bank (EL= 20.00m)
Maximum height for managing water level (EL=19.40m)
Minimum height for managing water level (EL= 18.80m)
Hydrostatic water level
Hydrodynamic water level (max flow)
Height (m)
22.00
21.00
20.00
19.00
18.00
17.00
16.00
15.00
0
2,000
4,000
6,000
8,000
10,000
12,000
14,000
Distance from SPA CAMA (m)

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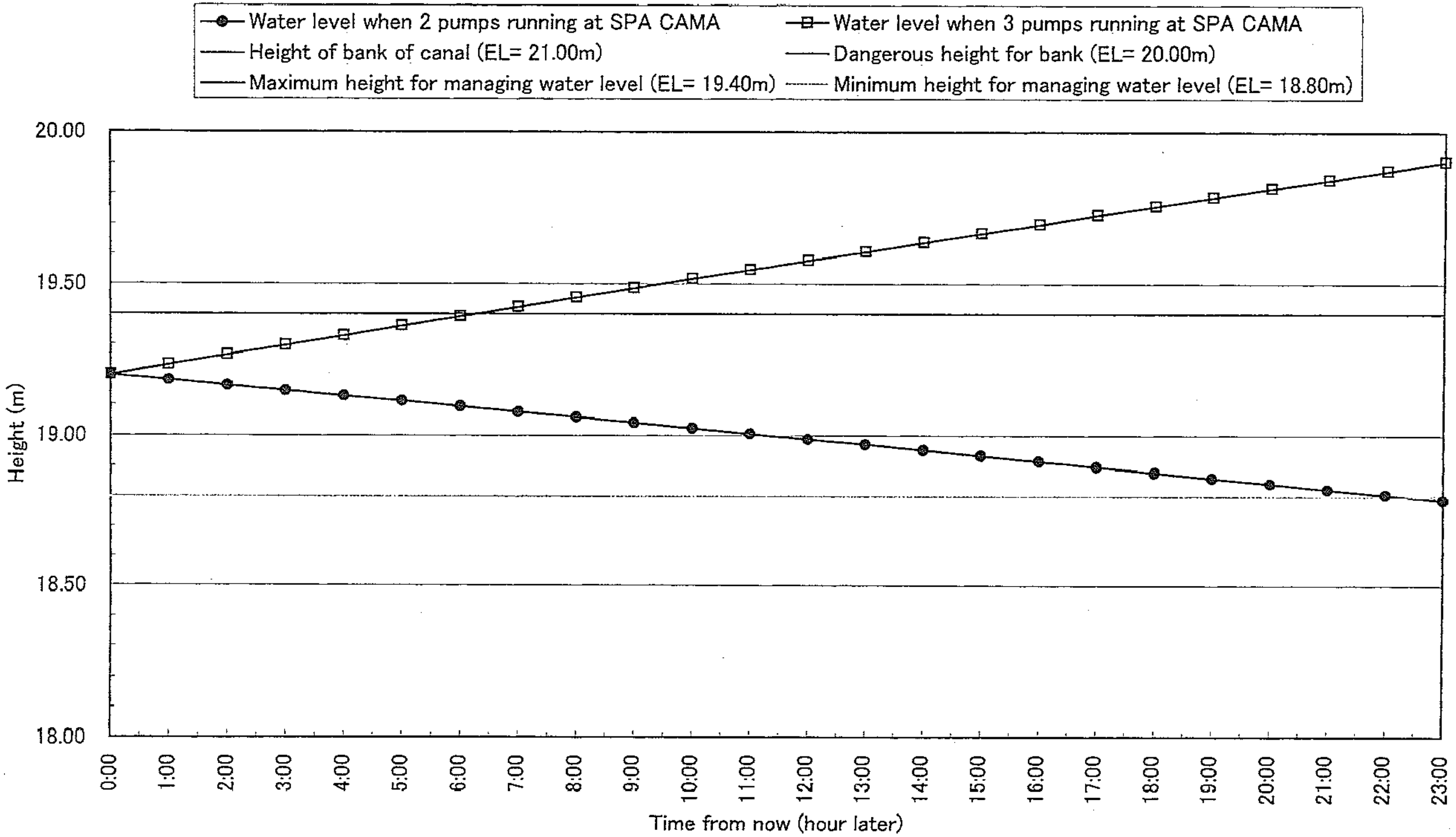
Calculation of the first state of water in CA between SPA CAMA and SRP1 GHIZDARU

point	distance from the beginning	distance between the two points	flow	1 : i (bottom)	Height of bottom	difference of height between the two points	width of bottom	1:m (slope)	n	depth of water	Water level
	m	m	m3/s		m	m	m			m	m
SPA CAMA	0			1,000,000,000	15.8000		8.000	1.5	0.020	3.4009	19.2009
Branch 1	500	500	6.00	1,000,000,000	15.8000	0.0000	8.000	1.5	0.020	3.4008	19.2008
Pump 1	1,200	700	5.74	1,000,000,000	15.8000	0.0000	8.000	1.5	0.020	3.4007	19.2007
Pump 2	3,000	1,800	5.57	1,000,000,000	15.8000	0.0000	8.000	1.5	0.020	3.4005	19.2005
Branch 2	6,000	4,800	5.40	1,000,000,000	15.8000	0.0000	8.000	1.5	0.020	3.4000	19.2000
Branch 2	6,000	2,000	5.13	1,000,000,000	15.8000	0.0000	8.000	1.5	0.020	3.4000	19.2000
Pump 3	8,000	3,900	4.96	1,000,000,000	15.8000	0.0000	8.000	1.5	0.020	3.3998	19.1998
SRP1 GHIZDARU	11,900			1,000,000,000	15.8000	0.0000	8.000	1.5	0.020	3.3995	19.1995

point	distance from the beginning	distance between the two points	difference of height of water surface	1 : i (water surface)	width of water surface	area	velocity	R	velocity (confirming)	flow (confirming)	volume in this section
	m	m	m		m	m2	m/s	m	m/s	m3/s	m3
SPA CAMA	0				18.203	44.556		20.262			
Branch 1	500	500	0.0001	7,614,751	18.202	44.554	0.135	20.262	0.135	6.00	22,277
Pump 1	1,200	700	0.0001	8,333,995	18.202	44.553	0.129	20.261	0.129	5.74	31,187
Pump 2	3,000	1,800	0.0002	8,849,066	18.202	44.549	0.125	20.261	0.125	5.57	80,189
Branch 2	6,000	4,800	0.0005	9,410,469	18.200	44.540	0.121	20.259	0.121	5.40	213,792
Branch 2	6,000	2,000	0.0002	10,407,812	18.200	44.540	0.115	20.259	0.115	5.13	89,080
Pump 3	8,000	3,900	0.0004	11,131,267	18.199	44.537	0.111	20.258	0.111	4.96	173,693
SRP1 GHIZDARU	11,900				18.198	44.530		20.257			
					average 18.201						total 610,218

Calculation of water level at SRP1 GHIZDARU from now



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Calculation of water level in CA at SRP1 GHIZDARU from now

(Case 1)

hours later	time	additional volume	additional volume from now	additional area from now (average)	additional depth from now (average)	Water level at SRP1 GHIZDARU	total volume in CA
		m3	m3	m2	m	m	m3
0:00	15:00					19.199	610,218
1:00	16:00	−3,744	−3,744	−0.315	−0.017	19.182	606,474
2:00	17:00	−3,744	−7,488	−0.629	−0.035	19.165	602,730
3:00	18:00	−3,744	−11,232	−0.944	−0.052	19.147	598,986
4:00	19:00	−3,744	−14,976	−1.258	−0.070	19.130	595,242
5:00	20:00	−3,744	−18,720	−1.573	−0.087	19.112	591,498
6:00	21:00	−3,744	−22,464	−1.888	−0.105	19.095	587,754
7:00	22:00	−3,744	−26,208	−2.202	−0.122	19.077	584,010
8:00	23:00	−3,744	−29,952	−2.517	−0.140	19.060	580,266
9:00	0:00	−3,744	−33,696	−2.832	−0.158	19.042	576,522
10:00	1:00	−3,744	−37,440	−3.146	−0.175	19.024	572,778
11:00	2:00	−3,744	−41,184	−3.461	−0.193	19.006	569,034
12:00	3:00	−3,744	−44,928	−3.775	−0.211	18.988	565,290
13:00	4:00	−3,744	−48,672	−4.090	−0.229	18.970	561,546
14:00	5:00	−3,744	−52,416	−4.405	−0.247	18.952	557,802
15:00	6:00	−3,744	−56,160	−4.719	−0.265	18.934	554,058
16:00	7:00	−3,744	−59,904	−5.034	−0.283	18.916	550,314
17:00	8:00	−3,744	−63,648	−5.349	−0.301	18.898	546,570
18:00	9:00	−3,744	−67,392	−5.663	−0.320	18.880	542,826
19:00	10:00	−3,744	−71,136	−5.978	−0.338	18.862	539,082
20:00	11:00	−3,744	−74,880	−6.292	−0.356	18.843	535,338
21:00	12:00	−3,744	−78,624	−6.607	−0.375	18.825	531,594
22:00	13:00	−3,744	−82,368	−6.922	−0.393	18.806	527,850
23:00	14:00	−3,744	−86,112	−7.236	−0.412	18.788	524,106

