INTERNATIONAL COURT OF JUSTICE

CASE

CONCERNING THE GABCIKOVO-NAGYMAROS PROJECT

(HUNGARY/SLOVAKIA)

MEMORIAL

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ANNEXES

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TABLE OF CONTENTS

Annex 13

COMMISSION OF THE EUROPEAN COMMUNITIES
CZECH AND SLOVAK FEDERATIVE REPUBLIC
REPUBLIC OF HUNGARY

FACT FINDING MISSION ON VARIANT C OF THE GABCIKOVO-NAGYMAROS PROJECT

MISSION REPORT

Bratislava
October 31, 1992

LIST OF CONTENT

EXECUTIVE SUMMARY

In connection with trilateral negotiations held in London on October 28 between the European Commission (CEC), the Czech and Slovak Federative Republic (CSFR) and Hungary on Variant C of the Gabcikovo-Nagymaros project it was decided to carry out a Fact Finding Mission composed of one expert from each of the three parties.

The Mission met first time on October 29 in Györ, carried out an on-site inspection of the ongoing work on October 30 and held the concluding meetings in Bratislava on October 30-31, 1992.

Very significant construction activities are presently going on. The scheduled completion of the Gabcikovo complex and the structures of the variant C project are summarized below :

SCHEDULED COMPLETION	1/11-92	15/11-92	1/1-93	1/3-93	1995
GABCIKOVO COMPLEX					
Ship locks (finished)					
Power station incl.					
1 turbine	X				
3 turbines			X		
5 turbines				X	
VARIANT C COMPLEX					
Ths					
By-pass weir			X		
Closing dams, dike		X			
Floodplain weir			X		
Mosoni by-pass weir	X				
Phase 2					
Ship lock, weir and power station					X

The design flood discharge for the final Variant C is based on a 10,000 year flood event, whereas a 100 year (1 % risk of per year) is accepted during the construction period.

According to the scheduled completion the structures are expected to be ready and fully fortified to resist the design flood without large damages as follows:
- November 15, 1992: Winter design flood (6000 m^3/s)
- March 1, 1993: Summer design flood (10600 m^3/s)

It is technically possible to direct the main part of the discharge to the old Danube around January 1, 1993.

Should a flood occur now before the connecting dams and dike are fully fortified, the constructions could be damaged from erosion.

It is not likely that a flood would give rise to an extraordinary flooding hazard in areas outside the main existing dikes.

The closure of the Danube and the subsequent separation of the flow into two parts resulting in smaller discharge in the Danube has had significant immediate environmental impacts (groundwater and floodplain ecology) as well as a termination of the navigation for a period of approximately 11 days.

In theory, the ongoing activities with Variant C could be removed. However, in practise this will cause significant environmental problems. The cost of removing the structures are roughly estimated to at least 30 % of the construction costs.

A number of possible scenarios are described in the report. Scenarios for stopping of work for 1, 3 and 12 months and of alternative operation strategies (directing the main discharge to old Danube or to Gabcikovo) have been elaborated with respect to which work has to be completed to protect the structures against flood as well as to environmental impacts. The different scenarios have furthermore different organisational and economical implications.

The members of the mission agree to the content of the Mission Report. In addition, both the CSFR and the Hungarian representative have prepared separate statements, enclosed as appendices E and F of Mission Report, containing more specific proposals.

1. INTRODUCTION

Paragraph 1 of the Agreed Minutes of the Meeting between the European Commission (CEC), the Czech and Slovak Federative Republic (CSFR) and Hungary on 28th October 1992 on the Gabcikovo/Nagymaros Project reads as follows:

> " It was agreed that all works on Variant C of the Gabcikovo/Nagymaros project will be stopped at a date specified by the EC Commission on the basis of the fact finding mission composed of one expert from each side (Commission, CSFR and Hungary), taking into account the risk of damage to existing structures including navigation, of ecological damage to the region and of flooding (Spring 1993 or sudden surges) as well as of ecological damage to the region. The mission shall report as soon as possible, but not later than Saturday October 31st at 12 noon.
>
> The CSFR undertakes to guarantee to maintain the whole ("whole" means not less than 95 %) traditional quantity of water into the whole old Danube river bed, including the section between Rajka and Palkovicovo, and to refrain from operating the power plant."

The following three experts have been appointed to constitute the Fact Finding Mission:

* CEC: Mr. Jens Christian Refsgaard, Chief Hydrologist, Danish Hydraulic Institute (Team Leader)

* CSFR: Professor, Dr. Igor Mucha, Faculty of Natural Science, Comenius University, Bratislava.

* Hungary Dr. Péter Bakonyi, Managing Director, VITUKI Consult Rt, Budapest.

The three experts were assisted by colleagues as listed in Appendix A. The Fact Finding Mission meet first time on Thursday, October 29 in the afternoon in Györ, Hungary. On Friday, October 30 an on-site inspection of the ongoing work was made and the concluding meetings were held in Bratislava on October 30-31.

2. STATUS OF ONGOING WORK

The mission carried out an on-site inspection of the ongoing work on Friday morning, October 30, 1992.

In both countries the original plans for the Gabcikovo scheme (see enclosed brochure) is completed except for the closure of the Danube river at Dunakiliti and the

(1) Completion of the hydropower station (installation and testing of turbines) at Gabcikovo.

Variant C consists of a complex of structures. The construction of these are planned for two phases. The structures include (see the sketch in Appendix B):

(2) By-pass weir controlling the flow into the river Danube.
(3) Dam closing the Danubian river bed and connecting dams/dike.
(4) Ship lock for smaller ships.
(5) Spillway weir.
(6) Hydropower station.
(7) Floodplain weir (weir in the inundation).
(8) Intake structure for the Mosoni Danube.
(9) Intake structure in the power canal.

The construction of the structures 1,2,3, 7 and 8 are included in Phase 1, while the remaining 4,5 and 6 are a part of Phase 2.

The status of the work is as follows:

(1) Hydropower station (HEP) and ship locks at Gabcikovo

The HEP is designed for peak power production. The planned 8 turbines have a nominal capacity of 4,000 m^3/s. At present five turbines and generators are being installed, the remaining three turbines are not planned for installation in the near future.

Turbine no 7 is being tested in these days at half capacity producing 40 MW power with a discharge around 200 m^3/s. Turbine no 8 has been tested hydraulically but not yet electrically. The remaining three turbines are currently undergoing a hydraulic testing programme. The testing programme allows for discharges to be between 80 and 120 m^3/s.

The five turbines and generators are planned to be fully tested and delivered by the contractor to the investor ready for power production according to following time schedule:

turbine no 7 : 1-11-1992

turbine no 8 : 1-12-1992
turbine no 6 : 1- 1-1993
turbine no 5 : 1- 2-1993
turbine no 4 : 1- 3-1993

By high water the maximum capacity is approximately 610 m^3/s per turbine.

At the preferred operational water level of 131.1 m asl (reference baltic msl) the design head is approximately 22 m.

The two ship locks (each 34 m wide and 275 m long) has a total capacity of 1970 m^3/s when open. With five turbines operationally installed the total combined hydraulic capacity of the turbines and locks are thus:

$5 \times 610\ m^3/s + 1970\ m^3/s \Rightarrow 5020\ m^3/s$.

If more turbines are installed the capacity of the canal of approximately 5200 m^3/s will be the flood discharge limited by the velocity in the power canal.

(2) Dam closing the Danube river bed and connecting dams/dike

The closure of the Danube river bed started on October 23, when the discharge was at a low of 800 m^3/s. The closure was completed on October 27. The crest level of the dam on the day of on-site inspection was approximately 131 m asl. The dam is not yet fully tightened leaking water approx 150 m^3/s. During the field visit the water level in the reservoir varied between 128.8 and 129.0 m asl.

The connecting dike between the downstream (d/s) part of the reservoir and the left hand side of the Danube is currently not fully fortified. There remains still 10 % of the dike to be strengthened to withstand waves. The connecting dams between the weirs are not yet finished and need to be fortified several places. Completion of the work on the dams and dike is planned to be finished by mid of November.

(3) By-pass weir controlling the flow into the river Danube

The flow into the river Danube from the reservoir is lead via this weir.

The weir consists of four tanter gates each 18 m wide with sill level at 126.5 m asl. The maximum hydraulic capacity of the weir at the reservoir water level 131.0 m asl is 1460 m^3/s, whereas the capacity is approximately 700 m^3/s at a water level of 129.0 m asl.

To repair the bottom protection and river sides d/s the weir it was closed totally on Oct. 29. It will be opened not later than Oct 31.

The weir is expected to be fully operational by the end of December 1992, but can until then be operated by temporary measures.

(7) Flood plain weir (weir in the inundation)

The weir consists of 20 tanter gates each 24 m wide with sill level at 128.0 m asl.

At present none of the gates can be operated and only four gates has the full hydraulic capacity. Due to the level of the terrain d/s the weir, 16 gates has a reduced capacity. A small part of the concrete works are not yet finished. The entire structure is planned to be fully operational by the end of 1992.

When finalized each of the gates has a hydraulic capacity of 230 m^3/s (total capacity if the weir is 4600 m^3/s) at the maximum water level of 131.1 m asl. The capacity at a water level of 129.0 m asl is estimated to be 60 m^3/s per gate.

In front of the gates a temporary non-fortified protective dike has been established with a crest level at 129.5 m asl. It is planned to be heightened to the level 130.5 m asl early November. When the dike is eroded or removed in case of high water level, the weir has at the moment a discharge capacity of 2340 m3/s corresponding to a water level of 131.1 m asl because of the high ground level downstream the weir.

(8) Intake structure at entrance to the Mosoni Danube

In the intake structure for the Mosoni Danube a small hydropower station with two turbines has been constructed with a bypass capacity of 25 m^3/s corresponding to a water level of 131.1 m asl and 20 m^3/s at 129 m asl. The concrete works at the construction are not completed but a by-pass consisting of two pipes is in basic ready for operational use. Installation of the turbines will not be completed for a longer period. Water to the Mosoni Danube can be supplied when the prepared supply canal on Slovak territory is connected to the Mosoni Danube on Hungarian territory. This work is planed to be completed by November 1, 1992.

(9) Intake structure in power canal.

The intake structure located in the power canal allowing for a maximum discharge of 250 m^3/s to be supplied to a river arm in the inundation d/s the Dunakiliti weir close to Dobrohost is completed. Sill level of the structure is at 128.5 m asl.

<u>(4)</u> <u>Ship lock</u>
<u>(5)</u> <u>Spillway weir</u>
<u>(6)</u> <u>Hydropower station</u>

Between the by-pass weir and the floodplain weir a temporary dike has been established and fortified with geo-textiles and rock boulders up to the level 131.1 m asl. The crest level of the dike is at 133.8 m asl.

From the Mosoni intake structure to the Danubian dam closure the front is protected against seepage with a 30 m deep sheet piling.

These works are a part of Phase two and are projected to be ready for use ultimo 1995. At maximum water level the hydraulic capacity of the ship lock and spillway weir is 5000 m^3/s and the capacity of the HEP is 1300 m^3/s. The sill level of the spillway weir is at 120.5 m asl., which is the same as in the existing river bed.

3. POTENTIAL FLOODING RISKS OF THE EXISTING STRUCTURES OF VARIANT C.

The design flood discharge for the project variant C (including phase 1 and 2) is based on a 10000 year flood event, i.e. a risk of 0.01% to occur within a year.

For the construction period usually a larger risk than 0.01% is accepted. Assuming a 1% risk per year as acceptable during the construction period (100 year flood event) the corresponding design flood discharge depending on the period of the year is:

- Full year : 10600 m^3/s
- Summer season (March - October) : 10600 m^3/s
- Winter season (October - March) : 6000 m^3/s

Hence, the flooding risk of stopping the work depends on the period during which the work will be stopped. For example stopping the works for 15 days in November until a final decision is made (either restart construction work with continued completion/fortification of structures or final abandonment and hence no more consideration to damage risks to structures) requires one (lower) level of finalization of the present structures before it is possible to stop the work, while stopping the work for more than a year while international arbitration takes place requires another (higher) level of finalization.

The flood discharge capacities of the structures are summarized in the table in Appendix C for six different stages with regard to degree of finalization of the structures and water level in the reservoir. The key figures are as follows:

1. discharge capacity on the 30-10-1992 at the waterlevel 129.0 m asl is <u>3120 m^3/s</u>

2. discharge capacity on the 30-10-1992 at the waterlevel 131.1 m asl is <u>6655 m^3/s</u>

3. discharge capacity on the 15-11-1992 at the waterlevel 131.1 m asl is <u>7265 m^3/s</u>

4. discharge capacity on the 01-01-1993 at the waterlevel 131.1 m asl is <u>10135 m^3/s</u>

5. discharge capacity on the 01-03-1992 at the waterlevel 131.1 m asl is <u>11500 m^3/s</u>

6. discharge capacity on the 31-12-1995 at the waterlevel 131.1 m asl is <u>19385 m^3/s</u>

In the period until January 1993 the water level in the reservoir is planned to be operated between 128 and 129 m asl, allowing for navigation. In case of a flood in this period the water level could rise up to the waterlevel 131.1 m asl. After this period the water level is planned to be operated close to the desired 131.1 m asl. This implies that stages 1 is a mean flow situation while stages 2 and 3 represents flood events. Stages 5 and 6 represents ordinary reservoir operation during all flow situations after completion of phase 1 and 2 respectively.

In a possible flood situation some of the not yet finished structures might be damaged depending of the peak and duration of the flood.

Should a flood occur now before the remaining 10 % of the dike between the d/s reservoir and the left hand side of the Danube is protected against waves the dike could be damaged from erosion. The unprotected dams connecting the structures could likewise be damaged due to erosion. Protection of the floodplain behind the floodplain weir is not yet carried out and during a flood it will erode. The stability of the weir will however not be in immediate danger. Parts of the side-protection of the by-pass weir could suffer as well, this construction is however being fortified at the moment so this risk is only eminent for a few days from this date.

After completion of the dike and the by-pass weir (tentative mid november) the winter 100 years flood can pass the structures.

When the dike, by-pass weir and floodplain weir is finished (end of 1992) the hydraulic capacity of variant C equals $Q_{1\%,\ year}$. To meet the design criterion $Q_{0.01\%,\ year}$ phase 2 has to be completed.

As concerning the flooding risk to areas outside the embankments it is not likely that a flood would give rise to an extraordinary flooding hazard in areas outside the main existing dikes.

Although not direct related to the works of variant C the most flood endangered reach of the Danube in the area of interest is the left hand side between Palkovicovo (milage km 1811) and Medvedov (milage km 1806) due to extensive siltation and inadequate dredging.

The effects and implications of the stages with respect to operation and environment are further elaborated in chapter 6 of this report.

4. CONSEQUENCES/IMPACTS OF ONGOING WORK

In the following both the immediate and the longer term effects of the ongoing work are being assessed.

4.1 Hydrological and water management aspects

As a consequence of the ongoing works the Danube discharge is separated in two parts, one part supplied to the navigation channel and power canal leading to Gabcikovo and the other part going into the existing Danube bed through the by-pass weir. Because the gates of the temporary weir are not yet operational, it is not possible fully to govern the water flow and separation between the two parts.

The water management possibilities are restricted until the various parts of the hydraulic structures are fully completed. The future management capabilities of the different structures may be summarized as follows:

* <u>By-pass weir</u>: When the four gates are made fully operational, discharges can be varied from 0 m^3/s to 1460 m^3/s.

* <u>Spillway weir</u>: When the spillway weir is constructed, a discharge of up to approximately 5000 m^3/s can be lead through the weir. Under non-flooding operation it is possible to operate the gates individually and vary the discharge between 0 m^3/s and 5000 m^3/s.

  The sill level of the weir is at 120.5 m asl this implies that it is possible by flushing the reservoir to create flows similar to pre-reservoir conditions in the d/s river Danube.

* <u>Hydropower unit</u>: The discharge can be regulated up to 1300 m^3/s.

* <u>Flood plain weir (weir in the inundation area)</u>: When the 20 gates at the weir on the flood plain become operational and the other remaining construction works related to the weir are finalized, the discharge into the existing Danube can be varied from 0 m^3/s to 4,600 m^3/s.

* <u>Intake structure for Mosoni Danube</u>: When this gate is put into operation the discharge into the Mosoni Danube can be varied up to 25 m^3/s throughout the year. At present there is no flow from the Danube to the Mosoni Danube.

* <u>Intake structure in power canal dike</u>: When this structure is completed is will be possible to divert

up to 250 m^3/s from the power canal to a river arm close to Dobrohost.

After completion of variant C the full complex of structures can provide comprehensive possibilities for regulating the discharges both in low flow and flood situations.

4.2 Environmental impacts

The major environmental consequences are related to the groundwater resources and to the ecology in the floodplain connected to the existing Danube. Both the groundwater system and the floodplain ecology is heavily dependent on the water level (and its variation) in the existing Danube river.

Impacts for groundwater in general and floodplain ecology.

The immediate effects on the groundwater of a smaller discharge in the Danube is a lowering of the groundwater table in the areas close to the river at both the Czecho-Slovakian and the Hungarian sides. Such lowering of the ground water table will have negative impacts on the floodplain ecology (see below) and to some extent also on the agriculture. The long term effects may include changes in the ground water quality.

The effects on floodplain ecology is a result both of the lowering of the groundwater table, resulting in poorer water supply to the riverside vegetation, and of a less frequent inundation of the flood plain.

Thus, the environmental impacts of reducing the discharge in the Danube are negative, unless proper remedial actions are taken. CSFR has included a budget of 2.4 billion CSK for construction of underwater structures as part of Phase 2 of the Variant C. Below is indicated some possible elements in a scheme for remedial measures:

* Small underwater weirs in the main rivers to increase the water levels. This can ensure that the groundwater table will not be lowered in average over time.

* Gate operation to vary discharges, so that a main part of the dynamics of the hydrological system with water table fluctuations can be maintained.

* Opening of the connection between the main Danube channel and the side channels (meanders). Today these connections has (for navigation purpose) been completely closed for discharges less than 2000 m^3/s. The dynamics in these stagnant river arms is poor

resulting in periods with very poor water quality.

* Adding of dredged material from the reservoir to the river thereby reducing the potential bed erosion and increasing the water level.

Such remedial measures are made possible because the navigation at this reach now can take place in the artificial channel instead of in the Danube.

The exact impact on the groundwater and the floodplain ecology as well as on the remedial actions cannot be quantified accurately without detailed studies and without close cooperation between CSFR and Hungary. Within the framework of the ongoing PHARE project "Danubian Lowland - Ground Water Model" such investigations will be carried out for the Slovakian areas.