Case: Water level when 2 pumps running at SPA CAMA	
Water flow balance at SRP1 GHIZDARU	−1.04 m3/s
Water level in CA at SRP1 GHIZDARU now	19.199 m
Total volume in CA now	610,218 m3
Average of width of water surface now	18.201 m
Length of canal CA	11,900 m
Slope of canal (1: m)	1.5
Time of now	15:00

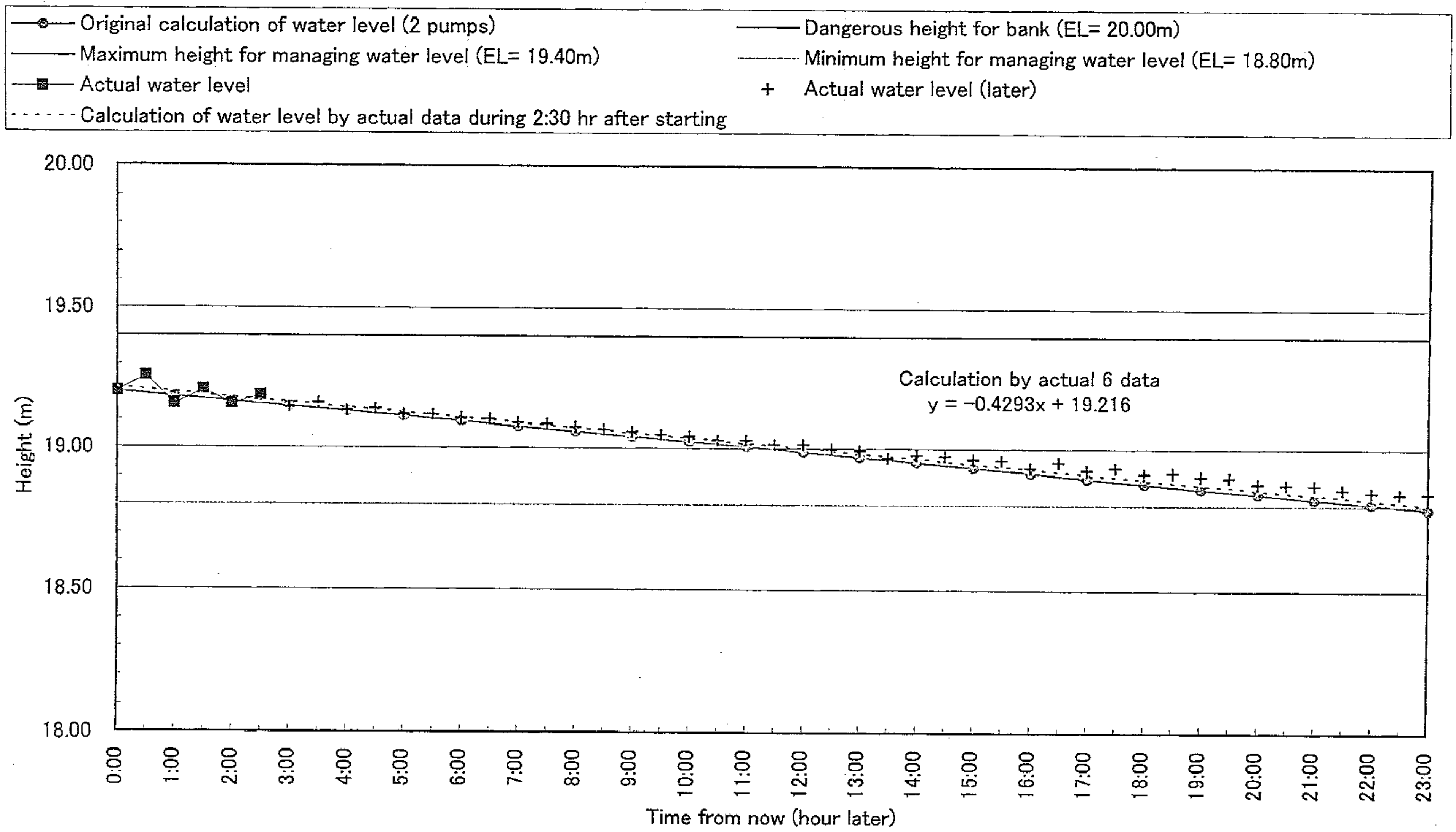
Calculation of water level in CA at SRP1 GHIZDARU from now

(Case 2)

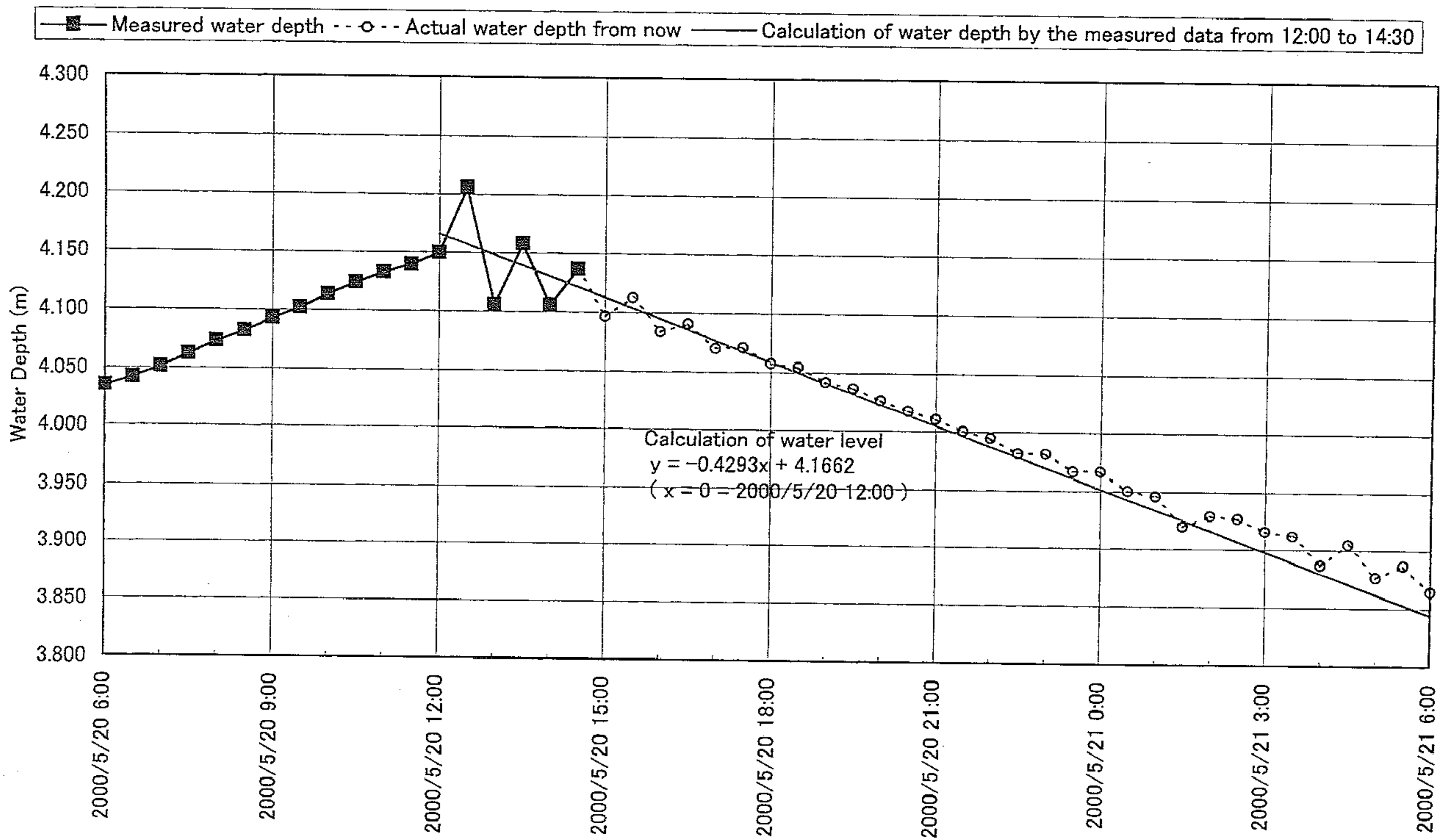
hours later	time	additional volume	additional volume from now	additional area from now (average)	additional depth from now (average)	Water level at SRP1 GHIZDARU	total volume in CA
1:00							
		m3	m3	m2	m	m	m3
0:00	15:00					19.199	610,218
1:00	16:00	7,056	7,056	0.593	0.032	19.232	617,274
2:00	17:00	7,056	14,112	1.186	0.065	19.264	624,330
3:00	18:00	7,056	21,168	1.779	0.097	19.296	631,386
4:00	19:00	7,056	28,224	2.372	0.129	19.328	638,442
5:00	20:00	7,056	35,280	2.965	0.161	19.360	645,498
6:00	21:00	7,056	42,336	3.558	0.192	19.392	652,554
7:00	22:00	7,056	49,392	4.151	0.224	19.423	659,610
8:00	23:00	7,056	56,448	4.744	0.255	19.455	666,666
9:00	0:00	7,056	63,504	5.336	0.286	19.486	673,722
10:00	1:00	7,056	70,560	5.929	0.317	19.517	680,778
11:00	2:00	7,056	77,616	6.522	0.348	19.548	687,834
12:00	3:00	7,056	84,672	7.115	0.379	19.579	694,890
13:00	4:00	7,056	91,728	7.708	0.410	19.609	701,946
14:00	5:00	7,056	98,784	8.301	0.440	19.640	709,002
15:00	6:00	7,056	105,840	8.894	0.470	19.670	716,058
16:00	7:00	7,056	112,896	9.487	0.501	19.700	723,114
17:00	8:00	7,056	119,952	10.080	0.531	19.730	730,170
18:00	9:00	7,056	127,008	10.673	0.561	19.760	737,226
19:00	10:00	7,056	134,064	11.266	0.590	19.790	744,282
20:00	11:00	7,056	141,120	11.859	0.620	19.819	751,338
21:00	12:00	7,056	148,176	12.452	0.649	19.849	758,394
22:00	13:00	7,056	155,232	13.045	0.679	19.878	765,450
23:00	14:00	7,056	162,288	13.638	0.708	19.907	772,506

Case: Water level when 3 pumps running at SPA CAMA		
Water flow balance at SRP1 GHIZDARU	1.96	m3/s
Water level in CA at SRP1 GHIZDARU now	19.199	m
Total volume in CA now	610,218	m3
Average of width of water surface now	18.201	m
Length of canal CA	11,900	m
Slope of canal (1: m)	1.5	
Time of now	15:00	

Calculation of water level at SRP1 GHIZDARU by actual data in the beginning of starting pumps



Calculation of Water Depth in CA at SRP1 GHIZDARU in the begining of starting pumps



Canals

Present situations and problems on canals and solutions

1. Present situation

1-1. Landform and geology

1-1-1. Landform

From the geomorphological point of view, the system area is divided into two distinct units:

– the Danube lower terrace, located in the Southern part of the area; it has a width of 8 km and presents a N-S slope ; the ground levels vary between 20.0 m and 25.0 m above the Black Sea level ;

– the high plain, which covers about 90% of the area with levels between 87 m and 92 m and which is crossed by N-W directed valleys.

1-1-2. Geology

The geological structure of the covering deposits on the lower terrace consists of sands and sands with gravel, 15 m thick, topped by silty-clayey deposits.

In the high plain area we find a complex of sands and gravel whose thickness increases towards the North from 4 to 10 m and even to 20 m.
This complex is covered up to the ground level by a clayey layer (25-30 m deep), consisting of lake deposits.

The groundwater table is generally to be found in 2 – 3 m thick pervious deposits (.sands and gravel); its level ranges between 20 and 30 m from ground surface.

1-1-3. The results of geological survey (implemented in November 1999)

1) Outlines

We made geological surveys at the following points and made soil mechanics tests in November 1999 (with ISPIF).

Borehole No.1 : beside CA1 canal at SPPA6 (10m apart from the canal)
Borehole No.2 : beside CA canal at the middle point between Cama and Ghizdaru (15m apart from the canal)
Borehole No.3 : beside lab-canal in ICITID (20m apart from the canal)

2) Results

The results are mentioned in the annex.

[Borehole No.1]

- Upper side (till 4m depth) is brown silty faint sandy stiff clay, and lower side is yellow stiff clay.
- There is no ground water in the hole.
- Permeability of both layers is very low.

[Borehole No.2]

- Upper side (till 5m depth) is yellow stiff sandy clay, and lower side is yellow fine sand.
- Ground water exists from the depth of 6.6m.
- Permeability of upper side layer is very low.

[Borehole No.3]

- Most of Layers are stiff clay.
- There is no ground water in the hole.
- Permeability of both layers is very low.

1-2. Situations of canals

1-2-1. Outlines of canals

1) CA canal

SPA. Cama pumping station discharges 77.5 m3/sec (max) into the spilling basin at the head of CA canal.

CA canal is fully lined with a 10 cm in situ cast concrete layer and consists of two sections :

a) Section I

Section I conveys water from SPA Cama main supply pumping station up to the limit of the high plain, where the first re-pumping station (SRP1 Ghizdaru) is located, and is 7.55 km long.

The canal bottom width is 8.0 m, water depth is 2.90 – 3.45 m, the inner slope is 1 : 1.5 – 2.0, and the outer one is 1 : 2.5.

b) Section II

Section II takes over the water lifted by SRP1 Ghizdaru and conveys it to the branching point of CA1 and CA2 canals, and it is 3.0 km long.

It has a starting discharge of 74.0 m3/sec.

It is an "in-fill" canal with 7 to 10 m high embankments on the first 2.0 km, and the remaining 1 km is implemented "in-cut" to depths of 5.0 m.

Invert width is 10.0 m, the water depth is 3.5 m, the inside slope is 1 : 1.5, and the outside one is 1 : 2.5.

2) CA1 and CA2 canals

The 74 m3/sec flow conveyed by CA canal is divided into 30 m3/sec which are taken over by the CA1 supply canal, which serves the Eastern par of the area, and 44 m3/sec taken over by the CA2 canal, which distributes water to the western part.

CA1 canal is 22.8 km long, and is equipped with 4 level regulator gates, which divided it in 5 reaches.

The canal is lined with reinforced precast concrete 3.0 × 1.5 m rectangular slabs, 6 cm thick.

CA2 canal is 44.0 km long, with a lifting station of 10.3 m3/sec at km 27 + 090, and the canal is equipped with 6 level regulator gates, which divides it into reaches.

Both canals have inner slopes of 1 : 1.5 and are executed in cut, fill or half section, according to the surrounding ground conditions.

3) The branch canals

The branch canals, at distances of 4 – 6 km, have a total length of 187.5 km. The lining of these canals is made with large precast reinforced concrete slabs or small concrete slabs.

4) Control of water level

The regulator gates are operating on hydraulic control.

The storage of the water volume, as required by the variation of the demand within a day, is achieved in all the reaches, between the hydrodynamic and hydrostatic levels.

1-2-2. Constructions of canals

1) CA canal

a) Lining : Situ-cast concrete lining

The lining concrete was cast in situ by the specialized machinery.

b) Joints

The materials of joints are concrete mortar or asphalt mortar.

c) Drains

There are 15 – 25 cm of gravel under the lining, and drain pipe under the bottom.
There are gravel drains along the bottom of the bank slope out side of canal.

2) CA1 and CA2 canals

a) Lining : Pre-cast concrete slabs lining

The sizes of the slabs are as follows:

3.0m * 1.5m * 0.06m; 2.0m * 1.0m * 0.06m; 0.5m * 0.5m * 0.06m.

b) Joints

The materials of joints are concrete mortar or asphalt mortar.

c) Drains

There is no drain.