Implementation of such remedial actions can start now but can not function optimally until the fully regulation possibilities of the hydraulic structures are ready. It is strongly recommended to carry out some of the simpler measures as soon as possible and at the same time to carry out comprehensive investigations on how most optimally to optimise the environmental impacts. Such investigations should be carried out in close cooperation between the two countries.

Immediate impacts observed in Hungary

As a result of the closure of the Danube the discharge in the main channel of the Danube decreased from 800-900 m^3/s on October 24 to 227 m^3/s at Rajka and 356 m^3/s at Dunaremete on October 28 (see Appendix D).

Due to the sudden drop of the discharge in the main channel the water level decreased by 3.0 m at 1850 rkm and by 2.4 m at 1825 rkm in less than 4 days.

Some effects of the decrease of the river water level are:

- the side branches have been cut of from the main channel;
- the water from the downstream part of the side branches disappeared immediately;
- the ground water table has decreased. As a result of this higher energy consumption may be required for pumping of groundwater at Feketeerdö (the water supply of Mosonmagyaróvár). The present water supply at Dunakiliti, Darnózseli and Rajka are directly threatened as the abstraction is based on dug wells having limited depth;
- due to the very sudden drop of the river water level the embankments, the parallel training structures and other river training works have at some places

slided into the Danube;

- the water has disappeared from the ports between the river sections 1811-1850 (Ásványráró, Dunaremete, Dunakiliti);
- the ecological balance of the side branches has become disturbed as water disappeared from the branches.

Impacts for Bratislava water supply

In case the navigation channel is open but without allowing discharge to the turbines the water in the d/s part of the reservoir near Samorin will be practically stagnant. Thus in this part of the reservoir significant eutrophication and sedimentation of organic matter (algae) will take place all over the reservoir. As a result of this the groundwater quality in the area in general and for the Samorin Water Works in particular are seriously threatened. The Samorin Water Works today produces a main part of the water supply for Bratislava. The groundwater quality is not likely to be negatively affected if a significant discharge is maintained through this part of the reservoir into the navigation channel and power canal. This reservoir has been designed and constructed with special consideration to avoiding sedimentation in the parts of the reservoir from where the infiltrating water travels to the groundwater wells fields of Samorin Water Works.

General remark

Finally, it is important to emphasize that the **environmental conditions in certain respects are deteriorating today due to river bed erosion and thus lower ground water tables** (decline varying from approximately 2 m over the last 30 years near Bratislava to approximately status quo near Komarno). Thus the riverside vegetation is slowly drying out resulting in significant changes in vegetation species etc, and the conditions for agricultural water supply through capillary rise from the low ground water tables are no longer good enough and hence more irrigation is required. It is realized that sudden changes as a consequence of e.g. the Gabcikovo - Nagymaros project will occur immediately, and that it will take some time until a new ecological balance develops. However, the "status quo" situation (i.e. pre-dam conditions) is neither a stationary nor a natural situation, but rather a (slower) transition from one cultural landscape to another one with the inherent consequences of this on the ecological conditions.

4.3 Navigation

As a consequence of the ongoing works the navigation route in the existing Danube navigation channel has been closed. Instead the new navigation channel and power canal with the navigation locks at Gabcikovo are being opened.

The bed level in the navigation channel is at the shallowest point 125.5 m asl. The ship locks at Gabcikovo has a threshold of 123.0 m asl. According to the Danube Commission design criteria a minimum water level of 129.0 m asl. in the upstream part of the channel and 126.5 m asl.in the downstream part is required for navigation.

It is planned to open the channel for navigation on November 3 1992. Thus, the immediate impact of the ongoing works is the disruption of navigation for the period from October 23 to November 3, 1992.

When the navigation channel is operational the navigation should be improved as compared to the previous situation, because the water depths will be larger than in the existing Danube and the ships will save a part of the energy required for transport.

5. IRREVERSIBILITY OF ONGOING ACTIVITIES AND COSTS OF RESTORING PRE-DAM STATUS QUO

In principle, the ongoing activities with Variant C could be reversed. The structures, excluding some of the underground parts like sheet piling and injections, could in theory be removed. The cost of removing the structures are roughly estimated to at least 30 % of the construction costs. There will be negative environmental effects during the demolition of the structures and the deposition of the waste materials.

It is therefore relevant to evaluate under which circumstances the Variant C structures could have only insignificant and very local effects if they are not fully removed. Such "functional reversibility" is possible for a scenario like:

* If the Dunakiliti weir and the other structures on Hungarian territory are being operated according to the original plans the gates in the Variant C structures can be kept fully open and will not have any significant effect.

6. IMPACT ASSESSMENT FOR VARIOUS SCENARIOS OF STOPPING/FINALIZING THE WORK AND OPERATION OPTIONS

In this chapter impact assessments are carried out for various scenarios of stopping the work and various operation possibilities. The scenarios are divided into structural and operational ones, the first primarily related to flood damage risks and the last one mainly related to environmental issues.

The following three structural scenarios are considered:

I The work will be stopped for a period of no longer than one month, until a final solution is found.

II The work will be stopped for a period of no longer than three months, until a final solution is found.

III The work will be stopped for a period of one year allowing international arbitration to take place.

The following three operational options are considered:

A The "whole" traditional quantity of water is directed into the old Danube river bed.

B The main part of the water is diverted to Gabcikovo, only maintaining a minimum flow in the old Danube of 600 m3/s.

C A combination of A and B

The following combinations of structural and operational scenarios are technically possible:

- I + B
- I + C
- II + B
- II + C
- III + A
- III + B
- III + C

For all scenarios the following two points applies:

* Some of the immediate and local environmental impacts can to some extent be remediated by fully reversible measures such as moving of soils, planting of trees, etc. The Mission recommends such measures to be implemented as soon as possible.

* With regard to the dates mentioned in the structural scenarios (sections 6.1 - 6.3) they should be taken as indications only. Basically, the Mission is describing which constructions have to be completed in order to obtain the necessary protection against

flood damages to the structures. The dates are hence based on work schedules for the project implementation as informed by the designers and technicians of the contractor. The Mission cannot exactly assess whether the contractor can conform with these time schedules; however it is realized that there are considerable uncertainties related to such type of work.

6.1 Structural scenario I: Work stopped for duration of one month

Structural aspects

To allow the works to be stopped for a period of one month in the coming winter season and accepting a design flood discharge of 6000 m^3/s (1 % risk of exceedance) the following works on the structures have to be completed:

- Fortification of the dams and dike.
- Erosion protection downstream the inundation weir (as far as possible).

According to the informed project plans it should be possible to carry out this work by November 15 1993.

Other aspects

Stopping the work for one month and maintaining the organisation (2500 working persons, 400 trucks, etc.) for resuming the work, if that is decided, has some considerable organisational and financial implications.

6.2 Structural scenario II: Work stopped for duration of up to three months

This is from a technical point of view the longest possible period the work can be stopped in the coming winter until a final solution is decided upon. Unless, it is then decided to finally stop the work and abandon the hydraulic structures the work must continue in order to be prepared for the potential summer flood.

Structural aspects

To allow the works to be stopped for a period of up to three months in the coming winter season and accepting a design flood discharge of 6000 m^3/s the following works on the structures have to be completed:

- Fortification of the dams and dike.
- Erosion protection downstream the inundation weir

(as far as possible).

According to the informed project plans it should be possible to carry out this work by November 15 1993.

However, according to the informed work schedules it will not be possible to stop the testing and preparation of the turbines for operational use for more than one month; otherwise the number of turbines tested and ready for operational use cannot be increased to five by the start of March 1993.

Other aspects

According to the informed project plans completion of the necessary structural work (except at Gabcikovo) requires two months of work. Stopping the work at the earliest possible date (approximately 15 November 1992) and resuming it three months later has significantly larger organisational and financial implications than stopping for one month (Scenario I), and it may not be practically feasible. It is therefore recommended that the necessary structural works be completed (1 January, 1993 according to the informed project plans), before the three months stopping of work.

6.3 Structural scenario III: Work stopped for duration of one year

Considering a one year period for stopping of work to be a transition period equivalent (from the point of view of risk to structure damages) to the construction period, a yearly design flood discharge of 10600 m^3/s (1% risk of exceedance) can be applied.

However, for longer periods than one year of stopping the work, the structures can be considered to be in a more permanent state; hence the risk level corresponding to 0.01% should be used as the basis for the design flood. Flood protection against such a design flood of 15000 m^3/s thus requires construction of the Phase 2 structures of the Variant C. Consequently, one year is the longest period for stopping of work until a final solution is found.

Structural aspects

To allow the works to be stopped for a period of one year and accepting a design flood discharge of 10600 m^3/s the following works of the structures have to be completed (further to Scenario I):

- The downstream area of the inundation weir including protection works.
- The concrete works in front of the openings of the inundation weir in order to make it possible to close the opening with beams.
- The number of turbines fully tested and ready for operational use must be increased to five.

According to the informed project plans it should be possible to complete the turbine work by March 1, 1993 and the other work by January 1, 1993.

Other aspects

Stopping of construction works for one year would result in a significant amount of extra cost due to amongst others existing contracts. The extra costs will be considerably lower if 15 gates of the inundation weir will be completed instead of the second measure mentioned above.

6.4 Operational scenario A: "Whole" discharge back to the old Danube

Technical aspects

Technically, the main part of the Danube discharge can be directed into the existing river bed through the by-pass weir and the floodplain weir under the structural conditions corresponding to Scenario III. The exceptions for directing all discharge into the old Danube are:

* Some discharge will be required for operating the navigational locks. The amount of water required to fill one ship lock is approx. 175000 m^3, in the projects plans 40 passages are assumed every day. This results in an average daily discharge of 81 m^3/s, which cannot flow to the old Danube.

* Some additional discharge will be required for testing turbines and generators in Gabcikovo.

* During flood operation a significant discharge has to go through Gabcikovo, see the table in Appendix C.

Environmental impacts

This operation will ensure basically status quo in the old Danube, i.e. there will only be minor impacts on the floodplain ecology and groundwater systems in general.

Directing all discharge to the old Danube will, on the other hand, result in a major threat to the Samorin Water Works, which produces a main part of the water supply for Bratislava. This threat is associated to stagnant water and algal growth in the downstream part of the reservoir. Hence this effect will be serious in the growth season during summer.

Other aspects

Not utilizing the hydropower plant at Gabcikovo at all (except in flood situations) has significant direct economical losses as compared to the scenario B.

6.5 Operational scenario B: Main part of water directed to Gabcikovo

In this scenario a high operational priority is given to hydropower generation. A minimum discharge to the old Danube of 600 m^3/s in the winter season and 1200 m^3/s in the summer season is assumed.

Technical aspects

This operational scenario is possible both in connection with the structural scenarios I, II and III.

Environmental impacts

This operation will result in immediate negative environmental impacts for the floodplain ecology and the groundwater systems near the Danube.

Directing a main part of the discharge to Gabcikovo will, on the other hand, most likely ensure the groundwater quality at Samorin, and hence the water supply for Bratislava.

6.6 Operational scenario C: Combination of A and B involving a trade off between different interests

Realizing that both operational scenarios A and B result in serious environmental damages to the region it is relevant to investigate alternative operation policies where a trade off is made between the different key interests represented in A and B. This calls for optimization of operation policies.

A possible element, which amongst others could be investigated further are, in a flexible way, to vary between operations A and B according to the situations in the Danube flood plain and the Samorin reservoir. This could e.g. imply that the whole discharge to the old Danube be maintained 3-5 days per week, flushing of the Samorin Reservoir and hydropower production be done for 2-4 days per week.

It should be emphasized that it is not necessarily simple to achieve at the most optimal operation strategy and that it will most likely be more complex than the above example. However, the mission believes that it would be possible to define more optimal scenarios maintaining the major part of the advantages of A and B and at the same time not containing the main disadvantages of A and B. Realizing that the largest environmental damages will not occur until the coming summer season (after March 1993), the mission strongly recommends to carry out studies for optimization of the operation within the coming few months.

In addition to the above non-structural action, it is emphasized that a more final optimization with full weight to the ecological conditions most likely includes a range of regulation measures within the flood plain area itself. The recommended detailed investigations for such measures and subsequent implementation will take a few years.

Both the short term and long term studies as well as the subsequent implementations should take place in close cooperation between CSFR and Hungary.

Bratislava, October 31, 1992

For the CSFR : Dr. Igor Mucha

For Hungary : Dr. Péter Bakonyi

For the CEC : Mr. Jens Christian Refsgaard

APPENDIX A

Members of the three delegations:

For the European Commission:

Mr. Jens Christian Refsgaard, Chief Hydrologist, Danish Hydraulic Institute (Member of Fact Finding Mission)

Mr. Jan M. Van Geest, Director Infrastructure, DHV Consultants, The Netherlands

Mr. Jesper T. Kjelds, River hydraulics and sediment transport engineer, Danish Hydraulic Institute

For the Czech and Slovak Federative Republic:

Professor, Dr. Igor Mucha, Faculty of Natural Science, Comenius University, Bratislava.

Ing. Stefan Molnar, Office of Representative of Government of the Czech and Slovak Federative Republic for construction and management of Gabcikovo-Nagymaros hydropower scheme

For Hungary:

Dr. Péter Bakonyi, Managing Director, VITUKI Consult Rt, Budapest.

Dr. János Szekeres, Head of Dept., VITUKI, Budapest.

János Maginecz, researcher, VITUKI, Budapest.

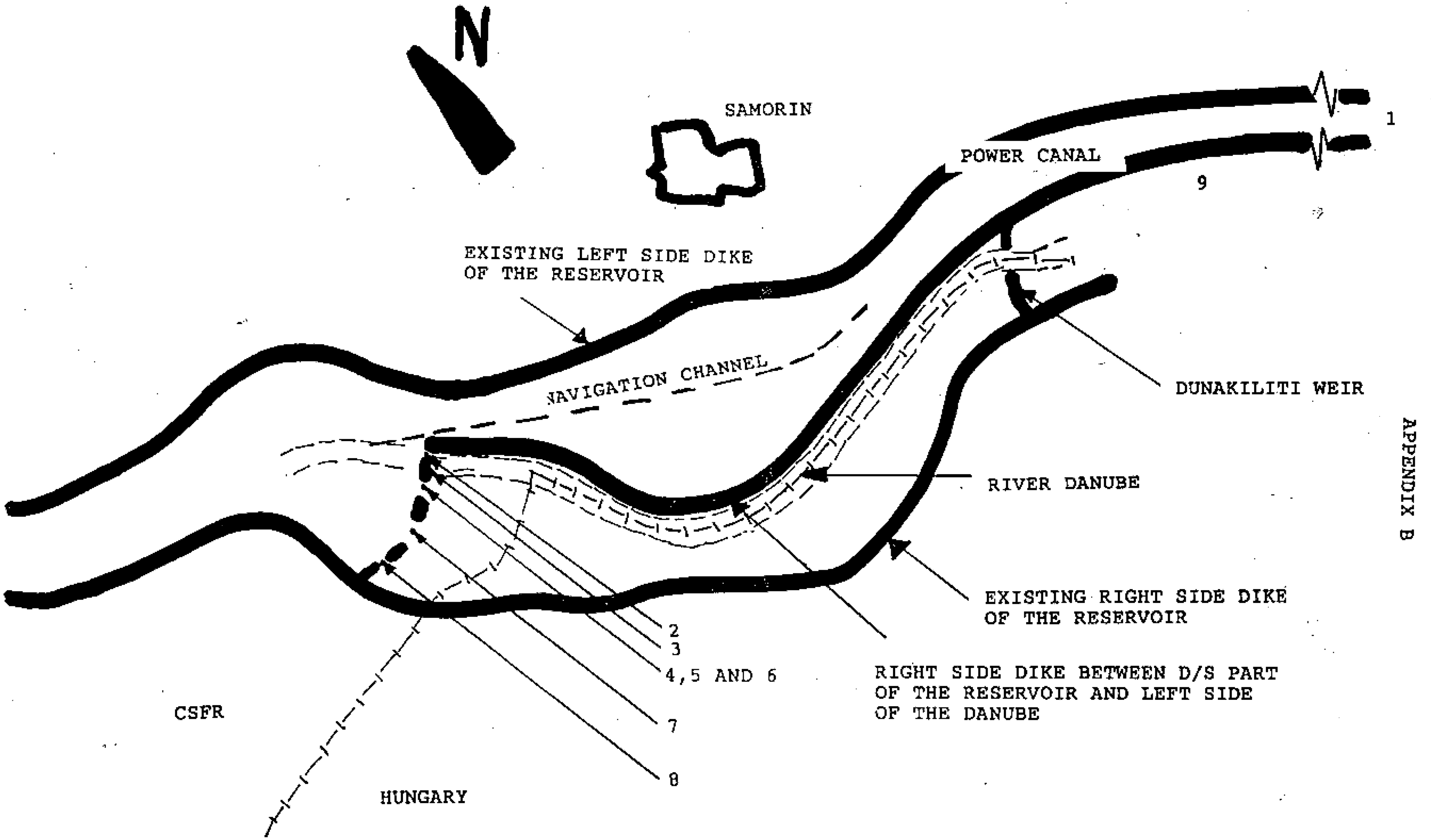
Mr. György Jakus, Director, North Trans-Danubian Water Authority, Györ

Mr. Tivadar Gerencsér, Director, North Trans-Danubian Environmental Inspectorate, Györ

Mr. Lajos Horváth, Head of Dept., North Trans-Danubian Environmental Inspectorate, Györ

György Hábel, special adviser, Budapest

István Molnár, special adviser, Budapest


N
SAMORIN
POWER CANAL
1
9
EXISTING LEFT SIDE DIKE
OF THE RESERVOIR
NAVIGATION CHANNEL
DUNAKILITI WEIR
RIVER DANUBE
EXISTING RIGHT SIDE DIKE
OF THE RESERVOIR
RIGHT SIDE DIKE BETWEEN D/S PART
OF THE RESERVOIR AND LEFT SIDE
OF THE DANUBE
2
3
4,5 AND 6
7
8
CSFR
HUNGARY

APPENDIX B

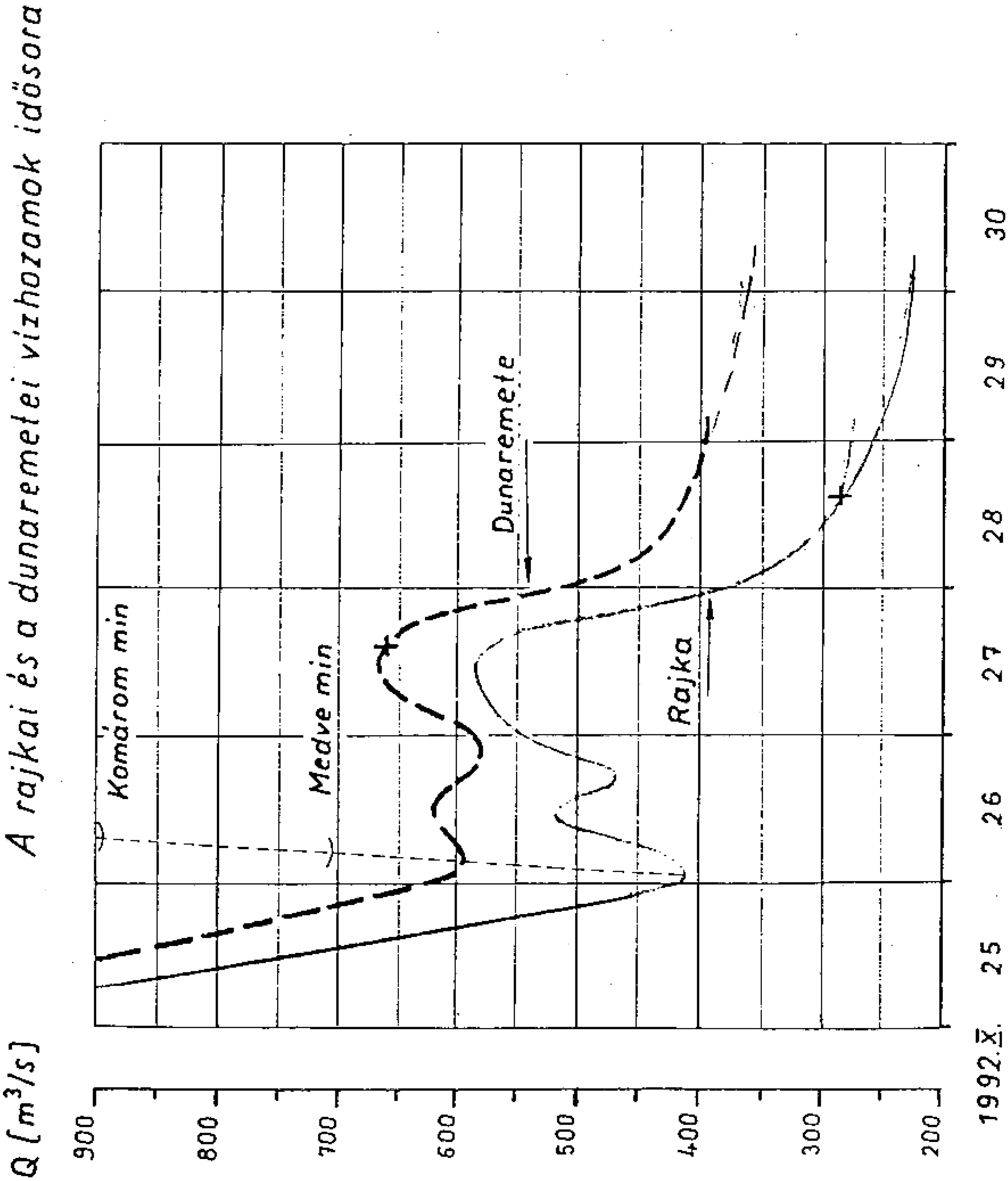
Appendix C

DISCHARGE CAPACITIES [m^3/s] OF ALTERNATIVE C.
(according to the scheduled completion and stated water levels)

PERIOD	30-10-92	30-10-92	15-11-92	01-01-93	01-03-93	31-12-95
WATER LEVEL m asl	129.0	131.1	131.1	131.1	131.1	131.1
GABCIKOVO COMPLEX						
Ship locks	1500 *	1970	1970	1970		
Power station	500 *	610	1220	1830	5200	5200
Water intake in dike		250	250	250		
ALTERNATIVE C PHASE 1						
By-pass weir	600 *	1460	1460	1460	1460	1460
Floodplain weir	500 *	2340	2340	4600	4600	4600
Mosoni weir	20	25	25	25	25	25
ALTERNATIVE C PHASE 2						
Locks,weir and HEP						6300
TOTAL	3120	6655	7265	10135	11500	19385
DESIGN FLOODS						
$Q_{1\%,\ winter}$	6000	6000	6000	6000	6000	
$Q_{1\%,\ year}$						10600
$Q_{0.01\%,\ year}$						15000

* : estimated values.

APPENDIX D


A rajkai és a dunaremetei vízhozamok idősora
Q [m3/s]
900
800
700
600
500
400
300
200
1992.X.
25
26
27
28
29
30
Komárom min
Medve min
Dunaremete
Rajka

COMENIUS UNIVERSITY, FACULTY OF NATURAL SCIENCES
GROUND WATER DIVISION

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APPENDIX E

COMMISSION OF THE EUROPEAN COMMUNITIES

FACT FINDING MISSION ON
Variant C of the GABCIKOVO - NAGYMAROS Project

Part of the MISSION REPORT
elaborated by Univ. Prof. Igor Mucha,
on behalf of Czech and Slovak Federative Republic

Final version
Bratislava
October 31, 1992

This document is an attached part of the final report of the Fact Finding Mission on Variant C of the Gabcikovo - Nagymaros Project, elaborated by the three experts who have been appointed by the CEC to constitute the Fact Finding Mission. This document is elaborated to express the standpoint of the Czecho-Slovakian part of the Fact Finding Mission and is signed separately.

Czecho-Slovak part of the Fact Finding Mission generally agreed with the facts which are expressed in the Main Fact Finding Document.

In the Introduction of the main document of the Fact Finding Mission there is statement, written as a preamble, from the Minutes of the Meeting between the EC, CSFR and Hungary held on 28th Oct. 1992 on the Gabcikovo-Magymaros Project. These Minutes are presented as a valid documents. A part of the Fact Finding Mission document applies these Minutes as basis for various scenarios of stopping/finalizing the Gabcikovo scheme.

The Minutes are not yet approved by Federal and Slovak Government and therefore it is not possible to recognize it as terms of references for the Mission. It is technically not possible "to guarantee to maintain the whole (not less than 95 %) traditional quantity of water into the whole old Danube riverbed".

Taking into account the risk of damage of existing structures, including navigation facilities, ecological damage, flooding risk, it is not possible to stop "all works" until the all dikes are fortified at the projected level. By-pass weir controlling the flow into the river must be fully operational and the flood plain weir in inundation should be at least on the left side ready for operation. The service roads should be ready and surrounding area tidied up.

Czecho-Slovak part of the Fact Finding Mission cannot accept scenarios in chapter 6 of the Main document if there are some risks according to damage of objects of the structure, risk of a flood, arising navigation problems and endangering of ground water quality. Czecho-Slovak part cannot accept additional expenses, arising from changes of type of work, changes of the project and changes in the operational management.

As an acceptable scenario for the trilateral negotiation following proposal is presented. At a date specified by the EC commission on the basis of the Fact Finding Mission the Czecho-Slovakia will stop works on Variant C as specified:

- work on ship lock,
- work on spillway weir and hydropower station (for transfer of sheet ice),
- assembly of electric generators on the turbines No. 1, 2, 3,
- assembly of five flood plain weir tanter gates.

All this work can be stopped immediately during the work of the trilateral group of experts, but the interruption of work can be only until July 1993.

All the necessary fortification works on by-pass weir, flood plain weir, intake structure for Mosoni Danube, intake structure in power canal dike will progress until their final completion. All the finishing arrangement of surface, roads, inundation area behind the flood plain weir will be finalized. The goal of this work is to obtain fully operational structures for management of discharges and maintaining water levels.

According to the operational options included in the chapter 6 and taking into account ecological, financial, navigational and flooding optimization a combined variant of optimization of water diversion to Gabcikovo and old Danube river bed and maintaining the water levels will be used. According to the Treaty on the border rivers from 1976 (article 3 and point 2) the water will be divided equally between the old Danube river bed and power canal. During floods water will be optimally distributed between old Danube river bed and power canal to lower potential risk of flooding downstream from Bratislava. During the whole period data for further optimization work on Hungarian and Slovakian sides will be collected to lower environmental risks as much as possible and eventual to improve the pre-dam conditions.

Univ. prof. Igor Mucha

APPENDIX F.

Dessenting voice: The Fact Fiding Mission assessed the immediate effects of the construction of Variant C. However the statements of the report are correct, due to different interpretation of the Terms of Reference stated in the Aggreed Minutes of the Meeting between the EC, the CSFR and Hungary on 29th October I include a scenario which I believe corresponds to the intent of those who signed that Aggreement.

Structural scenario IV: Work stopped immediatelly and the discharge put back into the Danube

This scenario corresponds to the first point of the Aggreed Minutes of the Meeting between the European Commission, the CSFR and Hungary on 29th October. The basic idea is to stop all works on Variant C of the Gabcikovo/Nagymaros project and to route the "whole" traditional quantity of water into the Danube at Rajka.

It is envisaged that all work should be stopped immediatelly except what is ment to mentain stability of structures and to improve the discharge capacity of the weir in inundation.

Work to be completed in a short period:
- complete reopening of the by-pass weir;
- completion of the bed protection downstream of the first 4 openings of the weir in inundation;
- connection of the first 4 openings of the weir in inundation to the Danube;
- completion of the water intake for the Mosoni Danube;
- opening of the first 4 openings by removing the protective dyke on the upstream part.

The work to be stopped include:
- construction of the closure of the Danube at Cunovo;
- construction of the weir, power station and ship lock complex;
- completion of tanter gates of the by-pass weir;
- mounting of tanter gates on the weir in inundation.

The work that can go on:
- protection work on the tail water of the by-pass wier;
- bed protection on the closure dam if it was necessary;
- completion of the rest of the openings by finishing the concrete work of the runways at the upstream part of the structure, the bed protection down stream and the excavation of the connecting channel to the Danube;
- opening the structures one by one, two by two etc. as soon as they are ready.

By carrying out this project the discharge capacity of the existing structures of Alternative C will be increased from the immediat 600 m^3/s (excluding the leakage through the closure of the Danube; approx 150-200m^3/s) at a water level of 129 m a.s.l. to approximately 600+20*60=1800 m^3/s at the same water level. The discharge capacity of the weirs can be increased by increasing the water level in the reservoir but in this case some additional work (i.e. fortification of dykes) should be completed.

Pét Bak

Péter Bakonyi
Hungary

Annex 14

COMMISSION OF THE EUROPEAN COMMUNITIES
CZECH AND SLOVAK FEDERATIVE REPUBLIC
REPUBLIC OF HUNGARY

WORKING GROUP OF INDEPENDENT EXPERTS ON VARIANT C OF THE GABCIKOVO-NAGYMAROS PROJECT

WORKING GROUP REPORT

Budapest
November 23, 1992

TABLE OF CONTENTS

APPENDICES:

A: Agreed Minutes of the Meeting between the European Commission, the CSFR and Hungary on 27th October 1992 on the Gabcikovo/Nagymaros Project

B: Terms of References for the Working Group

C: Members of the three delegations assisting the Working Group

D: Statement from J. Binder, Director Water Economy Construction on state of work.

E: Sketch of Variant C of Gabcikovo-Nagymaros

F: Discharge capacities of Variant C structures

G: Figures illustrating the present (pre-dam) state and trend in the area

H: Figures illustrating the observed immediate impacts

I: Summary of impacts for different scenarios

J: Figures illustrating Scenario C

K: Hungarian proposals for redirecting the Danube to the former river bed

L: Statement by the Hungarian representative

M: Statement by the CSFR representative

1. INTRODUCTION

At a meeting held in London on 28th October, 1992 between the European Commission (CEC), the Czech and Slovak Federative Republic (CSFR) and the Republic of Hungary an agreement was reached regarding the Gabcikovo/Nagymaros Project, cf. Appendix A. In accordance with the Agreed Minutes from this meeting a Fact Finding Mission composed of one expert from each side (EC, CSFR and Hungary) submitted a report on October 31, 1992, /Ref 1/ and the present Working Group was formed.

The Terms of References for the Working Group are given in Appendix B. The Working Group has after consultation with Mr. Pablo Benevides, Director DGI, Commission of the European Communities made the following clarifications of the Scope of Work in the Terms of References:

* An assessment of the need for the CSFR to make the closure of the Danube after October 22 lies outside the Scope of Work. However, the issue is partly dealt with in Section 3.1 of the report.

* Assessment of earth quake risk and potential damage lies outside the Terms of References.

* The term "existing (pre-dam) conditions" refers to the situation before starting to operate Variant C (October 22, 1992) as far as point (iii) in the Scope of Work is concerned, whereas it refers to the situation before construction of the Gabcikovo works as far as point (iv) in the Scope of Work is concerned.

The Working Group is composed of the following six experts:

CEC: Mr. Jens Christian Refsgaard, Chief Hydrologist, Danish Hydraulic Institute, Denmark (Team Leader).

Mr. Jan M. Van Geest, Director, DHV Environment and Infrastructure, The Netherlands.

Mr. Johann Schreiner, Director, Norddeutsche Naturschutzakademie, Germany.

Professor, Dr. Heinz Löffler, Head of Zoological Department, University of Vienna, Austria.

* CSFR: Professor, Dr. Igor Mucha, Faculty of Natural Science, Comenius University, Bratislava.

* Hungary Professor, Dr. Gabor Vida, Head of Department of Genetics, Eötvös L. University, Budapest.

Professor Löffler joined the group on November 15, while the other five members were present throughout the period. The six experts were assisted by colleagues as listed in Appendix C. The Working Group had its first formal meeting on November 9, 1992 in Bratislava. Field inspections were carried out on November 9, 10 and 22 both in Czecho-Slovakia and in Hungary. During the period November 9 - 14 the Working Group worked in Bratislava and during the period November 15 - 23 in Budapest.

The Working Group has obtained all relevant data and information requested from the two Governments. The report is based on this information.

2. VARIANT C STRUCTURES AND STATUS OF ONGOING WORK

The Fact Finding Mission (FFM), cf Ref. /1/, carried out an on-site inspection of the ongoing work on

(a) October 30, 1992

The Working Group (WG) visited the site of the construction twice, namely on

(b) November 9, 1992

(c) November 22, 1992, i.e. one day after the deadline decided by the EC for stopping the construction.

In addition, data has been obtained from reports, designers, constructors and from meetings with the person in charge of the construction work (Mr. J. Binder). A statement from Mr. Binder on the status of work as per November 21, 1992 is enclosed as Appendix D. The status of the work including the facts observed on the three visits are summarised in this chapter.

In both countries the original structures for the Gabcikovo scheme are completed except for the closure of the Danube river at Dunakiliti and the

(1) Completion of the hydropower station (installation and testing of turbines) at Gabcikovo.

Variant C consists of a complex of structures, located in Czecho-Slovakia within the area of the original Variant A. The construction of these are planned for two phases. The structures include (see the sketch in Appendix E):

(2) By-pass weir controlling the flow into the river Danube.
(3) Dam closing the Danubian river bed.
(4) Floodplain weir (weir in the inundation).
(5) Intake structure for the Mosoni Danube.
(6) Intake structure in the power canal.
(7) Earth barrages/dikes connecting structures

(8) Ship lock for smaller ships (15 m x 80 m).
(9) Spillway weir.
(10) Hydropower station.

The construction of the structures 1 - 7 are included in Phase 1, while the remaining 8 - 10 are a part of Phase 2 scheduled for construction 1993-95.

The status of the work was as follows:

(1) Hydropower station (HEP) and ship locks at Gabcikovo

The HEP is designed for peak power production. The planned 8 turbines have a nominal capacity of 4,000 m^3/s. At present five turbines and generators are being installed, the remaining three turbines are not planned for completion in the near future. By high head the maximum capacity is approximately 610 m^3/s per turbine. At the designed operational water level of 131.1 m asl. (reference Baltic msl) the design head is approximately 22 m.

All turbines need a period, depending of the discharge in the channel, for operational testing, because the whole equipment is a prototype.

The two ship locks (each 34 m wide and 275 m long) has a total hydraulic capacity of 1970 m^3/s when open. With five turbines operationally installed the total combined hydraulic capacity of the turbines and locks are thus:

$$5 \times 610\ m^3/s + 1970\ m^3/s \Rightarrow 5020\ m^3/s.$$

If more turbines are installed the capacity of the canal of approximately 5200 m^3/s will be the flood discharge limited by the velocity in the power canal.

(a) FFM visit on October 30:

- Turbine no 7 was being tested at half capacity producing 40 MW power with a discharge around 200 m^3/s. Turbine no 8 had been tested hydraulically but not yet electrically. The remaining three turbines were undergoing a hydraulic testing programme. The testing programme allows for discharges to be between 80 and 120 m^3/s.

(b) WG visit on November 9:

- The head varied between 14.9 and 17.6 m, and the upstream water level varied between 127.17 m and 128.14 m.

- One of the ship locks were opened for traffic while the other one was being repaired after having been damaged by some debris.

The status on November 12, according to information from Mr. J. Binder, director Water Economy Construction, was that turbines No. 4 & 7 were being electrically tested at about 2/3 capacity (61 MW each). Turbine No. 8 was undergoing hydraulic testing at a discharge of 80 m^3/s. Turbines No. 6 & 5 are scheduled to be ready for electrical testing by the end of November and hydraulically tested by the end of December 1992.

(c) WG visit on November 22:

- One of the shiplocks was operating while the other one was being tested after a period of repair. Two of the turbines were operated with a discharge of 500 and 100 m^3/s respectively. Bottom protection downstream of the power plant was being carried out. The water levels varied between 127.98 and 128.37 m asl. upstream and 113.08 and 112.28 m asl. downstream of the power plant from 7 to 13 hours.

- Although it is not a part of Variant C but has an effect on its operation it is mentioned that at the outlet of the downstream canal (at 1811 rkm on the Danube) the closing dam was being removed. About 2/3 of it had been removed and according to the judgement of the Working Group it may take about two months more to remove the dam completely.

(2) Closure of the Danube

The closure of the Danube river bed started on October 23 and was completed on October 27. One week earlier the discharge was at a low of about 850 m^3/s, while it increased from 1400 to 1860 m^3/s during the period of closure.

(a) FFM visit on October 30:

- The crest level of the dam was approximately 131 m asl. The dam was not yet fully tightened leaking water approx 150 m^3/s. The water level in the reservoir varied between 128.8 and 129.0 m asl.

(b) WG visit on November 9:

- The crest level of the closure had been raised to 133,8 m asl. The width of the crest was about 40 m. There was very little leakage through the closure. The structure was being prepared for tightening and leakage control by a vertical impermeable wall and stony wave protection.

- The water level in the reservoir was between 128.65 and 128.80 m asl.