1-2-3. Present situation of lining

1) CA canal

There are some damages on the lining, like having clacks, changing its position up or down, or having destruction by the develops of clacks and changes, and there are plants at the joints or clacks, but most part of lining is still in good conditions after the 25years of services.

2) CA1 and CA2 canals

There are some damages on the lining, like having clacks on the slabs, changing its position up ,down or aside, having gaps at the joints, or having destruction by the develops of clacks, changes and gaps, and there are plants at the joints or clacks.

1-2-4. Water loss from canals

We measured water loss from canals by measuring changes of water level in September 2000, when all pumps are in intermission.

The results and calculations of loss of electric energy are mentioned in the annex.

1-2-5. Ground water state beside CA1 canal

We measured the level of ground water in four boreholes beside CA1 canal from July to September 2000.

The results are mentioned in the annex.

2. Solutions for lining

2-1. Solutions to improve water loss from canals

Most popular solutions for concrete cast lining canal or pre-cast concrete slab lining canals are mentioned in the annex.

2-2. Water loss from canals with non-permeable sheets under the slabs

We measured water loss from lab-canal in ICITID which has non-permeable sheets under the slabs.
The results are mentioned in the annex.

2-3. Calculations of effects

Calculations of water loss in the case of using non-permeable sheets under the slabs are mentioned in the annex.
We can save much money, especially from CA1.

2-4. Cost performance

The cost of sheets is around 10 – 20 USD/m2 (without works) in Japan.

Calculations of cost performance of the solutions by non-permeable sheets under the slabs are mentioned in the annex.

The cost performance of the solutions by non-permeable sheets under the slabs is not so good in Giurgiu area.

That means the water loss from canal is not so high in Giurgiu area, because of the good soil features (stiff clay with quite low permeability).

But if the price is less, cost performance of the solutions by non-permeable sheets under the slabs will be good in the area where the soil is sandy and the permeability is high.

2-5. Others

For sandy area, the clays in the water can reduce water loss when the clay sinks between the clacks or gaps, therefore it will be better to keep mud on the bottom in some level. (See annex.) (But muddy water is not good for pumps or other equipment.)

Solutions to improve water loss from canals

Solution	Outline of solution	Merits	Cares	Costs
Geomembrane (Non-permeability sheets)	Putting non-permeability sheets under the concrete lining.	- We can put the sheets on the shape of existing canal after taking off the concrete lining blocks, and it is easy to put sheets. - The improvement of water loss is almost perfect. - The sheets are adjustable to changes of shapes of canals for long term services.	- Some kinds of anchors are necessary to fix the sheets, for instance, fixing the sheets on the shoulder of canals with putting the sheets under the soils. - To avoid the water loss from the joints, it is necessary to put some widths of sheets on the others and make the contact tight. - It is necessary to have some drains in the places where the ground water level is high.	10 – 20 USD/m2 for sheets only (without works)
Sealing joints	Putting some materials between the concrete lining blocks	- We can put the liquid type materials between the concrete lining blocks without taking off the concrete lining blocks. - We can put the soft solid type materials between the concrete lining blocks after taking off the concrete lining blocks, and it is easy to put materials between concrete blocks. - The improvement of water loss is almost perfect, if the works are perfect. - The soft solid type materials are adjustable to little changes of shapes of canals.	- For the perfect effects, it is necessary to put the materials between the concrete lining blocks carefully and perfectly. - The materials are not adjustable to big changes of shapes of canals. - It is necessary to have some drains in the places where the ground water level is high.	10 – 20 USD/kg for materials only (without works)

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PIT
REZULTATEL[illegible]
LABC[illegible]

Borehole No. 1.

Depth (m)	Stratum thickness (m)	Underground water depth (m)	Stratification	Geological formation	DENUMIREA STRATULUI / STRATUM DESCRIPTION	Number and type of sample (☐ Jar, ☒ Tube, Monolith)	Depth (m)	Clay (colloidal) 0.002	Clay 0.005	Silt 0.05	Fine sand 0.25	Medium sand 0.50	Coarse sand 2.00	Gravel 70.00	Cobbles	Non-uniformity coefficient	Liquid limit W_L	Plastic limit W_P	Plasticity index I_P	Water content W%	Consistency index I_c
0.30	0.30	FĂRĂ APĂ (NO WATER)			Pământ vegetal. Topsoil																
					Argilă prăfoasă fin nisipoasă cafenie plastic vârtoasă cu concrețiuni calcaroase. Brown silty faint sandy stiff clay with calcareous concretions.	1	1.00														
						2 ☒	2.00	29	12	48	11						49.1	16.3	32.6	17.9 / 18.0	0.95
						4	3.00														
4.10	3.80					5 ☒	4.00														
					Argilă gălbuie plastic vârtoasă cu concrețiuni calcaroase; de la D = 7.60 m culoarea este cafenie. Yellow stiff clay with calcareous concretions; from the depth D = 7.60 m the colour is brown.	7	5.00														
						8 ☒	6.00	41	12	38	9						51.4	17.2	34.2	19.4 / 19.3	0.93
						10	7.00														
						11	8.00														
						13	9.00														
10.00	5.80					14 ☒	10.00		64	37	5						65.2	18.2	47.0	20.0 / 20.6	0.96

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BOREHO
PIT
REZULTATE
LAE

Borehole No. 2.

Depth (m)	Thickness (m)	Underground water (m)	Stratum description	Number and type of sample	Depth (m)	Clay (colloidal)	Clay	Silt	Fine sand	Medium sand	Coarse sand	Gravel	Cobbles	Non-uniformity coefficient	Liquid limit W_L	Plastic limit W_P	Plasticity index I_P	Water content %	Consistency I_C
0.40	0.40		Pământ vegetal. Topsoil.																
			Argilă nisipoasă gălbuie plastic vârtoasă. Yellow stiff sandy clay.	1	1.00														
				3	2.00	21	10	28	36	5					33.8	12.2	21.6	12.6 / 10.5	0.
				4	3.00														
4.00	3.60			6	4.00	15	10	13	50	7					26.3	11.3	15.0	14.9 / 15.6	0.
4.60	0.60		Nisip argilos gălbui plastic vârtos. Yellow claiey stiff sand.	7	5.00	8	4	11	62	14	1								
		6.60	Nisip fin gălbui; de la D = 6.60 m nisipul este sub apă, are zone cimentate, fragmente de gresie si pietris. Yellow fine sand; from the depth D=6.60m the sand is saturated, with cemented areas, sand stone and gravel.	8	6.00	1	2	7	60	10				3.2					
				9	7.00														
				10	8.00				92	6				1.75					
				11	9.00														
10.00	5.20			12	10.00				29	64	5	2		1.61					

Sample type: Jar / Tube / Monolith

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PROFILU[illegible]
BOREHOL[illegible]
PIT
REZULTATEL[illegible]
LAB[illegible]

Borehole No. 3

Borehole depth (m)	Stratum thickness h	Underground water depth	Stratification	Geological formation	Denumirea stratului / Stratum description	Number and type of samples	Depth (m)	Clay (colloidal) <0.002	Clay 0.005	Silt 0.05	Fine sand 0.25	Medium sand 0.50	Coarse sand 2.0	Gravel 20	Cobbles	Non-uniformity coefficient	Liquid limit w_L	Plastic limit w_p	Plasticity index I_p	Water content w%	Consistency index I_c
0.40	0.40				Pământ vegetal / Topsoil																
		FĂRĂ APĂ (NO WATER)			Argilă cafenie plastic vârtoasă (la D= 1.0 m argilă plastic consistentă) cu concrețiuni calcaroase; între adâncimile D=4.80÷6.30 m și D=8.40÷9.50 m culoarea este gălbuie.	1	1.00	36	13	41	10						54.6	17.4	37.2	30.6	0.64
					Brown stiff clay (at D=1.0 m soft clay), with calcareous concretions; between depths D=4.80÷6.30 m and D=8.40÷9.50 m the colour is yellowish.	4	2.00	28	17	49	6						49.4	16.7	32.7	20.6 / 22.0	0.83
						5	3.00														
						6	3.60		50	47	3						55.6	17.1	38.5	22.0 / 22.6	0.85
						7	4.00														
						8	5.00														
						9	6.00														
						10	6.30		51	45	4						50.4	16.5	33.9	22.0 / 23.1	0.80
						11	7.00														
						12	8.00														
						13	8.30		54	43	3						54.0	16.5	37.5	19.8 / 19.5	0.92
						14	9.00														
						15	9.70		71	29							65.5	19.0	46.5	23.2 / 21.2	0.95
10.0	9.60					16	10.00														