(c) WG visit on November 22:

- There was about 5-10 m^3/s leakage through the right third of the closure. It is much more than the leakage seen on November 9. On the left-downstream side of the closure an about 30-40 m wide gravel dam was built - to prevent leakage - which covered 2/3 of the dam width.

According to information from Mr. J. Binder (November 12) the remaining work except the stony wave protection is scheduled to be completed by January 1, 1993, but will be delayed if freezing occurs before then.

<u>(3) By-pass weir controlling the flow into the river Danube</u>

The flow into the river Danube from the reservoir is lead via this weir.

The weir consists of four tainter gates each 18 m wide with sill level at 126.5 m asl. The maximum hydraulic capacity of the weir at the reservoir water level 131.0 m asl. is 1460 m^3/s, whereas the capacity is approximately 650 m^3/s at a water level of 129.0 m asl.

Due to unexpectedly difficult geological conditions large erosion problems have been experienced at the bottom and river sides downstream the weir. Therefore, additional fortification is being carried out, and the full operation of the weir with maximum possible discharges have been delayed.

(a) FFM visit on October 30:

- To repair the bottom protection and river sides the weir was closed totally on Oct. 29 - 30.

(b) WG visit on November 9:

- Fortification of the downstream bed protection was carried out while discharging about 300 m^3/s into the Danube.

According to information from Mr. J. Binder (November 12) the protection works are gradually progressing, so that the structure is expected to enable a flow of about 600 m^3/s under daily circumstances on November 21 and about 800 m^3/s on November 25, 1992 (if work continues). The work is scheduled to be completed by January 1, 1993, so that a maximum discharge of 1460 m3/s, depending on the reservoir water level, can pass.

(c) WG visit on November 22:

- A barge of about 50 m length sank in front of the by-pass weir closing two and a half of the openings. The water was spilling over the barge providing some water for the two fully blocked openings while in the third opening the water was both spilling over the barge and running besides it. The fourth gate - which was not blocked by the barge - was completely closed.

- Protection work was going on - similarly to the situation experienced during the previous visits - on the spillway of the by-pass weir. According to Mr. Binder the works would be finished within the next two days.

The four tainter gates are expected to be fully operational by the end of December 1992, but can until then be operated by temporary measures.

(4) Flood plain weir (weir in the inundation)

The weir consists of 20 tainter gates each 24 m wide with sill level at 128.0 m asl. When finalized each of the gates has a hydraulic capacity of 230 m^3/s (total capacity if the weir is 4600 m^3/s) at the maximum water level of 131.1 m asl. The capacity at a water level of 129.0 m asl is estimated to be 60 m^3/s per gate.

In front of the gates a temporary non-fortified protective dike has been established. When the dike is eroded or removed in case of high water level, the weir has a discharge capacity ranging from 2500 to 4000 m^3/s corresponding to a water level of 131.1 m asl, depending on the actual ground level downstream the weir.

The floodplain weir and the bottom protection were originally designed for use only in flood situations (few days per year). This design has been modified as a result of the London Meeting to allow daily use. Along the Danube right bank a spillway is under construction and the downstream bed will be protected with additional 100,000 m^3 stone. This work is scheduled to be completed by January 1, 1993.

(a) FFM visit on October 30:

- None of the gates could be operated and only four gates had the full hydraulic capacity. Due to the level of the terrain downstream the weir, 16 gates had a reduced capacity. A small part of the concrete works were not yet finished.

(b) WG visit on November 9:

- 10 gates were being prepared for opening. Upstream bed protection was completed; downstream bed protection was not yet completed and the tail water channel was being dug out and protected.

- The crest level of the temporary dike in front of the gates was at 130.5 m asl.

According to information from Mr. J. Binder (November 12) the tail water channel would be ready by January 1, 1993, whereupon all the 20 gates can be opened for daily use. According to schedule the entire temporary dike will be abolished by January 15, 1993.

(c) WG visit on November 22:

- 15 of the tainter gates were mounted, but the concrete work was not done. Five of the tainter gates were lying behind the openings on the ground.

- 10 of the openings had an about 10 m wide bed protection on the downstream side. It was to be elongated to have 50 m width. The rest of the gates had no tail-water protection.

- The road on top of the structure was ready, covered with asphalt.

- The protective earth dam upstream the structure was widened and heightened to about 131 m asl.

<u>(5) Intake structure at entrance to the Mosoni Danube</u>

In the intake structure for the Mosoni Danube a small hydropower station with two turbines has been constructed with a bypass capacity of 25 m^3/s corresponding to a water level of 131.1 m asl and 20 m^3/s at 129 m asl. The concrete works at the construction are not completed but a by-pass consisting of two pipes is used operationally. Installation of the turbines will not be completed for a longer period. A supply canal on Slovak territory is connected to the Mosoni Danube on Hungarian territory.

Discharge to the Mosoni Danube started on October 30, 1992 with about 10 m^3/s. After lining of the supply canal (scheduled for completion by November 1) the discharge can be increased to 20 m^3/s. The entire structure, except the power station, is scheduled for completion by March 1993.

(6) Intake structure in power canal.

The intake structure located in the power canal allowing for a maximum discharge of 234 m^3/s to be supplied to a river arm in the left bank of the floodplain downstream the Dunakiliti weir close to Dobrohost is completed. Sill level of the structure is at 128.5 m asl.

A channel connecting the structure and the downstream river arm on the Slovak side was being dug (November 9). As a temporary measure two pipes of 1.2 m diameter were used to provide about 7 m^3/s discharge.

The entire work is scheduled to be completed by April 1, 1993.

(7) Earth dams/dikes connecting structures

The connecting dike between the downstream part of the reservoir and the left hand side of the Danube is currently not fully fortified.

(b) WG visit on November 9:

- There remains still 10 % of the dike to be strengthened to withstand waves. The connecting dams between the weirs are not yet finished and need to be fortified several places. Completion of the work on the dams and dike is planned to be finished by mid of November.

(c) WG visit on November 22:

- The wave protection of the left bank dike had been completed except at two places, where a few tens of meter protection was missing.

The road on top of the dams will be completed by January 1, 1993.

The wave protection of the protective dike upstream of the future structures (No. 8,9 and 10) and the earth barrages on the left and right hand side of the intake structure for the Mosoni Danube are not planned to be protected against wave actions as yet.

The wawe protection of the future structures No 8, 9 and 10 had been raised to about 130 m asl. (November 22).

<u>(8) Ship lock</u>
<u>(9) Spillway weir</u>
<u>(10) Hydropower station (HPS)</u>

Between the by-pass weir and the floodplain weir a temporary dike has been established and fortified with geo-textiles and rock boulders up to the level 130.0 m asl. Fortification up to 131.1 m asl. is scheduled to be completed by December 15, 1992. The crest level of the dike is at 133.8 m asl.

From the Mosoni intake structure to the Danubian dam closure the front is protected against seepage with a 30 m deep sheet piling.

These works are a part of Phase two and are projected to be ready for use ultimo 1995. At maximum water level the hydraulic capacity of the ship lock and spillway weir will be 5000 m^3/s and the capacity of the HPS is 1300 m^3/s. The sill level of the spillway weir is at 120.5 m asl., which is the same as in the existing river bed.

3. ASSESSMENT OF THE NEED AND URGENCY OF THE STRUCTURES IN FLOOD SITUATIONS AND WATER MANAGEMENT POSSIBILITIES IN DAILY OPERATION

In this chapter an assessment is made of the need and urgency of the structures in the light of the potential flooding risk, including the risk of causing damage to already constructed parts. Furthermore, the water management possibilities in daily operation of the structures are described.

3.1 Flood discharge capacities of structures

The design flood discharge for the project variant C (including phase 1 and 2) is based on a 10000 year flood event, i.e. a risk of 0.01% to occur within a year.

For the construction period usually a larger risk than 0.01% is accepted. Assuming a 1% risk per year as acceptable during the construction period (100 year flood event) the corresponding design flood discharge depending on the period of the year is:

- Full year : 10600 m^3/s
- Summer season (March - October) : 10600 m^3/s
- Winter season (October - March) : 6000 m^3/s

Hence, the flooding risk of stopping the work depends on the period during which the work will be stopped. For example stopping the works for some period during the winter season requires one (lower) level of finalization of the present structures before it is possible to stop the work, while stopping the work for more than a year (e.g. while international arbitration and further studies take place) requires another (higher) level of finalization.

The flood discharge capacities of the Variant C structures and the Gabcikovo complex are summarized in the table in Appendix F for different stages with regard to degree of finalization of the structures and water level in the reservoir. The key figures are as follows:

Date	Flood discharge capacity (m^3/s)
1991	10500
20-10-92	7000

30-10-92	2800
22-11-92	7900 - 9400
01-01-93	11500
31-12-95	19400

From a comparison of the above table and the design flood discharges of 6000 and 10600 m^3/s for winter and summer seasons, respectively, it appears that the situation by January 1, 1993 is expected to be equivalent to the pre-dam (1991) situation. However, it is also noticed that the flood discharge capacity on October 20, 1992 was insufficient to pass a summer design flood. If a flood larger than the discharge capacity should occur, it will cause damage to structures and may in addition cause a threat to areas outside the main existing dikes due to backwater effects from the structures.

In the period until January 1993 the water level in the reservoir is planned to be operated between 128 and 130 m asl, allowing for navigation. In case of a flood in this period the water level could rise up to the water level 131.1 m asl. After this period the water level is planned to be operated close to the desired 131.1 m asl.

In a possible flood situation some of the not yet finished structures might be damaged depending of the peak and duration of the flood.

Should a flood occur now before the remaining 10 % of the dike between the downstream part of the reservoir and the left hand side of the Danube is protected against waves the dike could be damaged from erosion. The unprotected dams at Cunovo connecting the structures could likewise be damaged due to erosion. Protection of the floodplain behind the floodplain weir is not yet carried out and during a flood it will erode. The stability of the weir will however not be in immediate danger. Parts of the side-protection of the by-pass weir could suffer as well, this construction is however being fortified at the moment so this risk is only eminent for a few days from this date.

The protection of the floodplain behind the floodplain weir was being carried out during the second field visit (November 9) and it is scheduled for completion by January 1, 1993.

After completion of the dike and the by-pass weir the winter 100 years flood can pass the structures.

When the dike, by-pass weir and floodplain weir is finished (end of 1992) the hydraulic capacity of variant C equals $Q_{1\%,year}$. To meet the design criterion $Q_{0.01\%,year}$ Phase 2 has to be completed.

As concerning the flooding risk in general it is not likely that a flood occurring after January 1, 1993 would give rise to an extraordinary flooding hazard in areas outside the main existing dikes.

Although not directly related to the works of Variant C the most flood endangered reach of the Danube in the area of interest is the left hand side between Palkovicovo (milage km 1811) and Medvedov (milage km 1806) due to extensive siltation and lack of dredging.

3.2 Water management possibilities

The Gabcikovo complex can regulate the discharge between 80 m^3/s (necessary for shiplocks) and 5200 m^3/s (maximum admissible discharge in the power channel).

Upon completion the weirs of the Phase 1 of Variant C (Mosoni Danube weir, floodplain weir, and by-pass weir) can regulate a discharge between 0 and 6100 m^3/s depending on the water level in the reservoir as follows:

Water table in reservoir (m asl.)	Maximum discharge capacity (m^3/s)
128.0	300
129.0	1450
130.0	3400
131.1	6100

The intake structure in the power channel can regulate a discharge between 0 and 234 m^3/s at a water level of 131.1 m asl. (from April 1993).

4. REVERSIBILITY OF ONGOING ACTIVITIES AND COSTS OF RESTORING PRE-DAM STATUS QUO

In principle, the ongoing activities with Variant C could be reversed. The structures, excluding some of the underground parts like sheet piling and injections, could in theory be removed. The cost of removing the structures are roughly estimated to at least 30 % of the construction costs. There will be some negative environmental effects during the demolition of the structures and the deposition of the waste materials.

It is therefore relevant to evaluate under which circumstances the Variant C structures could have only insignificant and very local hydraulic effects if they are not fully removed. Such "functional reversibility" is possible for a scenario like:

* If the Dunakiliti weir on Hungarian territory are being operated according to the original plans the gates in the Variant C structures can be kept fully open and will not have any significant effect.

* If the Danube closure is removed and the "whole" discharge is routed back to the Danube.

The technical possibilities to remove the Danube closure or to give the Danube a new by-pass weir are described in Section 8.4

5. OUTLINE OF STATE AND PRESENT TRENDS IN THE AREA

In general, large monitoring programmes are carried out and large data bases exist for both the Slovakian and Hungarian areas with regard to most of the key parameters. An overview map showing some of the key locations referred to in this chapter is provided in Appendix E-1.

5.1 River and discharge regime

The river regime and the local climate determine water levels and therefore inundation, groundwater and soil moisture regimes (together with the geology). The river regime also determines flow velocity and hence sediment regime and the dynamics of substrate and river channel morphology.

Before the 18th century the Danube split downstream of Bratislava into two almost identical arms. Near Bratislava it was partly a braided river with many small islands as a result of progressive sedimentation where the Danube entered into the plain. Both arms were however meandering river systems and the Small Danube still is.

Large changes occurred in the 19th century, when the first regulation works started. Within several decades of instability and retrogressive erosion of other meanders, the system changed into a braided river. Some of the older meanders are still present in the landscape.

Before the multiple impoundments in the upper Danube catchment areas and the embankment and endikement in Austria, Slovakia and Hungary the Danube was still a free-flowing braided river with a wide floodplain that extended far beyond the present dikes. The floodplain absorbed much of the peak floods, which consequently were slowly rising and long-lasting in most years. Also flow velocities may have been lower than today.

With the past endikements, especially during the last century, flood peaks became steeper and higher, flooding more frequent but in general with a shorter duration. The original zonation in vegetation towards higher grounds and associated forests was largely 'diked' out of the system. Most of the higher, no longer flooded soils, were converted into agricultural lands. Although some remnants of these woods are still existing, especially on the Hungarian side the lands in between the dikes were consequently flooded more often and the river arms flushed and scoured more intensively.

These river regulation works let to deliberate and natural cutting off and bundling of river branches into one main, straightened and heavily fortified channel for navigation. This remaining channel is characterized by rapid water level fluctuations and very large stream velocities (1.3 - 2.3 m/s at medium and 0.8 - 1.8 m/s at low flow situations). The cut off branches are only activated at higher discharges.

Within the river branches many small weirs and dams were built, so most of them behave like cascade systems at low discharge. Some of them are continuously overflowing, while others may have dry and stagnant sections depending upon groundwater seepage and infiltration.

Key figures illustrating the discharge regime of the Danube are given in the table below based on the 1901-50 discharge time series at Bratislava, ref /11/:

Discharge characteristic	Discharge value (m^3/s)
Average	2025
Month with min. average flow Month with max. average flow	1441 (December) 2785 (Juni)
Typical low flow (average of annual minimums)	848
Typical high flow (average of annual maximums)	5316

The discharge regime at Bratislava is characterized by the duration curve shown in Appendix G-2. The relation between discharge and water level in the floodplain is shown for the site Dunaremete in Appendix G-3. Some key figures of importance for the floodplain are shown in the following table:

Characteristic flow situation	Discharge 1950-conditions (m^3/s)	Water level at Dunaremete (m)	Flow velocity in main channel at Dunaremete (m/s)	Average duration (days/year)	Frequency (events/year)
Flow largely confined to area within groynes in main channel	< 1000	2.3	1000 m^3/s => 1.4 m/s	< 1000 m^3/s: 13 days	Several times per year
Flow in main channel and permanent branches	< 1800	3.7	1500 m^3/s => 1.8 m/s	1000 - 1800 m^3/s: 42 days	Several times per year

Flow in a few river arms	1800 - 2500	3.7 - 4.5	1.8 - 2.0 m/s	1800 - 2500 m³/s: 122 days	Several times per year
Flow in some river arms	2500 - 3500	4.5 - 5.2	2.0 - 2.2 m/s	2500 - 3500 m³/s: 78 days	Several times per year
Flow in almost all river arms	3500 - 4500	5.2 - 5.6	2.2 - 2.3 m/s	3500 - 4500 m³/s: 17 days	Several times per year
Complete inundation of floodplain	> 4500	5.6	4500 m³/s => 2.3 m/s	> 4500 m3/s: 4 days	Once per year
Deep inundation of floodplain	6000	6.2	6000 m³/s => 2.4 m/s	> 6000 m³/s: < 1 day	Once per 3-4 years

A factor of particular importance for both the floodplain ecology ahd the groundwater regime is the river dynamics, which can be characterized by some key parameters given in the following two tables:

Parameter characterizing water level fluctuations	Water level variation calculated for Dunaremete 1980-89
Range of variation within the 10 years	1.9 - 6.6 m
Annual sum of water level fluctuations based on daily measurements	50 m
Annual sum of water level fluctuations based on 5-daily measurements	23 m
Annual sum of water level fluctuations based on 10-daily measurements	14 m

Water table fluctuation within a day at Dunaremete	Average number of days per year
0 - 10 cm	172
10 - 20 cm	119
20 - 30 cm	41
30 - 40 cm	14
40 - 50 cm	5
50 - 60 cm	3
60 - 70 cm	2
> 70 cm	6

The Mosoni Danube is presently not receiving water from the main Danube for 2-3 months per year.

5.2 Erosion and sedimentation in river system

The main channel has been significantly lowered due to erosion caused by a combination of several factors:

- dam construction in Austria in the last decades resulting in a sediment deficit;
- excavation of gravel downstream of Bratislava;
- natural erosion due to the very high velocities in the straightened and narrowed navigation channel; and
- prevention of bank erosion due to fortification of river banks.

Today, erosion takes place between Bratislava and Sap/Palkovicovo, downstream from where the eroded material sediments (and has to be dredged).

In some places the river bed has been lowered more than two meters, leading to lower groundwater levels, occasional drying out of river branches (e.g. downstream of Bratislava) and less flushing of most river branches. The lowering of the riverbed during the past 30 years has been particularly large between Bratislava and Rajka. It is estimated to be about 0.8 meter at Gabcikovo and near Bratislava about 1.5 meter.

According to Hungarian measurements the quantity and concentrations of suspended load on the Danube reach between Rajka and Medve show a decreasing trend, see the figure in Appendix G-4.

5.3 Surface water quality

The Danube water quality can according to Hungarian classification be categorized as 1st class regarding the majority of the components, as 2nd class regarding pH, orthophosphate, nitrite, BOD and 3rd class with regard to bacteria and some heavily degradable substances such as e.g. hydrocarbons.

The parameters for oxygen content and organic carbon shows a slightly improving trend, while deteriorating trends exist for nitrate and heavily degradable materials.

Due to high oxygen content, low organic carbon contents and the very small quantities of fine grained sediments the surface water quality is generally well suited for river bank infiltration, which is the major source of water supply along the Danube between Bratislava and Budapest.

The water quality of the side branches differs from that of the main Danube channel due to the much lower velocities and periods and places with stagnant water. In drier years a negative trend has been observed with high pH, high organic matter and low oxygen contents.

The major sources of water pollution are Morava and Bratislava.

5.4 Ground water regime

The ground water regime is to a large extent determined by the permeability of the main river channel and the variations in river water table. On the reach between Bratislava and Komarno an estimated 10 - 20 m^3/s infiltrates to gravel aquifers on the Slovakian side and 8 - 9 m^3/s between Rajka and Medve on the Hungarian side. This constitutes one of the largest ground water resources in Central Europe. Due to the very large permeabilities in the gravel aquifer the groundwater flow rates are very high (1 - 3 m/day).

The depth of the groundwater table is shown in Appendix G-5. It generally shows a depth of more than 5 meters close to Bratislava decreasing to around 1 m at Medve. The trend over the past 30 years has been a decrease in ground water tables ranging from about 2 meters around Bratislava to about zero at Komarno, see figure in Appendix G-6. This decrease is due to erosion of the river bed.

A very important feature of the ground water regime is the large ground water level fluctuations generated by the dynamics of the river water table. This is illustrated by the figures in Appendix G-7, where the influence of the river is evident for distances up to 10 km. Ground water level fluctuations are important as a mechanism for providing oxygen transfer through the soil horizons into the ground water.

5.5 Ground water quality

The ground water quality in the area dominated by the infiltration from the Danube is in general in a good state. Thus, the quality of the groundwater abstracted from the water works located close to the Danube is generally excellent.

For the areas farther away from the river, where the groundwater recharge partly originate from infiltration in agricultural and industrial areas, there are some problems with ground water pollution from point sources (e.g. from Slovnaft oil refinery starting in the 1960's, landfills and dumping sites) and from agrochemicals.

5.6 Fauna, flora and habitats in floodplain

The determining and sustaining factor of the biota of the floodplain between Bratislava and Palkovicovo is the natural and periodic water fluctuation of the Danube. The ongoing (pre-dam) trend with lowering of the Danube water level, changes in the character of the flood peaks, endikements, cutting off the side branches upstream and fortification of the main channel has stressed the biotic communities substantially during the last decades.

As a result of past groundwater decrease some areas of soft alluvial forests have been turned into hard alluvial forest. The latter were often cultivated with poplar and white willow. Furthermore, it is estimated that approximately 500 ha of the originally more than 2000 ha are not alluvial forest any longer. In addition, forestry has replaced many natural forests by plantations, where alien, introduced cultivars of poplar have been used.

The main characteristics of floodplain ecosystems is their mosaic structure and their dynamics depending on natural water fluctuation. Due to anthropogene effects this structure and dynamics was considerably disturbed and made the invasion of Solidago, Aster and Impatiens species possible.

Compared to other reaches of the Danube human impacts, including those mentioned above, have until now not been as large as elsewhere. Thus, quite original habitats with their typical fauna and flora could survive between and outside the dikes. Besides a huge variety of aquatic, semiaquatic and terrestrial associations the principal character of the landscape is given by the soft- and hardwood alluvial forests covering large parts of the land. The alluvial forests of the Szigetköz (2400 ha) are unique because of their peculiar species composition owing to its submontane features. Several hundreds of endangered and/or protected species here find suitable living conditions maintained by the high diversity of habitats.

As this type of alluvial forest almost completely disappeared from Europe, the significance of Szigetkoz from the point of view of conserving Europe's natural heritage is of outstanding importance.

5.7 Hydrological conditions for agriculture and forestry

The annual rainfall and evaporation amounts are of the same order of magnitude; however with significant different seasonal variations. Thus it is required with some additional water supply to the vegetation during the summer season. This extra water supply has traditionally been possible throughout the area by vertically upwards flow in the capillary zone from the groundwater table to the root zone. The necessary conditions for this are that the groundwater table is not too deep and that no (capillary breaking) gravel layer is located in between.

However, partly due to the decrease in groundwater tables during the past decades it has been necessary to make artificial irrigation for the agriculture. Thus, on the Slovakian side a comprehensive network of surface water channels has been developed for irrigation purposes. However, artificial irrigation has its disadvantages as compared to the natural situation, because the downwards water flux causes a considerable leakage of nitrates and pesticides.

The forestry conditions are also changing due to the gradually decrease in ground water tables. In some forest areas a transition from dominantly wet soft inundation forest to less wet hard inundation forest has occurred. This is especially the case in areas close to Bratislava. All these changes reflect anthropogene impacts.

In Szigetköz the flood plain poplar stands represent the highest productivity in Hungary (30-40 m^3/ha/year)

5.8 Navigation

According to the Danube Commission the following minimum parameters are required in areas, which are not influenced by backwater effects from weirs:

- width	180	m
- depth	2.5	m
- radius	1000	m

During the 1992 autumn low flow conditions the main navigation obstacles between Bratislava and Palkovocovo were:

* Five shallows with insufficient depth between Bratislava and the site of the Variant C structures

(Cunovo).

* Further four rough sections between Cunovo and Palkovicovo

The navigation conditions have been deteriorating in the area around Bratislava during the past years as illustrated in the following table:

Year (Source: Ceskoslovenska Plavba Dunajska)	Percentage of days with full navigation possibilities at Bratislava (water depth > 2.5 m)	Index ("100" corresponds to 1980 condition)
1980	64	100
1981	88	137
1982	73	112
1983	61	95
1984	51	79
1985	65	101
1986	54	85
1987	66	103
1988	62	96
1989	50	77
1990	46	72
1991	40	63

Between Dunakiliti and Asványráró six ports are situated. 35 - 40 ships are loaded or unloaded each year in these ports.

6. OBSERVED IMMEDIATE IMPACTS OF THE GABCIKOVO VARIANT C

Studying the impacts of Variant C is complicated by the fact that a distinguishing of its effects from those of the original project (Variant A) cannot be done clearly in all respects. The realization of Variant C took place in the area where the Variant A was planned and completed (with the exception of closing the Danube at Dunakiliti). Thus, the pre-dam (= pre-impact) conditions are characterized by already built dikes and already removed soils and vegetation. In addition to this, the construction of hydraulic structures of Variant C has been mostly completed.

6.1 River and discharge regime

After the closure of the Danube on October 25, 1992 the major part of the discharge has been diverted to Gabcikovo and only a minor part to the Danube downstream the closure. According to Slovakian project plans it was planned to put 600 m^3/s into Danube. However, due to technical problems at the construction site the Danube discharge has in periods been less than 300 m^3/s, which is about 20% of the average November discharge or 35% of the average of the annual minimum discharge. Discharge measurements carried out by Hungary downstream the closure are shown in Appendix H-1.

The reduced discharges have led to significant decreases in river water tables, typically by 2 - 3 meters as can be seen from the Hungarian measurements displayed in Appendix H-2. Most of the river arms had virtually no flows at the time just before the closure of the dam due to the low flow season. However, many of them are open at their downstream connection to the main river channel and had therefore (stagnant) water due to backwater effects from the main channel. In all cases the water levels of the river arms has been negatively affected.

The discharge in the Mosoni Danube has increased, see the hydrograph in Appendix H-3.

6.2 Erosion and sedimentation in river system

No specific observations have been made for investigation of this issue. However, the impacts on erosion and sedimentation are expected to take place gradually and with significant effects over periods of years.

6.3 Surface water quality

No specific observations have been made for investigation of this issue. However, the impacts on surface water quality are expected to occur mainly after the winter season.

6.4 Ground water regime

The following three factors have had some immediate impacts on the ground water regime:

* Higher surface water levels in the reservoir have caused an increase in ground water in areas near the reservoir.

* Lower water tables in the river downstream the closure have resulted in decrease of ground water levels in this area.

* Higher discharges and water levels in the Mosoni Danube have caused an increase in ground water tables in nearby areas.

These effects are spreading to larger areas with time, and in some areas the effects of more of the above factors are superimposed and to some degree counterbalancing each other. This is illustrated by the ground water level observations shown in Appendix H-4.

In some villages in Hungary the water supply is based on dug wells with limited depth. In some of these the drop in ground water table has resulted in drying out of the wells. In the areas where the ground water abstraction is done from deeper wells, including the bank filtration schemes, no immediate effects on ground water availability have occurred.

6.5 Ground water quality

Analyses of ground water quality have so far not indicated any impact. However, this could not be expected either within this short time period.

6.6 Fauna, flora and habitats

During the works on realizing the Variant A most of the valuable habitats in the floodplain upstream Dunakiliti, except the Danube (>5000 ha) were destroyed by digging off or heaping up. This is in particular the case for the alluvial forests between the new dikes.

In addition, the operation of Variant C has influenced the Danube seriously. There is a reduction of the discharge for a reach of about 40 km downstream the dam to an extreme low level, which is considerably lower than the ever recorded minimum. In connection with this flow velocities and water depths decreased to unnatural values and most side branches (about 100 km) dried out.

This causes a huge immediate damage to all water organisms especially those living in the side branches, e.g. fish and benthic organisms (mainly the mussels). The remaining shallow waters fail as spawning grounds. If the situation as described above will continue until the beginning of the vegetation period most of the fauna and flora depending on floodplain ecosystem conditions will be heavily damaged and may have resulted in the loss of essential portions of populations and thus in reduction of genetic diversity and thus adaptibility. This especially concerns the four areas that are already protected or are proposed to be protected as nature reserves.

Immediate effects on flora especially water flora cannot be excluded.

Upstream the dam the river changes to an impounded lake for a length of 10 km with significantly smaller flow velocities. Thus, the river system will on this reach change its character. This causes a loss of many habitats for rheophil organisms.

Constructing the dam interrupted migration of fish and many species of water insects so they cannot reach their reproduction zones upstream.

6.7 Hydrological conditions for agriculture and forestry

As a result of the changed ground water levels the hydrological conditions for agriculture and forestry have changed. However, except for fisheries this is presumeably not having any effect until the beginning of the growing season.

6.8 Navigation

The navigation route in the Danube main channel was closed on October 23, 1992. Instead the new navigation channel with the locks at Gabcikovo has been opened. One of the two locks has been in routine operation since November 9, while the second was being tested on November 22, 1992. The Working Group has not been able to obtain specific data on the number of ships, which have passed the locks during the past two weeks.

The new channel and locks represent an improvement of the navigation conditions with respect to the following factors:

* No problems with shallow water depths any longer between Bratislava and Sap/Palkovicovo.

* Shorter travel times for barges between Bratislava and Komarno t/r.

* Saving of energy.

In the Danube downstream the dam, on the other hand, navigation has become virtually impossible. Thus, ships cannot reach the harbours of Ásványráró, Dunaremete and Dunakiliti because of insufficient water depth. Thus Hungary has lost 40 km international navigation route.

6.9 Other factors

With the filling of the navigation canal the previously used road connection between three villages on the Slovakian side and Bratislava has been cut off. Thus today, Bratislava can be reached via Gabcikovo dam, a detour of in one case 35 km. Instead a road on top of the Variant C structures, providing a 8 km shorter connection to Bratislava, has been prepared.

During the works on Variant A the topsoil was removed from an area of 5300 ha upstream Dunakiliti. This area will be flooded for the reservoir. Valuable types of soils specific of the floodplains were lost.

Compared to the former wetlands the new reservoir will have some influence on micro- and mesoclimate. According to a study carried out by the Slovak Hydrometeorological Institute (SHMU) the effects are estimated as small. However, there is a considerable uncertainty on this issue.

The character of the scenery upstream the dam has been completely changed by the measures preparing Variant A. Variant C created changes in landscape character upstream the dam as well as downstream. Upstream the dam the typical and highly structured floodplain scenery has been lost. Downstream the desiccated river branches and the remaining extent of the Danube are obvious symptoms of the destruction of the landscape. To some extent and in contrast to the upstream situation the character of the former floodplain could be restored by enough water discharge in the Danube and remedial measures. As a substitute the lake (reservoir) has been created as a new element in the landscape.

7. OUTLINE OF POSSIBLE REMEDIAL MEASURES ON NEGATIVE ENVIRONMENTAL IMPACTS

The construction of Variant C causes large impacts on the environment. In this chapter some possible measures to avoid, remediate or compensate the negative impacts on the environment are outlined. It should be emphasized that the measures described in the following do not necessarily constitute recommendations of the Working Group. It is rather a list of measures ranging from substantial changes of Variant C design to small additional measures. The specific combinations of these measures are presented in the various scenarios in Chapter 8 and in the recommendations given in Chapter 9.

7.1 Restoring the floodplain ecosystems in the reservoir area

Between the left and right side dikes floodplain ecosystems could be restored to a great extent between Bratislava and Rajka by removing the closure of the Danube. In addition, suitable measures can be taken to allow navigation through the navigation canal and to stop bed erosion in the Danube. If these restoration measures are not implemented only single problems downstream the dam could be handled as described below. These, however, would not result in an overall environmental improvement.

7.2 Possible remedial measures for floodplain ecosystems downstream the Variant C dam

7.2.1 Objectives for creating a water regime according to natural conditions

It has to be the aim of remedial measures in the floodplains between Cunovo and Palkovicovo to restore the dynamics of water and substrate to the greatest possible extent resembling the natural conditions. This implies the splitting of the Danube discharge to the navigation canal and to the downstream Danube. The latter could be restored in that way that the typical water level hydrograph with flood periods and periods with low water level is achieved (perhaps in average at a slightly lower level).

7.2.2 Technical help for starting natural processes.

During the last decades the channel system was changed to a quite unnatural stage. A Danube discharge nearly as high as in pre-dam conditions would not be sufficient to improve the ecological situation compared to October 1992. Measures could be taken to reduce sole erosion and to start natural processes.

Shallow under-water weirs in the main channel situated in front of river branches could increase the water level and ensure that the groundwater table will not be lowered.

Removing the thresholds between the main channel and the side branches will then enable splitting up the discharge so that the flow velocity and the pulling power will reduce.

Removing the fortifications from the banks of the main channel will allow the river to saturate its bed load deficiency by lateral erosion.

All these measures together will initiate natural processes that guarantee a sufficient ground water recharge, a high diversity of ecosystems and a reduction of sole erosion.

7.2.3 Supply methods for the side branch system

If the priorities are not given to starting natural processes but rather to guarantee sufficient ground water levels and/or continuous water supply to the side branches a technical supply method could be pointed out.

There is a possibility to make small inlets/outlets in the weirs (between the main channel and the side branches) with a sill level just above the lowest navigation level.

7.2.4 Adding dredged gravel

To avoid bed erosion directly downstream the dam dredged gravel from the reservoir or the navigation canal can be added into the Danube downstream the weir. After completion of Phase 2 the spillway weir with the sill level at 120.5 asl. (the same as in the existing river bed) can help to manage erosion/sedimentation problems.

7.2.5 Further measures on reducing sole erosion

If the priorities are not given to start natural processes but rather to reduce sole erosion, besides adding of gravel two technical methods could be pointed out.

A possibility is to build belts of concrete in the sole of the main channel at right angles to the flow direction.

A further possibility exists in the fortification of the river bed in reaches where sole erosion is observed.

7.3 Other remedial measures

7.3.1 Fish pass

To enable fish migration a fish pass can be constructed in combination with the bypass weir or the spillway weir.

7.3.2 Shape measures in the reservoir

To compensate the loss of floodplain ecosystems in the reservoir shape measures can be taken especially in the farthest upstream part of the reservoir and in the area near Bratislava, which is inundated only one or a few times per year. These measures should enlarge the inundation area and the area with shallow water as much as possible. Islands and peninsulas should be established within the reservoir.

7.3.3 Optimizing floodplain habitats outside the area concerned

To compensate the loss of floodplain specific habitats in the area of the reservoir measures could be taken to optimize damaged floodplain habitats in the area between Rajka and Dunakiliti, outside the reach between Bratislava and Palkovicovo and by including some of the forests near the left dike downstream Bratislava into the inundation area.

7.3.4 Preventing negative impacts on infiltration water of the reservoir

It is widely accepted that by low velocities and because of the high nutrient contents the water quality in the reservoir is threatening especially at Samorin water works and the neighbouring area. This threat is associated to stagnant water and subsequent eutrophication and saprobic conditions in the downstream part of the reservoir.

In order to increase the velocity the navigation canal can be narrowed so that the velocity will be high enough to avoid sedimentation of dead algae material. In addition to this it might be necessary to seal the ground of the reservoir or the canal on places with too less velocity. Increasing of the flow velocity can be achieved by lowering the water table too.

8. ASSESSMENT OF IMPACTS FOR VARIOUS WATER MANAGEMENT SCENARIOS

In this chapter impact assessments are outlined for various scenarios of water management. Each scenario is prepared on the basis of a set of specified objectives. In the selection of objectives no constraints have been imposed by previous plans or agreements. It is emphasized that the members of the Working Group not necessarily agree to these objectives; however the Working Group agrees to the subsequent descriptions of technical possibilities, environmental impacts, etc. For each scenario the following aspects are described:

* Objectives and priorities
* Technical and water management aspects
* Possible time schedule for implementation
* Impacts on discharges
* Impacts on erosion/sedimentation
* Impacts on surface water quality
* Impacts on ground water regime and quality
* Impacts on fauna, flora and habitats
* Impacts on agriculture and forestry
* Impacts on navigation
* Other aspects

Some statistics describing the river water levels and their fluctuations in the floodplain are presented in Appendix H, where also a summary table indicating impacts for the various scenarios are presented.

8.1 Scenario A: 95% of average discharge to the Danube downstream the dam

In this scenario no remedial measures are considered.

8.1.1 Objectives and priorities

The objective to be achieved in this scenario is to maintain the present (pre-dam) conditions with regard to floodplain ecology and ground water conditions side to the maximum possible extent, and only to give higher priorities to the following:

- safety of existing hydraulic structures against flood damages;
- navigation; and
- discharge to the Mosoni Danube.

8.1.2 Technical and water management aspects

Technically, the main part of the Danube discharge can be directed into the existing river bed and the floodplain through the following three structures:

* By-pass weir. When the necessary protection work of the downstream river bed is completed (scheduled for January 1, 1993) a discharge of 1460 m^3/s can pass at a reservoir water level of 131.1 m asl. Until then less discharge can pass.

* Floodplain weir. When this structure is fully operational for daily use, including the necessary downstream bed protection work, a discharge of 4600 m^3/s can pass here corresponding to a reservoir water level of 131.1 m asl. This work is planned to be completed by January 1, 1993. By Nov. 21, 1992 it can only be used for emergency in case of floods (which have short durations), but not for daily operation.