Sample types: ☐ Borcan / Jar; ☒ Ștuț / Tube; ⊡ Monolit / Monolith

The Results of Soil Mechanics Tests

Point of test : Canal CA1 at SPPA6 (10m apart from the canal)

Date of test : November 1999

Test	Code	Unit	2.00m depth	6.00m depth	10.00m depth
Mechanical analysis					
clay (colloid)	< 0.002	%	29	41	
clay	< 0.005	%	12	12	64
silt	< 0.05	%	48	38	31
fine sand	< 0.25	%	11	9	5
coarse sand	< 0.50	%			
Consistency test					
liquid limit	WL	%	49.1	51.4	65.2
plastic limit	WP	%	16.3	17.2	18.2
plasticity index	IP	%	32.8	34.2	47.0
natural moisture ratio	W	%	18.0	19.3	20.6
consistency index	IC		0.95	0.94	0.95
Density test					
wet density	γt	gf/cm3	2.00	2.01	2.06
dry density	γd	gf/cm3	1.70	1.69	1.70
specific gravity	GS	gf/cm3	2.72	2.72	2.72
porosity	n	%	37.6	37.8	37.3
void ratio	e		0.60	0.61	0.60
degree of saturation	Sr	%	0.81	0.86	0.94
Permeability test (in lab.)	k	cm/s	1.39E-08	3.66E-08	2.26E-08

The Results of Soil Mechanics Tests

Point of test : Canal CA at the middle between CAMA and GHIZDARU (15m apart from the canal)

Date of test : November 1999

Test	Code	Unit	2.00m depth	6.00m depth	10.00m depth
Mechanical analysis					
clay (colloid)	< 0.002	%	21	15	1
clay	< 0.005	%	10	10	2
silt	< 0.05	%	28	18	7
fine sand	< 0.25	%	36	50	80
coarse sand	< 0.50	%	5	7	10
Consistency test					
liquid limit	WL	%	33.8	26.3	
plastic limit	WP	%	12.2	11.3	
plasticity index	IP	%	21.6	15.0	
natural moisture ratio	W	%	12.6	14.9	
consistency index	IC		0.98	0.76	
Density test					
wet density	γt	gf/cm3	1.89	1.77	
dry density	γd	gf/cm3	1.71	1.53	
specific gravity	GS	gf/cm3	2.67	2.65	
porosity	n	%	36.0	42.4	
void ratio	e		0.56	0.74	
degree of saturation	Sr	%	0.50	0.57	
Permeability test (in lab.)	k	cm/s	2.75E-07	1.57E-07	

The Results of Soil Mechanics Tests

Point of test : Lab-canal in ICITID (20m apart from the canal)

Date of test : November 1999

Test	Code	Unit	2.00m depth	3.60m depth	6.30m depth	9.70m depth
Mechanical analysis						
clay (colloid)	< 0.002	%	28			
clay	< 0.005	%	17	50	51	71
silt	< 0.05	%	49	47	45	29
fine sand	< 0.25	%	6	3	4	
coarse sand	< 0.50	%				
Consistency test						
liquid limit	WL	%	49.4	55.6	50.4	65.5
plastic limit	WP	%	16.7	17.1	16.5	19.0
plasticity index	IP	%	32.7	38.5	33.9	46.5
natural moisture ratio	W	%	22.0	22.6	23.1	21.2
consistency index	IC		0.84	0.86	0.81	0.95
Density test						
wet density	γt	gf/cm3	2.05	2.02	1.98	2.00
dry density	γd	gf/cm3	1.70	1.65	1.62	1.52
specific gravity	GS	gf/cm3	2.72	2.72	2.72	2.72
porosity	n	%	37.6	39.1	40.2	40.2
void ratio	e		0.60	0.64	0.67	0.67
degree of saturation	Sr	%	0.93	0.93	0.89	0.94
Permeability test (in lab.)	k	cm/s		4.56E-08	4.40E-08	7.54E-08

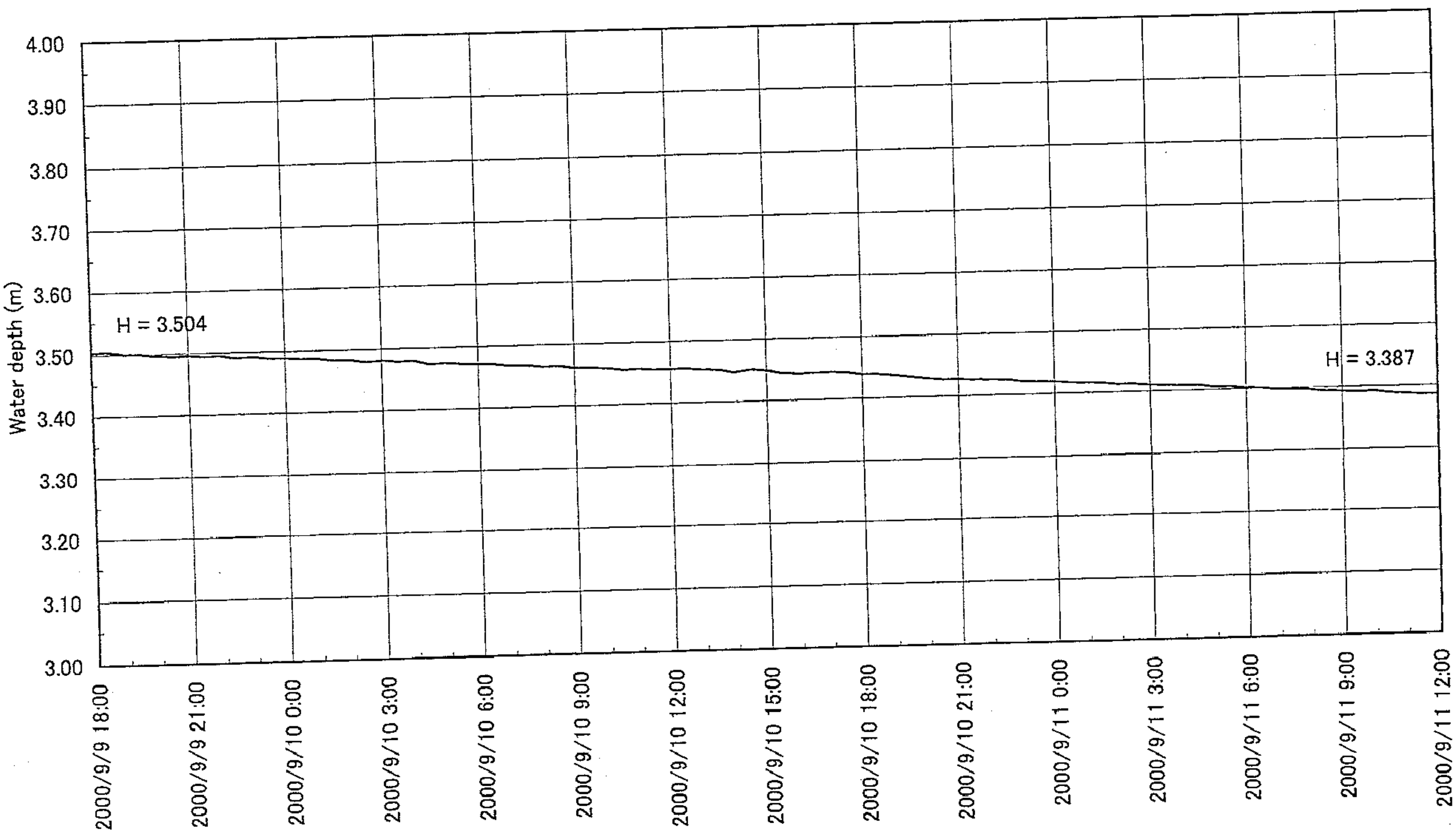
Water loss from canal CA and CA1

(Meassurement: September 2000)