* Water intake in dike. Through this structure a discharge of 234 m^3/s can pass at a water level of 131.1 m asl. The water through this structure reaches the left side of the floodplain just downstream of Dunakiliti. At the moment this intake can be used provisionally. The intake can be fully used by April 1, 1993.

In addition, a discharge of 6300 m^3/s will be able to pass the planned Phase 2 structures, which are scheduled for operation from 1996. These structures are necessary in order to be able to resist a permanent (10,000 year event) design discharge.

The discharge capacity to the Danube and the floodplain is summarized in the table below:

Discharge capacity of Variant C structures (m^3/s)	November 21 1992	January 1, 1993	Completion of Phase 2 (1996)
Flood event	6310	6310	12600
Daily operation	600[1)]	6310	12600

Note [1)]: From November 25 about 800 m^3/s

The discharge at Bratislava (excluding the infiltration to the aquifers) which is not directed into the Danube consists of the following parts:

* Some discharge is required for operating the navigational locks at Gabcikovo. 175,000 m^3 is required to fill one ship lock. With the projected 40 passages per day, this corresponds to 81 m^3/s.

* Some additional discharge will be required for the coming months for testing turbines and generators at Gabcikovo. It is required that these are ready for use in case of large floods. The Working Group has not been able to obtain specific information on exactly how much water will be required for this purpose.

* 25 m^3/s is required for Mosoni Danube.

* Between 10 and 50 m3/s is usually diverted to Maly Danube at Bratislava with generally higher flows during summer season for irrigation purposes.

* There will be seepage from the reservoir and the canal to the seepage canals. This is estimated to be about 40 m^3/s initially decreasing to about 20 m^3/s after some time. Some of this seepage (estimated to 5 m^3/s) is diverted into the Mosoni Danube, and it is possible to divert the remaining to the side branches in the floodplain close to Dobrohorst.

In summary, in the pre-dam conditions the discharge at a point just upstream the weir at Cunovo corresponds to the Bratislava discharge minus in average 30 m^3/s. Out of this discharge today about 100 m^3/s is not directed into the Danube + the Mosoni Danube.

8.1.3 Possible time schedule for implementation

According to the informed project plans Scenario A will be technically possible from January 1, 1993.

8.1.4 Impacts on discharges and water levels

The discharge required for testing the turbines during the coming months is not known exactly. The percentage of the discharge, which when testing of turbines is completed is directed to the Danube appears in the table below for different flow conditions.

Characteristic discharge	Discharge value based on 1901 - 50 Bratislava record (m^3/s)	Discharge to Danube + Mosoni Danube in % of pre-dam discharge at Cunovo
Typical low flow (average of annual minimums)	848	88 %
Month with minimum flow (December - average)	1441	93 %
Summer month with minimum flow (September - average)	1954	95 %
Typical high flow (average of annual maximums)	5316	98 %
Average annual discharge	2025	95 %

With the existing structures it will be possible to carry out this water management after January 1, 1993 for discharges up to the maximum of 6400 m^3/s. During the 90 year period 1901-90 a flood of 6400 m^3/s or higher was experienced in 16 of the years (approximately " 5 year event"). The discharge is higher than 6400 m^3/s in average for less than 1 day per year.

The situation for the Mosoni Danube is improved as compared to the present (pre-dam) conditions because permanent discharge throughout the year is now ensured.

According to results from calculations for a 10-year period shown in Appendix H the reduction of the Danube discharge will result in a reduction of the river water table by 19 cm in average. The range of water table variations for the 10-year period changes from 1.90 m - 6.56 m in the pre-dam conditions to 1.60 m - 6.51 m in Scenario A. The dynamics of the discharge and water level regime with the characteristic fluctuations is preserved.

However, it is noted that the water tables will be further reduced in the coming years due to erosion of the river bed downstream the dam (see Subsection 8.1.6 below). These effects will be largest just downstream the closure and will gradually decrease towards zero at the downstream confluence with the navigation canal.

8.1.5 Impacts on erosion/sedimentation

As an effect of the reservoir and the associated backwater effects, the flow velocities at and just downstream of Bratislava will decrease. Therefore, the ongoing bed erosion will decrease and maybe even be turned into sedimentation. This is a positive effect.

Some of the suspended sediment load and all the bed load will sediment in the reservoir.

At the Danube downstream the dam erosion will increase, because the sediment concentrations in the water passing the structures will be significantly reduced and the velocities in the Danube will be almost the same. This erosion will result in decreases in river and ground water tables. This is a negative effect.

8.1.6 Surface water quality

The surface water quality of the reservoir will be influenced by eutrophication and sedimentation. In this regard the reservoir conditions will be significantly different in the upstream part, where all the discharge passes and the downstream part, where only a few percentages of the discharge occur.

Due to the throughflow in the upstream reservoir, the eutrophication will be limited here, and will as compared to the inflowing flux of organic matter not add a significant contribution. On the other hand due to the sedimentation of suspended sediments containing organic material, the net change in organic material flowing through the structures into the downstream part of Danube may as well be a reduction. Thus, the impact on the surface water quality in the downstream Danube is uncertain.

Directing only about 4% of the discharge through the downstrea, part of the reservoir will, on the other hand result in almost stagnant water, algae growth and sedimentation of organic material.

8.1.7 Ground water regime and quality

The ground water table close to the reservoir will rise both at the Hungarian and at the Slovakian side, while the amplitudes of the ground water table fluctuations will be reduced. The higher ground water tables represent a positive effect, and if it is possible to maintain the dynamics of fluctuations (to some extent possible through management of water tables in seepage canals just outside the reservoir) the ground water conditions will generally be improved in these areas.

Due to the decrease in the river water table in the downstream floodplain area the ground water levels will decrease correspondingly. However, the dynamics of the ground water system with the characteristic fluctuations will be maintained. Thus, the groundwater quality will in general not be influenced.

However, due to eutrophication in the downstream part of the reservoir the groundwater quality is most likely to be threatened at the Samorin Water Works, which produces about 40 % of the water supply for Bratislava. This threat is associated to sedimentation of organic material due to stagnant water and algae growth in the downstream part of the reservoir. A layer of organic material at the reservoir bed, from where the infiltration to the aquifer takes place, may result in anoxic groundwater conditions. Hence, this effect may be serious starting with the growth season during the 1993 summer.

8.1.8 Impacts on fauna, flora and habitats

Upstream the dam habitats influenced by the dynamics of the river change to those characterized by more or less stagnant conditions. This causes damages to flora and fauna characteristic for floodplains. Aggradation processes will cause new wetland habitats.

Downstream the dam biocenoses, especially the aquatic, are influenced by water released from the reservoir. There will be changes of the physical and chemical parameters of the river water caused by the reduction of flow velocities and the larger water surface in the reservoir. The sizes of these changes determine the damages in fauna and flora typical for floodplain conditions. According to changes of the average water level there will be a shifting of the biocenoses.

Sensitive species of the fish fauna of the floodplain have disappeared during the low water period in November 1992. Restoration of the fish communities by natural processes will last a long time, perhaps they cannot reestablish themselves.

8.1.9 Impacts on agriculture and forestry

The potential impacts on agriculture and forestry takes place through changes in ground water tables. In both cases a ground water table at the bottom of the root zone (or so close to the root zone, that there is no gravel layer in between) is important. Deeper ground water tables may cause water shortage/need for irrigation, while higher ground water tables may cause water logging.

For the agriculture the increase in groundwater tables around the reservoir is positive, because the ground water table here has dropped several meters to a level for which irrigation is required. The decrease in the areas downstream the dam part is generally negative, although the influence on the Slovakian side may be counterbalanced through operation of the water tables in the seepage canal north of the power canal.

For the forestry, the impacts of the decrease in ground water tables depend on the depth of the gravel layer. In some areas it may have some negative impact, while in the major part of the area the effect will be negligible. For some areas close to Mosoni Danube or the reservoir the increase in ground water tables may have positive impact.

8.1.10 Impacts on navigation

The navigation can be ensured through Gabcikovo. However, two problems will occur on the reach between Gabcikovo and the downstream confluence point at Sap/Palkovicovo, due to the small discharge in the navigation canal:

* The manoeuvrability for ships are more difficult when passing from almost stagnant water to fast flowing water. This may require special remedial measures.

* Dredging will be required.

Navigation on the Danube downstream the dam between Conovo and Sap is possible locally. When Phase 2 of Variant C is constructed (1996), there is only a limitation for composite barges.

8.1.11 Other aspects

The hydropower plant at Gabcikovo cannot be utilized.

8.2 Scenario B: Main part of water to Gabcikovo

No remedial measures are considered in this scenario.

8.2.1 Objectives and priorities

The objective to be achieved in this scenario is to maximize hydropower generation, given a constraint of a minimum discharge to the Danube and the Mosoni Danube. The minimum discharge to the Danube is defined as 350 m^3/s, which is the order of magnitude of discharge recorded in the Danube since the closure of the Danube.

8.2.2 Technical ᐧ ıᒧ water management aspects

This scenario is possible with the existing structures.

8.2.3 Possible time schedule for implementation

Splitting of the water with 350 m^3/s to Danube is possible from today: However, the full hydropower generation is not expected to be possible until January 1, 1993.

8.2.4 Impacts on discharges and water levels

This operation will result in a continuation of the immediate negative impacts on discharges and river water levels experienced in the floodplain area, see Chapter 6. According to the calculations for a 10-year period shown in Appendix H the average water level will decrease by more than 3 m and the dynamics with the characteristic fluctuations will almost disappear.

The situation for the Mosoni Danube is improved as compared to the present (pre-dam) conditions, because permanent discharge throughout the year is now ensured.

8.2.5 Impacts on sedimentation/erosion

As an effect of the reservoir and the associated backwater effects, the present erosion at and just downstream of Bratislava will decrease and maybe even be turned into sedimentation. This is a positive effect.

Some of the suspended sediment load and all the bed load will sediment in the reservoir.

At the Danube downstream the dam erosion will decrease due to the decrease in velocities.

8.2.6 Impacts on surface water quality

Due to the throughflow in the reservoir (both the upstream and the downstream ones), the eutrophication will be smaller as compared to Scenario A, and will as compared to the inflowing flux of organic matter not add a significant contribution. On the other hand due to the sedimentation of suspended sediments containing organic material, the net change in organic material flowing through the structures into the downstream part of Danube may as well be a reduction. The net impact of the reservoir on the surface water quality in the downstream Danube is expected to be negative for the first couple of years and uncertain in the long term.

On the other hand the smaller velocities and much smaller depths in the Danube downstream the dam will result in significantly different (generally negatively) water quality conditions with regard to selfpurification, oxygen conditions, eutrophication, etc.

8.2.7 Impacts on ground water regime and quality

The ground water table close to the reservoir will rise both at the Hungarian and at the Slovakian side, while the amplitudes of the ground water table fluctuations will be reduced. The higher ground water tables represent a positive effect, and if it is possible to maintain the dynamics of fluctuations (to some extent possible through management of water tables in seepage canals just outside the reservoir) the ground water conditions will generally be improved in these areas.

With regard to the conditions in the floodplain and associated areas on both sides this operation will result in a continuation of the immediate negative impacts experienced during the past weeks. In the longer term, the change in dynamics with much smaller fluctuations may in addition influence the groundwater quality in a negative direction.

Directing a main part of the discharge to Gabcikovo will most likely ensure the groundwater quality at Samorin, and hence the water supply for Bratislava.

8.2.8 Impacts on fauna, flora and habitats

This scenario will have large impacts on fauna, flora and habitats.

Upstream the dam there will be no remarkable difference to the immediate impacts as described in Chapter 6.

Downstream the dam the alluvial forests and meadows depending on the Danube regime will completely change to mesophilic habitat types or disappear. The dynamic character of the river and the corresponding biota will also cease. From the present vascular flora most of the species specific to floodplains will be lost. There will be a rapid loss of the original diversity of aquatic invertebrates. Sensitive and rare species of the fish fauna will disappear or have already disappeared as an immediate effect. In the terrestrial insect fauna displacement of the species typical for the more humid biotopes will happen. Higher trophic levels will be influenced in a negative way.

8.2.9 Impacts on agriculture and forestry

For the agriculture the increase in groundwater tables around the reservoir is positive, because the ground water table here has dropped several meters to a level for which irrigation is required. The decrease in the areas downstream the dam part is generally negative, although the influence on the Slovakian side may be counterbalanced through operation of the water tables in the seepage canal north of the power canal.

For the forestry, the impacts of the decrease in ground water tables depend mainly on the depth of the gravel layer. For ground water table reductions of this order of magnitude (1-3 m) it will generally have a negative impact. The average annual wood production is estimated to decrease with 70 - 80 %. Outside the dikes a very slow transition process will take place. For some areas close to Mosoni Danube or the reservoir the increase in ground water tables may have positive impact.

8.2.10 Impact on navigation

The navigation will be ensured through Gabcikovo.

Navigation on the Danube will be limited or lost.

8.2.11 Other aspects

Hydropower production at Gabcikovo is possible.

8.3 Scenario C: Management of Variant C as planned by the Slovak Commission for Environment

Remedial measures are considered in this scenario.

8.3.1 Objectives and priorities

The objectives to be achieved in this scenario are to optimize the relation between hydropower generation and discharge to the Danube and Mosoni Danube. The minimum discharge into Danube is defined as 600 m^3/s in the winter and 1300 to 1500 m^3/s in summer period, which is approximately a 50 % : 50 % split between the power canal and the Danube.

8.3.2 Technical and water management aspects

Technical aspects:

This scenario can be initiated by use of the existing Variant C structures. However, the full management possibilities require the construction of the spillway weir, hydropower station and ship lock at Cunovo, scheduled under Phase 2.

Management aspects:

The general ecological requirements in the inundation area are prescribed by the Slovak Environmental Commission as follows:

- To secure communication between the dead-branch system and the Danube in both ways and to enable the flow through the branches from Dobrohost to Palkovicovo. Periodical inundation with river water according to the natural regime of flows.
- To secure the supply of water into Mosoni Danube according to conditions agreed by Czecho-Slovakia and Hungary in 1948, on the base of Paris Peace treaty.
- To secure the natural physiological processes of the actual flora of the old bed of the Danube during the vegetation period (mainly from March to September),
- To secure such a flow in the old river bed, which would enable the ground water level to touch the soil horizon and which would thus prevent the drainage effect of the river bed.
- To secure a minimal flow in river Danube of 600 m^3/s.

Proposal:

The main goal is to propose measures that the environment will be optimized by hydrological means. The remedy measures should treat the immediate impacts and improve the long-term pre-dam processes, e.g. stoping the ground water level decrease, stoping errosion in Bratislava, optimizing the ground water level depth and fluctuation and maintaining acceptable conditions in Danube.

Variant C - Phase 1

In previous model investigations a solution has been prepared for the reach between rkm 1811 and 1842 of the Danube river bed, according to which the parallel section of the river bed in the ford sections is to be stabilized by building of under water weirs (rock bottom thresholds). These weirs have maximum height of 1.0 - 1.3 m above the existing river bed bottom.

The same solution is possible from rkm 1842 to rkm 1851.75. In this part of Danube, between Rajka and Dunakiliti, it is possible to use Dunakiliti weir to optimize water and ground water levels.

Items of Phase 1:

- Water table in the reservoir between 128.5 and 130 m asl.
- Construction of underwater weirs.
- Fortification of the tail of inundation weir.
- Adding dredged gravel.
- Using Dunakiliti for water level management.

Variant C - Phase 2:

Phase 2 consists of:
- Completion of spillway weir, hydropower station and ship lock.
- Opening of connections between the main Danube canal and the side branches.
- Removal of part of the fortifications of the banks in the main Danube canal.
- Monitoring, interpretation of data and further optimization.
- Optimization of the division of the discharge.

The first and the second phase requires comprehensive monitoring of the effects of the remedial measures, mathematical modelling and further field work and simulation studies.

8.3.3 Time schedule for implementation.

Phase 1

The fortification work and the construction of the underwater weirs can be carried out in three months. It is expected that the remedial measures can be completed by spring 1993.

Phase 2

Further technical work, monitoring, field work, modelling and studies should be done until the full operational capacity of all structures is achieved. At this time definitive operational directives, monitoring and interpretation tools should be elaborated. It is expected that this phase will be completed by 1995.

8.3.4 Impacts on discharges and water levels.

The influence of underwater weirs on water levels and velocities according to discharge is similar to those outlined for Scenario E in Subsection 8.5.4. The height of the under water weirs should be optimised according to height of the opening of river branches and possibilities of adding the dredged gravel. A longitudinal section of the Danube with and without underwater weirs for stone underwater weirs are shown in Appendix I. Velocities over and between weirs are also included in Appendix I.

Generally, the height of weirs is proposed from 1 to 2 meters. Expected velocities are in the range from 0.5 to 2.7 m/s between weirs and from 0.9 to 2.6 m/s on top of the weirs.

8.3.5 Impacts on erosion and sedimentation

By operation of the reservoir during Phase 1 the erosion at Bratislava will not be stopped. A considerable part of the coarse sand and gravel will sediment in the upper part of reservoir. This can be dredged and put into the Danube just downstream the Cunovo weir.

During Phase 2 the present erosion at and just downstream of Bratislava will decrease and may be even be turned into sedimentation. This is a positive effect.

Some of the suspended load will sediment in the lower part of reservoir. For the Danube between Cunovo and Dunaremete, where the pre-dam condition was river bed erosion, erosion will be smaller. Adding gravel under Cunovo will improve the situation. Removal of river bank fortifications will increase lateral erosion and will together with underwater weirs result in increases of the river bottom. This will give more regularly distributed velocities along the Danube.

For the Danube between Sap and Komarno slight erosion is expected, which is a positive effect both for navigation and for flood protection of the downstream section of Danube.

Sedimentation process in the reservoir should be improved by optimizing discharge and hydraulic structures inside the reservoir.

8.3.6 Surface water quality

The surface water quality will be influenced by the eutrophication and the sedimentation mainly in the downstream part of the reservoir. Changing discharges between Danube and power canal can improve the situation. Additional research is needed on this issue. Due to the sedimentation the change of the water quality downstream from Gabcikovo is expected to be negligible. Surface water quality could improve also because of opening the river branch system and thus higher self purification capacities.

8.3.7 Ground water regime and quality

The ground water table close to the reservoir will rise both at Hungarian and Slovakian side. This will generally improve the ground water depth conditions in these areas.

Downstream the Cunovo Dam the river water table maintained to the previous conditions by the under water weirs and nearly the same ground water level fluctuation will generally ensure that the ground water quality close to the river Danube will not be influenced.

Assuming eutrophication in the downstream part of the reservoir will not be serious and flow velocity will be influenced by hydraulic structures, ground water quality will not be influenced. To ensure ground water quality for long term period, monitoring and additional studies are needed.

8.3.8 Impacts on fauna, flora and habitats

If it is possible to carry out the optimization with the results outlined above, the impacts on fauna, flora and habitats will be similar to those described in scenario E, cf. Subsection 8.5.8. Otherwise, the impacts may be larger.

8.3.9 Impacts on agriculture and forestry

If it is possible to carry out the optimization with the results outlined above, the impacts on agriculture and forestry will be similar to those described in scenario E, cf Subsection 8.5.9. Otherwise the impacts may be larger.

8.3.10 Impacts on navigation

Navigation will be ensured through Gabcikovo. There will be improvements with regard to:

- time saving.
- saving of energy.
- improvement of depth in Bratislava harbour.
- increment of turnover.

The completion of the ship lock (Phase 2) will enable navigation in the old Danube river, when discharge in the Danube will be higher than 2000 m3/s. A Minimum discharge into the Danube of 600 m^3/s enables navigation continuously for ships with dip of about 1 - 1.4 meters.

8.3.11 Other aspects

The hydropower plant at Gabcikovo will generate hydroelectric energy at reduced capacity.

8.4 Scenario D: Danube redirected to the former river bed

This scenario describes the reversibility. Various remedial measures are considered.

8.4.1 Objectives and priorities

The objectives to be achieved in this scenario are to redirect the Danube into its former bed, hence maintain - as much as it is possible both for low flow and for the higher discharges - the conditions prior to the closure of the Danube (i.e. before 20 Oct. 1992) with regard to the floodplain ecology, ground water conditions on both the Slovakian and Hungarian side and navigability of the Danube between Bratislava-Szap (Sap or Palkovicovo).

In addition it is an objective to improve the floodplain ecology by opening of side branches.

This scenario gives higher priority only to:

- nature and environmental protection,
- discharge to the Mosoni Danube and the Small Danube (Maly Dunaj),
- safety of all existing structures (except the closure of the Danube or other earth barrages/dykes of the system).

8.4.2 Technical and water management aspects

The existing structures of Variant C do not always allow the redirection of the 95% of the discharge into the Danube.

Technically it is possible to redirect the Danube to the former river bed. Two principally different approaches exist, namely by removing the closure in the old bed or by making a new river bed over some distance bypassing the closure. Some proposals prepared by Hungary are enclosed in Appendix J.

All of the proposed interventions would require additional measures - like reinstatement of the water supply of the Mosoni Danube, bed protection etc.

All of the measures can direct a discharge of about 11000 m^3/s back into the Danube. The split of it between the different structures and the new bed can be characterized:

* By-pass weir. After having finished the protection

work of the downstream energy dissipation basin it can pass 1460 m^3/s discharge at a reservoir level of 131.1 m asl.

* Floodplain weir. When this structure will be operational it can take about 4600 m^3/s at 131.1 m. asl.

* The main (reopened) bed of the Danube can - at about 2 m higher water level than the banks - take about 5000 m^3/s.

In summary the structures of Variant C plus the reopened Danube bed can pass a design flood during a temporary construction period ($Q_{1\%,year}$ = 10600 m^3/s). However, for passing a final design flood ($Q_{0.01\%,year}$ = 15000 m^3/s) it will be required either to construct the spillway weir, planned for Phase 2 of the Variant C or to utilize the power canal and the Gabcikovo complex as an additional flood spillway weir.

The fresh water supply of the side branches can be solved by reopening the upstream ends of the branches at or above the navigational low flow. The correct sizing of these openings would provide enough water for the revitalization of the side branches without disturbing the navigation and altering significantly the sediment and ice carrying capacity of the Danube.

The discharges which cannot be directed into the Danube are

- the discharge to the Mosoni Danube and
- the discharge to the Small Danube (Maly Dunaj).

8.4.3 Possible time schedule for implementation

The measures required to redirect the Danube to the old river bed can be implemented within 12 months.

8.4.4 Impacts on discharges and water levels

This scenario will assure the pre-closure conditions (except for discharges higher than 11000 m^3/s; i.e. for discharges up to a 100 year flood). The impact of this change will have no apparent effect on the hydrology, morphology and consequently on the water levels of this stretch.

The discharge to the Mosoni-Danube should be provided by traditional means i.e. by dredging a connection canal to the Danube.

As the discharge conditions in the Danube will be the same as before the closure the ground water table will also return to pre-dam conditions in both the Slovakian and the Hungarian side. The dynamics of the discharge and ground water regime will be maintained.

8.4.5 Impacts on erosion/sedimentation

Erosion/sedimentation will return to pre-closure conditions both in the area of the Cunovo reservoir and downstream to it. It raises the question of degradation of the main bed of the Danube and as consequence the water supply of the side branches. This problem should be solved.

8.4.6 Surface water quality

Surface water quality of the pre-closure conditions will be preserved. The improved flow through the side branches will improve the water quality of the side branches too.

As the downstream part of the reservoir is still connected to the upstream part it will receive water at higher water levels. However, some of this water will not be able to flow back and will cause stagnant water conditions. The possible effects of this should be studied.

8.4.7 Ground water regime and quality

The ground water levels will return to pre-dam conditions. It will raise questions in the region between Bratislava and Dunaremete, where the trend was unfavourable for the last 30 years.

8.4.8 Impacts on fauna, flora and habitats

This scenario allows the restoration of floodplain habitats in most of the reservoir area.

Downstream the dam pre-dam conditions for fauna, flora and habitat can be restored. Navigation will prevent developing the floodplain conditions nearer to nature. Even the dynamics of substrate as an important factor cannot be restored at the presence of navigation.

Reopening the side branches will bring better conditions for fauna and flora than in the pre-dam situation. Because of the completely restored facilities for fish migration this scenario gives the best possibilities for restoration of the fish communities by natural processes.

To maintain these better conditions for fauna, flora and habitats sole erosion of the Danube must be brought to tolerable values.

8.4.9 Impacts on agriculture and forestry

The supposed positive impacts of the higher ground water levels near the reservoir will disappear but life will return to the pre-dam conditions. The better fresh water supply of the side branches will improve the productivity of the fringe forests.

8.4.10 Impacts on navigation

In connection with the final phase of the construction works required for redirecting the Danube to its former bed, navigation will be stopped for a period of about one month.

Afterwards the pre-dam conditions would prevail. It means that the navigation problems of the stretch between Bratislava and Budapest should be solved by traditional methods.

8.4.11 Other aspects

The hydropower plant and the ship locks at Gabcikovo cannot be used.

The "power" canal, which will be used as spillway canal for flood situations in average a couple of days per century, will still require maintenance.

8.5 Scenario E: Step by step solution

This scenario includes remedial measures, which are proposed for implementation in two phases.

8.5.1 Objectives and priorities

The objectives to be achieved in this scenario are to maintain the water levels as well as the dynamics of both the surface water and the groundwater regimes downstream the dam according to the conditions prior to the closure of the Danube, to maintain the ground water quality and to maintain almost the same water quality in the reservoir as it was previously in the Danube.

Higher priorities are given to:

- maintaining the function of the Variant C structures,
- discharge to the Mosoni Danube,
- navigation.

8.5.2 Technical and water management aspects

The existing structures of variant C and the structures of the Gabcikovo complex can manage the water supply for this scenario. In order to achieve the objectives remedial measures are necessary. As well upstream in the reservoir and the navigation channel as in the Danube. The remedial measures are proposed to be implemented in two phases as follows:

Phase 1:

- Lowering of the water table in the reservoir to an operational level between 128.5 and 129 m asl.
- Construction of a fish-pass near the by-pass weir
- Construction of under-water weirs.
- Strengthening of the tail protection of the inundation weir (in execution).
- Adding dredged gravel to the Danube downstream the Cunovo weir.

Phase 2:

- Narrowing the navigation channel in the reservoir
- Sealing the bottom of the reservoir under areas with stagnant water.
- Opening of connections between the main Danube

channel and the side branches.

- Removing the fortifications of the banks of the main Danube channel.
- Optimizing floodplain habitats outside the areas concerned.
- Shape measures in the reservoir.

The discharge which is not directed into the downstream Danube consists of the following parts:

Phase 1:

(a) A discharge required for the water quality in the downstream part of the reservoir and for avoiding ground water quality problems for the Samorin water works. The key parameter in this regard is the velocity in the main canal in the downstream part of the reservoir. Assuming 0.35 m/s to be sufficient, the necessary discharge can be estimated to 400 - 600 m^3/s with larger values during the summer season. A part of this discharge will be lost by seepage. The remaining part can be used for locking of ships and for hydropower generation.

(b) By discharges in Bratislava higher than 2500 m^3/s about 60 % will a few times during the summer season be directed to the power canal in order to flush the reservoir.

(c) During flood situations in the summer season the 400 - 600 m^3/s will a few times be cut down to the discharge needed for the locking of ships in order to enable higher flood peaks to pass the floodplain.

A minimum discharge to the Danube of approximately 600 m^3/s (depending on the water level regime) should be guaranteed.

When switching to/from higher discharges as outlined under (b) and (c) above it must be ensured that the daily water level fluctuations in the Danube stays within the natural (pre-dam) regime.

Phase 2:

The division of the discharge has to be optimized. This requires comprehensive monitoring of effects of the remedial measures, mathematical modelling and further studies. As a result of the optimization it may be specified that a further part of the Danube discharge can be directed to the power canal, if it is proven not to be essential for the dynamics of the water regime in the flood plain after the completion of the Phase 2 remedial measures.

8.5.3 Possible time schedule for implementation

The construction of the under-water weirs will take about five months. The starting date depends on decision date and the time required for obtaining the necessary legal permissions. Thus, technically it would be possible to complete all the remedial measures of Phase 1 by June 1993.

The content of Phase 2 depends on the results of necessary monitoring, modelling and studies to be carried out during Phase 1.

8.5.4 Impacts on discharges and water levels

For investigating the impacts of under-water weirs on the water levels and velocities mathematical modelling has been carried out. A model already established for the river, cf. ref /3/, was used taking eight under-water weirs with a height of 2 - 2.5 m into account.

On the basis of the model calculations a modified rating curve for Dunaremete has been prepared, see Appendix K. The velocities vary between 0.6 ÷ 2.1 m/s in between the weirs and 1.2 - 3.1 m/s on top of the weirs as compared to 1.4 - 2.4 m/s in the pre-dam conditions. The water level variations for a calculated 10-year period, Appendix H, indicate that the effect of the particularly chosen design is a reduction in average water levels of 7 cm, and a preservation of the fluctuation pattern.

The results show that the desired effect of increasing the water levels without reducing the the velocities too much and of preserving the dynamics with the characteristic fluctuations is possible. However, an optimization of the design will be required.

The situation for the Mosoni Danube is improved as compared to the present (pre-dam) conditions, because permanent discharge throughout the year is now ensured.

8.5.5 Impacts on erosion/sedimentation

By operating the reservoir at water levels between usually 128 and 129 m asl. the erosion at Bratislava will not be stopped.

Some of the suspended sediment load and all the bed load will sediment in the reservoir.

For the Danube downstream the reservoir between Cunovo and Dunaremete, where the pre-dam condition was river bed erosion, it is not certain what the effects will be. On the one hand the sediment concentrations of the inflowing water will decrease (=> erosion). On the other hand, the velocities in the main channel will decrease (=> sedimentation). However, when the bank fortifications be removed as part of Phase 2, bank erosion will take place and the river bed sedimentation may be expected. This is a positive effect.

For the Danube between Dunaremete and Komarno, the present sedimentation conditions are expected to be changed to erosion, because the incoming flow carries less sediment concentrations. This is a positive effect.

8.5.6 Surface water quality

The surface water quality will be influenced by the eutrophication and the sedimentation which will occur in the reservoir. In this regard the reservoir conditions will be significantly different in the upstream part, where all the discharge passes and the downstream part, where only about 25% of the discharge occur.

Due to the throughflow in the upstream reservoir, the eutrophication will be limited here, and will as compared to the inflowing flux of organic matter not add a significant contribution. On the other hand due to the sedimentation of suspended sediments containing organic material, the net change in organic material flowing through the structures into the downstream part of Danube may as well be a reduction. Thus, the impact on the surface water quality in the downstream Danube is expected to be negligible.

Directing about 75% of the discharge to the Danube will, on the other hand result in smaller velocities. With e.g. 600 m^3/s (Phase 1) during summer periods the velocities will with a reservoir water level around 129 m asl. be in the order of 0.35 m/s in the main canal. This velocity is at the critically low side in order to avoid sedimentation of fine material. Furthermore, almost stagnant water may occur in the part of the reservoir outside the main canal, and flushing a couple of times during a summer may not be

9. RECOMMENDATIONS

9.1 The question of reversibility

Four scenarios all assume the continuous existence of the hydraulic structures and the use of the artificial canal for navigation with damming in Slovakia.

One of the five elaborated scenarios, scenario D, is based on the reversibility of the situation to a status equivalent to the status before closing the Danube, by removal of some of the Variant C hydraulic structures.

The choice between these two fundamentally different appoaches cannot be made by the Working Group, which just has pointed out the various consequences of adopting alternative objectives.

9.2 Recommendations in case it is decided not at this stage to redirect the Danube to its former river bed

9.2.1 Approach and priorities

However, independently of the above choice, the Working Group has the recommendations described in the following in case Scenario D should not have been chosen.

In the past, the measures taken for the navigation constrained the possibilities for the development of the Danube and the floodplain area. Assuming the navigation will no longer use the main river over a length of 40 km a unique situation has arisen. Initiated by technical measures the river and the floodplain can develop more naturally.

However, realizing that considerable uncertainties are associated to prediction of impacts of such major manipulations of natural ecosystems and that many of the impacts may easily become irreversible, the Working Group recommends a cautious and experimental approach, where new developments be taken in several steps on the basis of preceding and simultaneous comprehensive monitoring and studies.

In this process the Working Group recommends to give the highest priority to maintain or improve:

* the hydrological and ecological regime in the whole affected area, especially in the downstream

floodplain area;
* the ground water quality; and
* the navigation,

and to give a lower priority to:

* the production of hydropower, and
* the water quality in the downstream part of the reservoir.

9.2.2 Water management for the coming months

Scenario A (95% of the average discharge to the Danube using the existing structures) should be followed as soon as possible, but not later than January 1, 1993. From April 1993 the water management should gradually shift to the one described below.

9.2.3 Water management for the coming year(s)

By recommending the water management for the period from April 1993 and the following year(s) the following two aspects are emphasized:

* The exact content of the water management cannot be described with the present knowledge.

* The coming year(s) should be considered as a temporary period until a long term solution can be reached and the measures necessary to undertake in this period should not prejudge possible final solutions. As basis for deciding on the long term solution, in addition to legal and economic aspects, comprehensive monitoring, mathematical modelling and studies will be required. They are outlined in Subsection 9.2.5 below.

The following actions are recommended:

(a) A combination of monitoring, mathematical modelling and studies, as described in Subsection 9.2.4, should be initiated immediately.

(b) A Joint Danube-Gabcikovo Committee comprised of representatives from Hungary, Slovakia and EC should be established. This committee should have the authority to carry out the following tasks:

    * Technical supervision of the existing

structures with regard to safety functioning.

- * Preparation of a detailed operation manual prescribing how the water management should be carried out.
- * Control that the actual water operation is carried out in accordance with prescriptions given in the operation manual.
- * Reporting of any deviations from the agreed water management operation.
- * Reviewing the results of the monitoring, modelling and studies carried out and making the necessary adjustments to the water management taking the specified objectives into account.

(c) In the beginning of February, 1993 the details of the remedial measures and the water management for the 1993 summer season should be decided. This should be done on the basis of the results from the monitoring, modelling and study programme undertaken in the mean time, see Subsection 9.2.4.

(d) Under-water weirs in the Danube main channel should be constructed for some of the reach between Cunovo and Sap by April 1993. The detailed design will be decided upon as described under (c). It is considered important to start with implementation of some of the under-water weirs as experimental sites and monitore their effects in order to more precisely evaluate their design and function. It is emphasized that under-water weirs are reversible measures, because they can be removed without too big problems, if it is later on decided to redirect the Danube (and the international navigation) to the former river bed (Scenario D).

(e) After April 1993 the water management should shift towards the one described under Phase 1 of Scenario E. The exact content of this water management policy will be decided as described under (c). Tentatively, this is expected to imply that in the order of 25 % of the discharge (in average) be directed towards Gabcikovo. This is considered necessary in order to ensure the ground water quality for the Samorin Water Works. However, in order to do this and at the same time minimize the possible damages for the floodplain ecosystems it will be required to have constructed at least some of the under-water weirs in the Danube main channel.

(f) On the basis of the results from the monitoring, modelling and study programmes carried out during the summer season of 1993 the water management for the coming year should be reconsidered in November 1993. Depending on the results this may result in decisions regarding more or less water to the Danube, implementation of further remedial measures and modifications to existing ones, need for modifications to the monitoring, modelling and study programme.

9.2.4. Studies, monitoring and mathematical modelling required as basis for water management in 1993

The following programme is recommended to be initiated immediately:

(a) Monitoring of the effects of the present situation, which is likely to continue until the end of December, with regard to:

* Ground water quantity and quality. Many key parameters are already today being monitored. However, a supplementation with especially geochemical parameters from wells close to (or within) the reservoir is required.

* Sedimentation in the reservoir.

* Analyses of river and reservoir sediments with regard to organic pollutants and heavy metals.

* Surface water quality including hydrobiological aspects.

* Impact on fauna, flora and habitats in the affected area. This should include a quantititive evaluation of loss of biomass, especially of mussels.

(b) Optimization of the designs of the under-water weirs by use of mathematical modelling. The optimization should aim at preserving the pre-dam dynamic regime with respect to water level regime and should ensure that the velocities in the main channel are so large that the river bed continue to consist of coarse material.

(c) Assessment of the risk to the ground water quality, in particular between the reservoir and the Samorin Water Works. This has previously been studied but should be reconsidered taking the new data into account.

9.2.5 Studies, monitoring and mathematical modelling required for the long term

The following programme is recommended to be carried out within the coming 2-3 year period:

(a) Study aiming at establishment of a set of ecological objectives for the Danube floodplain landscape. This study must be carried out in close interaction with decision makers in the two countries.