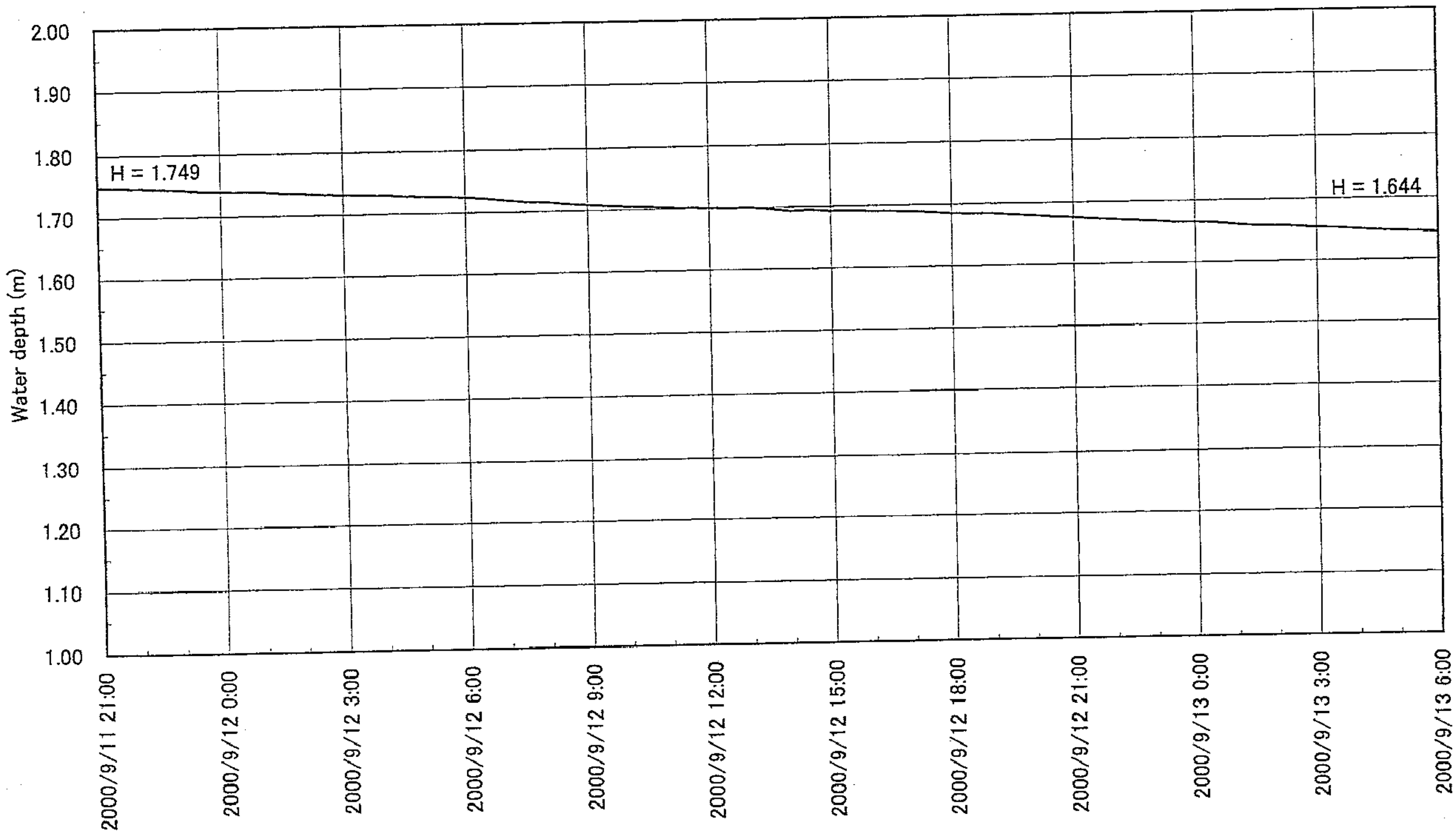
Item		Unit	Canal CA	Canal CA1
Water level in the beginning		m	3.504	1.749
Water level in the end		m	3.387	1.644
Decreace of water level		m	0.117	0.105
Measurement interval	T	hr	42	33
Decrease of water level per day	dH	m/day	0.067	0.076
Decrease of water level by evaporation per day	dHe	m/day	0.006	0.006
Decrease of water level by infiltration per day	dHi	m/day	0.061	0.070
Width of bottom	b	m	10.00	1.00
Slope of lining	1: m		1.5	1.5
Average depth	Hav	m	3.446	1.697
Average width of water surface	Wav	m	20.34	6.09
Water loss per day per 1m	Q'loss	m3/day/m	1.24	0.43
Length of lining in contact with water	R	m	22.42	7.12
Water loss per day per 1m2	Qloss	m3/day/m2	0.0552	0.0602
Length of canal	L	m	11,900	30,000
Area of lining in contact with water	A	m2	266,833	213,505
Water loss per day	Qloss	m3/day	14,728	12,854
Electric energy for pumping				
[SPA Cama]				
Discharge (1 pump)		m3/s	3.0	3.0
Power of Motor		kW	400	400
Electric energy per 1000m3		kWh/1000m3	37	37
[SRP1 Ghizdaru)				
Discharge (1 pump)		m3/s		6.0
Power of Motor		kW		5,000
Electric energy per 1000m3		kWh/1000m3		231
Total electric energy per 1000m3		kWh/1000m3	37	269
Loss of electric energy per day	Eloss	kWh/day	545	3,452
Electric energy charge (*)		USD/kWh	0.055	0.055
Loss of money per day		USD/day	30	190
Total days for irrigation in a year		day	120	120
Loss of money per year		USD/year	3,600	22,781

*) Electric energy charge : 1,345Lei/kWh = 0.055USD/kWh (as of October 2000)

Change of water level in canal CA at SRP1 GHIZDARU



Change of water level in canal CA1 at SPPA6



Water level in the boreholes beside the canal CA1 at SPPA6

The results of this measurement show the followings:

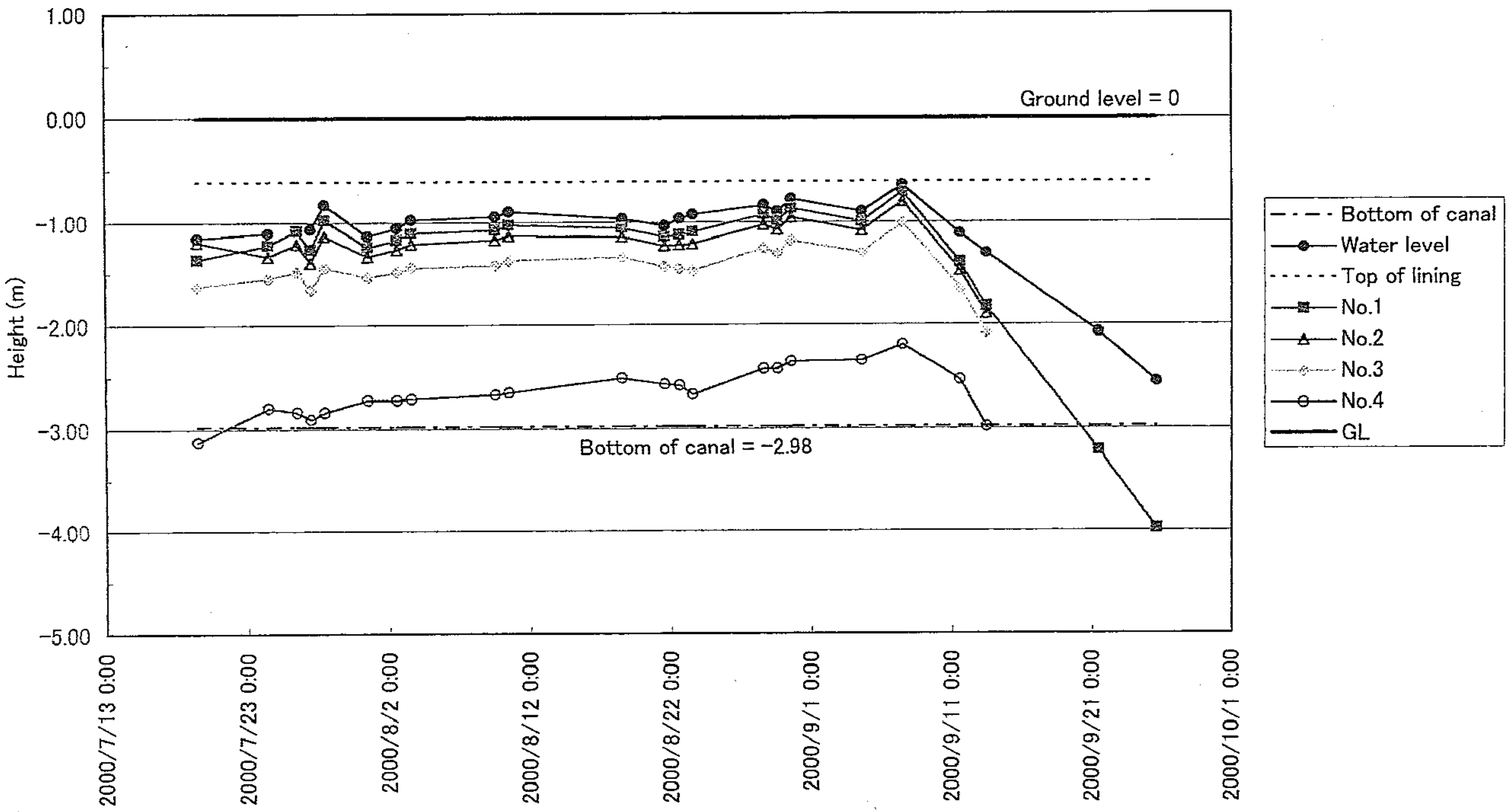
1) The water levels in the holes change almost in parallel with the change of water level in the canal, when the water level in the canal is usual level (water depth = around 2m).

Borehole No.		No.1	No.2	No.3	No.4
Depth of borehole	m	5.00	3.00	3.00	5.00
Distance from the center of the canal	m	5.00	7.00	9.00	19.00
Distance from the edge of the lining of the canal	m	1.00	3.00	5.00	15.00
Average difference of height from the water level in the canal	m	0.13	0.21	0.46	1.68

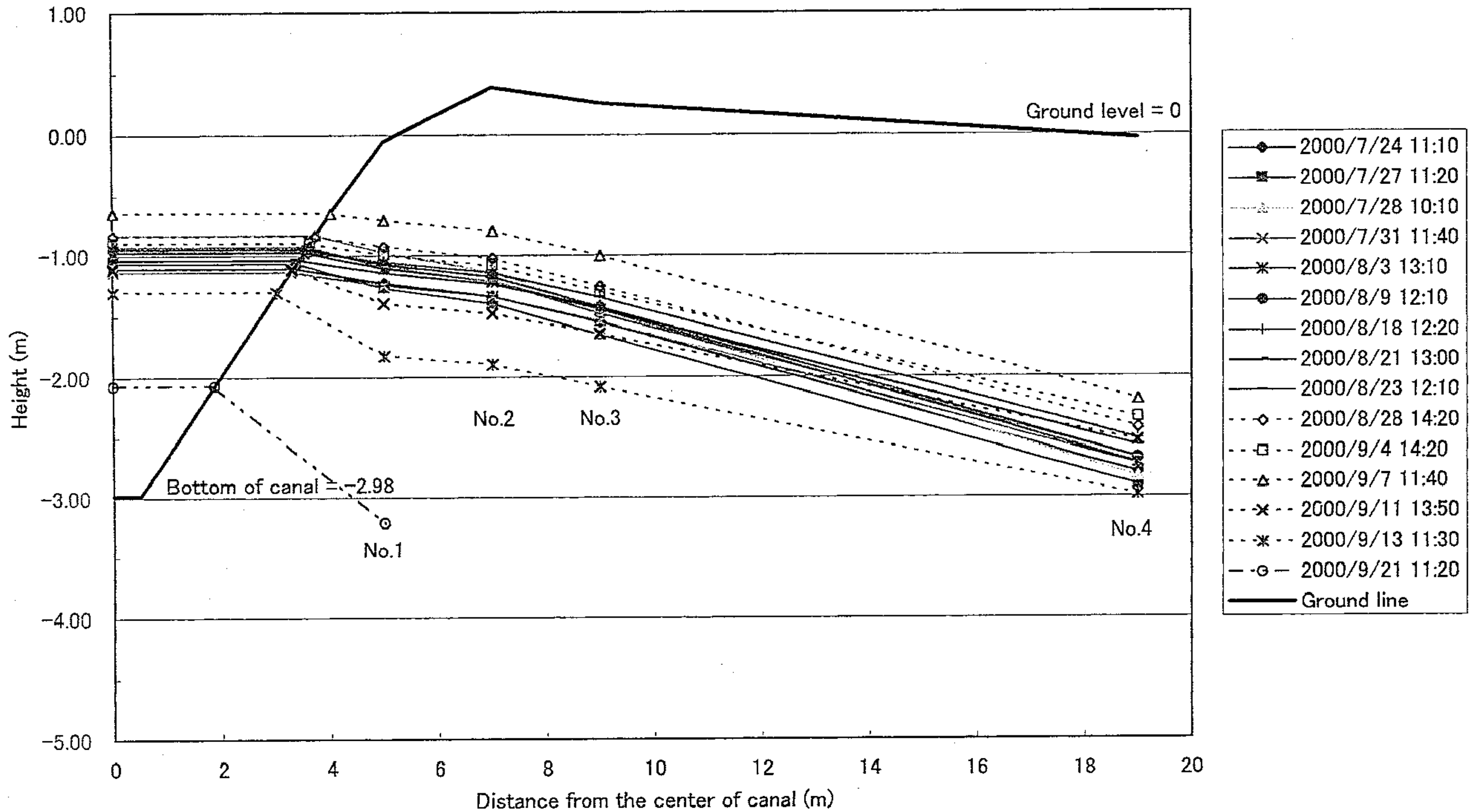
2) The water levels in the ground are between 1.0m and 2.0m depth at 5m apart from the canal, and between 2.0m and 3.0m depth at 15m apart from the canal.
Therefore some part of the water in the ground coming from the canal can be useful for some plants which have long roots near the canal.

3) The layer under around 2.0m depth has very low permeability. Because when the holes were bored, there was thin wet layer around 2.0m depth, and the soils under this level were almost dry.

Water level in the boreholes beside the canal CA1 at SPPA6



Water level in the boreholes beside the canal CA1 at SPPA6



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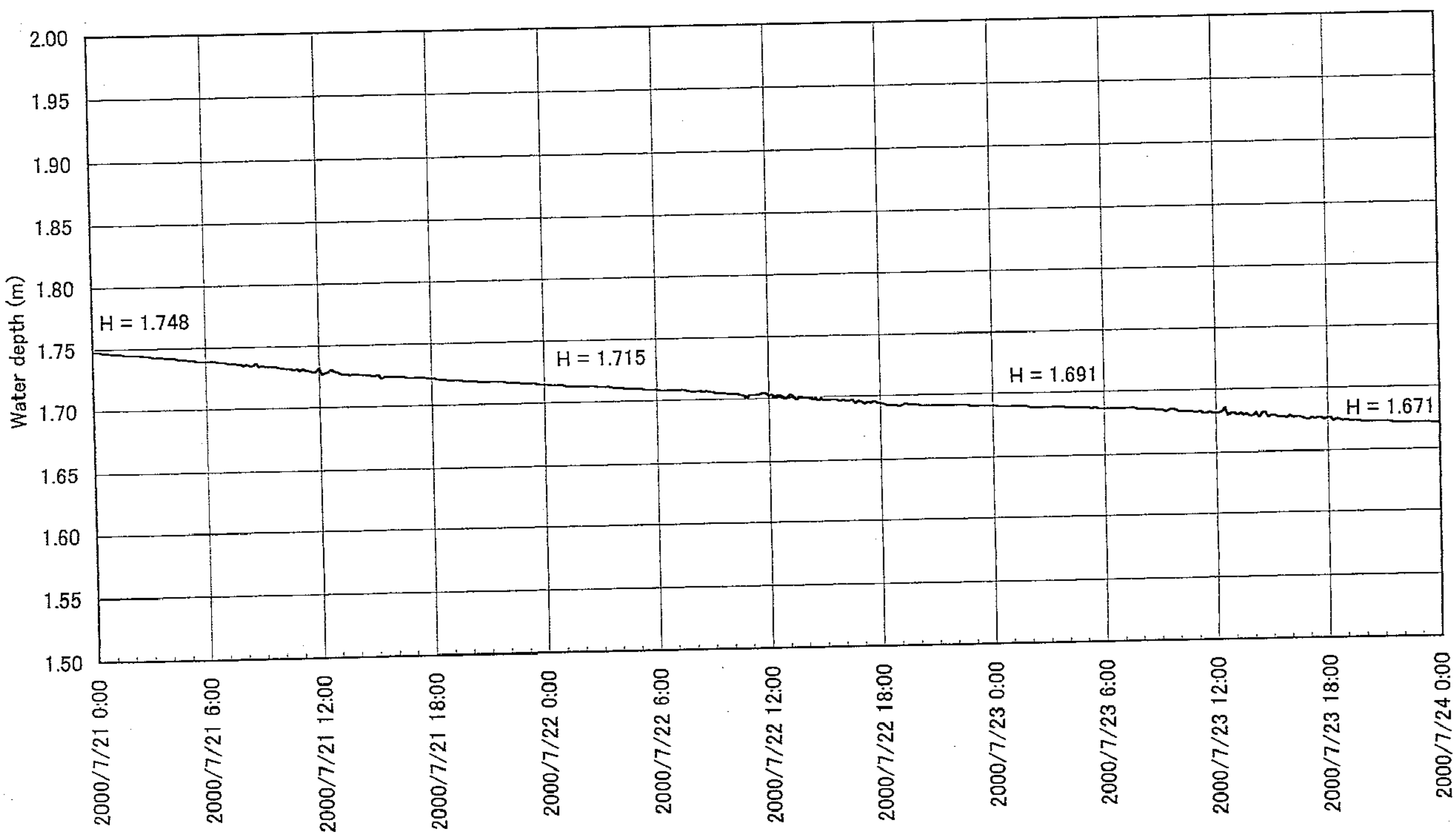
Water loss from lab-canal No.7 in ICITID

(Meassurement: July 2000)

Item		Unit	2000/7/21	2000/7/22	2000/7/23	Average
Water level in the beginning		m	1.748	1.715	1.691	1.748
Water level in the end		m	1.715	1.691	1.671	1.671
Decreace of water level		m	0.033	0.024	0.020	0.077
Measurement interval	T	hr	24	24	24	72
Decrease of water level per day	dH	m/day	0.033	0.024	0.020	0.026
Decrease of water level by evaporation per day	dHe	m/day	0.007	0.007	0.007	0.007
Decrease of water level by infiltration per day	dHi	m/day	0.026	0.017	0.013	0.019
Width of bottom	b	m	2.00	2.00	2.00	2.00
Slope of lining	1: m		1.5	1.5	1.5	1.5
Average depth	Hav	m	1.732	1.703	1.681	1.710
Average width of water surface	Wav	m	7.19	7.11	7.04	7.13
Water loss per day per 1m	Qloss	m3/day/m	0.187	0.121	0.092	0.133
Length of lining in contact with water	R	m	8.24	8.14	8.06	8.16
Water loss per day per 1m2	Qloss	m3/day/m2	0.0227	0.0148	0.0114	0.0163

*) Lining condition of lab-canal No.7 : Small slabs with thin sheet of vinyl poly-chloride under the slabs

Change of water level in the lab-canal No.7 in ICITID



Calculation of water loss in the case of using Non-permeable sheet for lining

(Canal CA)

Item		Unit	The existing condition	Improved condition with non-permeable sheet	Saved value (Difference)
Water loss per day per 1m2 (*)	Qloss	m3/day/m2	0.0552	0.0163	0.0389
Width of bottom	b	m	10.00	10.00	
Slope of lining	1: m		1.5	1.5	
Average depth	Hav	m	3.446	3.446	
Average width of water surface	Wav	m	20.34	20.34	
Length of lining in contact with water	R	m	22.42	22.42	
Length of canal	L	m	11,900	11,900	
Area of lining in contact with water	A	m2	266,833	266,833	
Water loss per day	Qloss	m3/day	14,728	4,349	10,378
Water loss per day per 1m	Q'loss	m3/day/m	1.24	0.37	0.87
Decrease of water level by infiltration per day	dHi	m/day	0.061	0.018	0.043
Decrease of water level by evaporation per day	dHe	m/day	0.006	0.006	
Decrease of water level per day	dH	m/day	0.067	0.024	0.043
Electric energy for pumping					
[SPA Cama]					
Discharge (1 pump)		m3/s	3.0	3.0	
Power of Motor		kW	400	400	
Electric energy per 1000m3		kWh/1000m3	37	37	
[SRP1 Ghizdaru]					
Discharge (1 pump)		m3/s			
Power of Motor		kW			
Electric energy per 1000m3		kWh/1000m3			
Total electric energy per 1000m3		kWh/1000m3	37	37	
Loss of electric energy per day	Eloss	kWh/day	545	161	384
Electric energy charge (**)		USD/kWh	0.055	0.055	
Loss of money per day		USD/day	30	9	21
Total days for irrigation in a year		day	120	120	
Loss of money per year		USD/year	3,600	1,063	2,537

*) Water loss (0.0552 m3/day/m2) was measured data in canal CA in Sep. 2000.

*) Water loss (0.0163 m3/day/m2) was measured data in lab-canal No.7 in ICITID in Jul. 2000.

**) Electric energy charge : 1,345Lei/kWh = 0.055USD/kWh (as of October 2000)

Calculation of water loss in the case of using Non-permeable sheet for lining

(Canal CA1)

Item		Unit	The existing condition	Improved condition with non-permeable sheet	Saved value (Difference)
Water loss per day per 1m2 (*)	Qloss	m3/day/m2	0.0602	0.0163	0.0439
Width of bottom	b	m	1.00	1.00	
Slope of lining	1: m		1.5	1.5	
Average depth	Hav	m	1.697	1.697	
Average width of water surface	Wav	m	6.09	6.09	
Length of lining in contact with water	R	m	7.12	7.12	
Length of canal	L	m	30,000	30,000	
Area of lining in contact with water	A	m2	213,505	213,505	
Water loss per day	Qloss	m3/day	12,854	3,480	9,374
Water loss per day per 1m	Q'loss	m3/day/m	0.43	0.12	0.31
Decrease of water level by infiltration per day	dHi	m/day	0.070	0.019	0.051
Decrease of water level by evaporation per day	dHe	m/day	0.006	0.006	
Decrease of water level per day	dH	m/day	0.076	0.025	0.051
Electric energy for pumping					
[SPA Cama]					
Discharge (1 pump)		m3/s	3.0	3.0	
Power of Motor		kW	400	400	
Electric energy per 1000m3		kWh/1000m3	37	37	
[SRP1 Ghizdaru)					
Discharge (1 pump)		m3/s	6.0	6.0	
Power of Motor		kW	5,000	5,000	
Electric energy per 1000m3		kWh/1000m3	231	231	
Total electric energy per 1000m3		kWh/1000m3	269	269	
Loss of electric energy per day	Eloss	kWh/day	3,452	934	2,517
Electric energy charge (**)		USD/kWh	0.055	0.055	
Loss of money per day		USD/day	190	51	138
Total days for irrigation in a year		day	120	120	
Loss of money per year		USD/year	22,781	6,168	16,613

*) Water loss (0.0602 m3/day/m2) was measured data in canal CA in Sep. 2000.

*) Water loss (0.0163 m3/day/m2) was measured data in lab-canal No.7 in ICITID in Jul. 2000.

**) Electric energy charge : 1,345Lei/kWh = 0.055USD/kWh (as of October 2000)

Calculation of cost perfomance of the solutions by non-permeable sheets

(Sheets price: 10USD/m2)

Item	Unit	Perfect improvement		Same condition as lab-canal	
		CA	CA1	CA	CA1
Lining area	m2	320,000	360,000	320,000	360,000
Unit price of the sheets	USD/m2	10	10	10	10
Total price	USD	3,200,000	3,600,000	3,200,000	3,600,000
Saved value per year	USD/year	3,600	22,781	2,537	16,613
Years for good balance	years	889	158	1,261	217

(Sheets price: 15USD/m2)

Item	Unit	Perfect improvement		Same condition as lab-canal	
		CA	CA1	CA	CA1
Lining area	m2	320,000	360,000	320,000	360,000
Unit price of the sheets	USD/m2	15	15	15	15
Total price	USD	4,800,000	5,400,000	4,800,000	5,400,000
Saved value per year	USD/year	3,600	22,781	2,537	16,613
Years for good balance	years	1,333	237	1,892	325

(Sheets price: 20USD/m2)

Item	Unit	Perfect improvement		Same condition as lab-canal	
		CA	CA1	CA	CA1
Lining area	m2	320,000	360,000	320,000	360,000
Unit price of the sheets	USD/m2	20	20	20	20
Total price	USD	6,400,000	7,200,000	6,400,000	7,200,000
Saved value per year	USD/year	3,600	22,781	2,537	16,613
Years for good balance	years	1,778	316	2,523	433

Change of water level in lab-canal Nr.6 in ICITID in the case of adding muddy water (approx. concentraition 0.5%)