(b) Establishment of a comprehensive mathematical modelling system coupled with the necessary data bases. This system should be fully tested and applied to some of the most urgent water management problems in a dialogue with the decision makers. The modelling system should cover the following aspects:
- groundwater, including geochemistry,
- unsaturated zone, including agricultural aspects,
- river hydraulics, including sedimentation/erosion and water quality,
- reservoir flow, sedimentation and water quality, and
- fauna, flora and habitats in floodplain.

with basically the same specifications as under the ongoing PHARE project "Danubian Lowland - Ground Water Model" except for more emphasis to floodplain ecological aspects and for equal coverage of the two countries.

(c) Establishment of a comprehensive monitoring programme, specifically tailored to provide the necessary data for the problems associated with the proposed water management. This programme will be a supplement to already existing general programmes within the following fields:

* ground water quality;
* reservoir conditions;
* sedimentation and erosion; and
* floodplain fauna, flora and habitat.

(d) Studies of the effects of under-water weirs and other remedial measures.

(e) Collection of more information about the reservoir, e.g. the extent of bituminous layers and the possible contamination with benzpyrenes is necesssary.

(f) Study of water quality of the navigation channel should be carried out for the estimation of organic loading.

(g) Economical assessment.

(h) Integration of the above in a decision support study.

Budapest, November 23, 1992

Jens C. Refsgaard

Jan Van Geest

Johann Schreiner

Heinz Löffler

SUMMARY OF IMPACT ASSESSMENTS FOR SCENARIOS*

Key parameter	Scenario A	Scenario B	Scenario C	Scenario D	Scenario E (Phase 1)
Date for possible start of specified water management operation	January 1993	November 1992	1993-95	November 1993	July 1993
Surface water regime					
- Danube average water level	0/-	-	- => +	0	- => +
- Danube w.l. fluctuations	0	-	-/0	0	0
- Danube velocities	0	-	-	0	-
- floodplain dynamics	0/-	-	- => +/?	0	0
- Mosoni Danube discharge	+	+	+	0	+
Effects of sedimentation/erosion					
- near Bratislava	+	+	+	0	0
- in reservoir	-	-	-	0	-
- between dam and Palkovicovo/Sap	-	0/-	0/- => +/?	0	- => +
- Downstream Palkovicovo/Sap	+	+	+	0	+
Surface water quality					
- upstream part of reservoir	?	?	?	0	?
- downstream part of reservoir	-	?	?	0	?
- Danube	- => ?	-	- => ?	0	- => ?
Ground water regime					
- near reservoir	+	+	+	0	+
- within floodplain	0/-	-	- => +	0	- => 0
- area behind	0	-	- => 0/+	0	- => +/0
Ground water quality					
- general	0	-	0	0	0
- near reservoir	-	0/-	0	0	-
Agriculture and forestry					
- agriculture near reservoir	+	+	+	0	+
- agriculture further downstream	0/-	-	- => 0	0	0
- floodplain forestry	0	-	0	0	0
Navigation (excl phase 2)					
- navigation canal	+	+	+	0	+
- Danube	-	-	-	0	-
Hydropower	0	+	+	0	+

Legend:
- \+ better/more than in pre-dam conditions
- \- worse/less than in pre-dam conditions
- 0 approximately same as in pre-dam conditions
- ? extraordinarily large uncertainty in assessment

* For fauna, flora and habitats + and - developments will be observed simultaneously

10. REFERENCES

The Working Group has made use of a large number of reports. The key references comprise the following:

/1/ Report of Fact Finding Mission on Variant C of the Gabcikovo-Nagymaros Project. Commission of the European Communities, Czech and Slovak Federative Republic, Republic of Hungary. Bratislava, October 31, 1992. 31 pp.

/2/ Report prepared by Professor Igor Mucha for the Working Group. Bratislava, November 20, 1992.

/3/ Report prepared by VITUKI Hungary on the Changes of Water Management of Szigetköz. 1992

/4/ Inception Report for CEC-CSFR PHARE project EC/WAT/1 "Danubian Lowland Ground Water Model". Prepared by a Danish-Dutch consortium headed by Danish Hydraulic Institute. July 1992.

/5/ Mucha I., et. al., Working Manual to consortium of invited specialists,Ground Water Consultants,Faculty of Natural Sciences,Comenius University, Bratislava, 1992

/6/ Mucha I, et. al., Poddunajská ní,ina - Model podzemných vôd,Podklady, priebe,né výsledky a návrhy opatrení pre optimalizáciu vodného diela Gabèíkovo a ochranu podzemných vôd, Konzultaèná skupina "Podzemná Voda",Prírodovedecká Fakulta, Univerzita Komenského, Bratislava, 1992

/7/ Rodak Dalibor, et. al., Zhodnotenie sedimentov dunajských náplavov z h¼adiska obsahu a migrácie kontaminujúcich látok v podzemných vodách, Konzultaèná skupina "Podzemná Voda",Prírodovedecká Fakulta, Univerzita Komenského, Bratislava, 1992

/8/ Mucha I, et. al., Kjelds J.T.,Klucovska J,Topolska J., Návrh optimalizácie zdr,e smernými a prieènymi stavbami, Konzultaèná skupina "Podzemná Voda",Prírodovedecká Fakulta, Univerzita Komenského, Bratislava, 1992

/9/ Rosina, Uhlár, Cábel, Doèasný manipulaèný poriadok pre uvedenie vodného diela Gabèíkovo do prevádzky doèasným rie,ením na území ÈSFR, Hydroconsult, Bratislava, 1992

/10/ Mucha I., et. al., Mechanizmus samoèistiacich procesov pri brehovej infiltrácii a podzemnej vody vodných zdrojov, Konzultaèná skupina "Podzemná Voda",Prírodovedecká Fakulta, Univerzita Komenského, Bratislava, 1992

/11/ Docasny manipulacny poriadok pre uvedenie vodneho diela Gabcikovo do prevadzky docasnym riesenim na uzemi CSFR. Hydroconsult, Bratislava, 1992.

/12/ Hydro-Quebec International, Rapport d'opinion sur certains aspects du projet affectant la mise en exploitation de la centrale Gabcikovo, Decembre, 1990

/13/ Geofyzika státni podnik Brno, Projekt geofyzikálních prací SVD-G, Seizmická stanica, 10. 12. 1990

/14/ Magyar Tudományos Akadémia ad hoc bizottság. A magyar csehszlovák közös Duna-szakasz rehabilitációját megalapozó kutatások. Összefoglaló zárójelentés, 1990-1991 (Survey for the rehabilitation of the Hungarian-Czechoslovakian common Danube-reach)

/15/ Stellungsnahme des WWF über Gabcikovo-Nagymaros Projekt, im August 1989

/16/ A C változatot vizsgáló három oldalú szakmai bizottság munkájához összeállított tájékoztató anyagok, VITUKI kézirat, 1992

/17/ On the ecological-environmental effects of the Gabcikovo Nagymaros System. Summary of the Ecological Risk Assessment based on the research reports, standpoints and opinions of the Hungarian Academy of Sciences, manuscript, 1992

/18/ Seismological risks of the Gabcikovo Barrage System, manuscript, 1992

APPENDIX A

Agreed Minutes of the Meeting between the European Commission, the CSFR and Hungary on 27th October 1992 on the Gabcikovo/Nagymaros Project

Agreed Minutes of the Meeting between the European Commission, the CSFR and Hungary on 28th October 1992 on the Gabcikovo/Nagymaros Project.

1) It was agreed that all works on variant C of the Gabcikovo/Nagymaros project will be stopped at a date specified by the EC Commission on the basis of the fact finding mission composed of one expert from each side (Commission, CSFR and Hungary), taking into account the risk of damage to existing structures including navigation, of ecological damage to the region and of flooding (Spring 1993 or sudden surges). The mission shall report as soon as possible, but not later than Saturday October 31st at 12 noon.

The CSFR undertakes to guarantee to maintain the whole* traditional quantity of water into the whole old Danube riverbed, including the section between Rajka and Palkodicobo, and to refrain from operating the powerplant.

2) A working group of experts shall be set up immediately, consisting of three experts nominated by the European Commission, assisted by one expert appointed by Hungary and the CSFR each. The three Commission experts shall be specialists in respectively environmental matters, hydrology and water architecture.

3) The task of the working group will be to:

i) make an on-site inspection of the structures of variant C;

ii) assess the need and urgency of these structures in the light of the potential flooding risk, including the risk of causing damage to already constructed parts;

iii) assess the immediate consequences/impacts of these structures relating to:

* environment;
* hydrological and water management aspects;
* navigation, and

iv) assess the reversibility of these structures and assess the cost for restoring the status quo ante, i.e., the situation existing prior to the construction of the dam.

The group will report its findings to the Trilateral Meeting to be held in Brussels on a date to be agreed by the three parties (within 15 days), and make suggestions on urgent measures to be taken. The findings shall not prejudice the evidence produced within the context of the legal procedures described under paragraph 4 below.

4) Both the CSFR and Hungarian delegations expressed their commitment to submit the dispute connected with the Gabcikovo/Nagymaros project with all its aspects, including legal, financial and ecological elements, to binding international arbitration or to the International Court of Justice.

5) This agreement does not prejudge the legal rights of the parties.

For the Czech and Slovak Federation Delegation ....

For the Hungarian Delegation ....

For the European Commission ....

* "whole" means not less than 95%

APPENDIX B

Terms of References for the Working Group

COMMISSION
OF THE EUROPEAN
COMMUNITIES

Brussels, October 29, 1992

Directorate General
External Relations
Operational Service PHARE
PHOS 1. HCS/

Terms of References
Working Group of independent experts
on the Gabcikovo-Nagymaros Dam

1. Introduction and participants

A Working Group of experts has been established consisting of three independent experts nominated by the Commission of the European Communities and one expert nominated by the Government of Hungary and one expert nominated by the Czech and Slovak Federal Republic.

The selected experts are specialists in environmental matters, hydrology and dam construction and other aspects related to building in water.

The nominated experts are:

* Mr. Jens Christian Refsgaard, Team Leader
(Hydrological and environmental aspects), Danish Hydraulic Institute
* Mr. Johannes M. van Geest,
(Engineering, navigation and economic aspects), DHV, The Netherlands
* Mr. Johann Schreiner, North German Environment Academy,
(Environmental and ecological impacts)
* One expert to be nominated by Hungary
* One expert to be nominated by CSFR

The Group will work under the supervision and coordination of Mr. Jens Christian Refsgaard (Team Leader).

Short term expertise could be provided by the Commission of the European Communities in highly specialised areas if requested by the Team Leader.

2. Scope of Work

The Working Group will:

i) Make an on-site inspection of the structures of Variant C and describe the state of work;

ii) Assess the need and urgency of these structures in the; light of the potential flooding risk, including the risk of causing damage to already constructed parts;

iii) Assess the (immediate) consequences/impacts of these structures relating to:

* Environment, covering:

  - Erosion and Sedimentation in River and River Reservoir System
  - Surface Water Quality
  - Ground Water Regime
  - Ground Water Quality
  - River and Flood plain Ecology

* Hydrological and water management aspects and

* Navigation

The assessment will be based on an outline of existing (pre-dam) conditions and trends.

iv) Assess the reversibility of these structures and assess the cost of restoring the status quo ante, i.e., the situation existing prior to the construction of the dam.

v) Make suggestions for (urgent) measures and, if necessary, studies to be (under) taken to improve the present conditions.

4 Reporting

The Working Group will prepare a detailed and concise Final Report signed by all five participating experts. The Final Report will contain a short executive summary. The Working Group will report its findings to a Trilateral Meeting between the Commission of the European Communities, CSFR and Hungary in Brussels, November 27, 1992.

The Team Leader will on a regular basis inform the Commission of the European Communities, Mr. Pablo Benavides or his representatives (Messers. Guggenbuhl, Aldershoff and Stausboll) about progress in work and potential problems. The Team Leader will present an (oral) report to Mr. Benavides in Brussels November 13, 1992.

The members of the Working Group can report only to the Commission of the European Communities. Public statements, participation in press conferences etc. is strictly prohibited and no persons not directly involved should receive information on the work and progress. The final Report will be confidential until otherwise decided by the Commission of the European Communities.

3 copies of the Final Report should be submitted to:

* Mr. Benavides, Director, Commission of the European Communities
* Mr. Pirek, Vice minister for Foreign Affairs of the CSFR
* Mr. Martonyi, Secretary of State for International Economic Relations of the Republic of Hungary

5. **Time schedule**

The Working Group will start its work November 6, 1992 at 10.00 AM at a location which will be communicated later by the Commission of the European Communities.

The Final Report should be submitted November 23, 1992 at 16.00 PM.

The Working Group should present its findings to the Trilateral Meeting arranged in Brussels on November 27, 1992.

6. **Location**

The Working Group will work the first week in Bratislava and the second week at a suitable location in Hungary.

7. **General**

All relevant data and information should be made available by the two Governments to the Working Group, and any problems in this respect should be reported immediately by the Team Leader to the Commission of the European Communities.

Pablo Benavides,
Director

Contacts:	Phone	Fax
Mr. Benavides	(32 2) 29 61 299	29 64 304
Mr. Guggenbuhl	29 51 474	29 65 958
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APPENDIX C

Members of the three delegations assisting the Working Group

Members of the three delegations:

For the European Commission:

Jens Christian Refsgaard, Chief Hydrologist, Danish Hydraulic Institute
(Member of Working Group)

Jan M. Van Geest, Director DHV Environment and Infrastructure, The Netherlands
(Member of Working Group)

Johann Schreiner, Director, Norddeutsche Naturschutzakademie, Germany
(Member of Working Group)

Professor, Dr. Heinz Löffler, Head of Zoological Department, University of Vienna
(Member of Working Group)

For the Czech and Slovak Federative Republic:

Igor Mucha, Faculty of Natural Science, Comenius University, Bratislava
(Member of Working Group)

Stefan Molnar, Civil Engineer

Julius Sutor, Soil Management Expert

Jan Cabel, Water Management Expert

Jozef Fury, Water Management Expert

Lubomir Bansky, Student, Comenius University

For Republic of Hungary:

Gabor Vida, Head of Department of Genetics, Eotvös L. University, Budapest
(Member of Working Group)

Adrienne Hajosy, Geophysicist

Ferenc Meszaros, Biologist

György Tóth, Geologist

János Gyurkó, Civil Engineer

Pál Liebe, Civil Engineer

Péter Bakonyi, Civil Engineer Budapest.

APPENDIX D

Statement from J. Binder, Director Water Economy Construction on state of work.

[illegible]
PRE VÝSTAVBU A PREVÁDZKU SÚSTAVY
VODNÝCH DIEL GABČÍKOVO — NAGYMAROS

Representativ of the Governments
of the ČSFR and Slovak Republik for
the waterwork Gabčíkovo-Nagymaros
Ing. Dominik K o c i n g e r

1. Mr. P. Benavides
fax: 00 322/2964305
Bruxelles Belgium (KES)

2. MR. Van Geest
fax: 00-361/1183993
Budapest - Hungary

23. november 1992

Gabčíkovo: Information about the Temporary Suspending of Works.

Based on the technical inspection of the structures of the socalled variant C, realised by the working group on 22 November 1992, there was reached the following agreement about the suspension of structural works until 27 November 1992:

All works on the variant C will be suspended, besides:

1. Works in removing of the submerged vessel upstream of the bypass weir.
2. Remedial works on the spillway and banks of the bypass.
3. Works on the sealing of the closure of the Danube channel.

The suspension does not concern the works on structures of the original solution, according to the valid Treaty.

In the case of increased flows necessitating the use of the weir in inundation, necessary measures will have to be taken operatively also within these structures.

The suspension of works, even for the time of five days, will cause a daily loss preliminarily estimated to 7 mil Kčs and in the case of floods, the probability of damages on the unfinished structures as well as in the downstream region, will be accordingly increased.

Yours sincerely

Discharge capacity review of the structures.

1, **Litle Danube** - continuosly 50 m^3/s

2, Intake into **Mosoni Danube** - continuosly 20 m^3/s

3, **By-pass Weir**

3.1. At present after repairing damage (ship and spillway) (rating curves of weir are not valid) **300 m^3/s**

3.2. After repairing damages and after stabilization of spillway (after January 1992) 600 m^3/s

4, **Weir in inundation**

These valuse are only valid if weir spill-way is completly fortified

4.1. ***20 segments***:	at water level **129.0** m asl. from 01/93	760 m^3/s
	at water level **130.0** m asl. from 02/93	2400 m^3/s
	at water level **131.1** m asl. from 04/93	4800 m^3/s
4.2. *During summer flooding*		
	at water level **131.5** m als. in 1993	6000 m^3/s

5, Intake structure into river branch system

5.1	Phase 1 :	2 pipes of diameter 1200 mm continuosly from 12/92 .	7.2 m^3/s
5.2	Phase 2 :	(canal into river branch system) at water level **131.1** m asl. from 04/93 according to the need maximaly	234 m^3/s

6, Ship locks (at present and future)

6.1 Navigation through 1 lock : (continuosly)
by-pass discharge through other lock at water level diference:

H= 16 m	510 m^3/s
H= 19 m	560 m^3/s

6.2 Without navigation : 1 by-pass (continuosly)

at water level 128.0 m ... *H= 16 m*	680 m^3/s
at water level 131.1 m ... *H= 19 m*	740 m^3/s

6.3 Weir operation : 1 ship lock

at water level 128.0 m	640 m^3/s
129.0 m	830 m^3/s
131.1 m	1320 m^3/s

In case of passing floods it is possible according to the CSFR norm to use one ship lock for navigation and one for by-pass. If water is passing trough by-pass during weir operation in the same ship lock then discharge capacity will be :

at *H= 16 m*	**400 m³/s**

From this it is clear, that discharge capacitie of both ship locks (when navigation is stopt) for passing of the big floods is at water level

128.0 m	**1040 m³/s**
129.0 m	1203 m³/s
131.1 m	1720 m³/s

For passing through of higher discharges it is possible to use combinations of by-pass and weir operation on both ship locks, that means maximum discharge:

at water level	128.0 m	(2x400 + 2x640)	2080 m³/s
at water level	129.0 m	(2x400 + 2x830)	2460 m³/s
at water level	131.1 m	(2x400 + 2x1320)	3440 m³/s

<u>Hydropower plant</u>

Present :	2 agregates	1000 m³/s	
	1 agregate	60 m³/s	
	total:		1060 m³/s
to 24.11.1992	3 agregates	1500 m³/s	
	1 garagate	60 m³/s	
	total:		1560 m³/s
to 31. 11. 1992	5 agragates		2500 m³/s

Maximal amount of water discharge trough Gabcikovo water structure (hydropower plant and ship locks) is limiteg by maximum dicharge of power canal at water level 131.1 m asl. is 5000 m³/s.

Ing. Julius Binder

signed by his representative

Ing. Stefan Molnar

APPENDIX E

Sketch of Variant C of Gabcikovo-Nagymaros

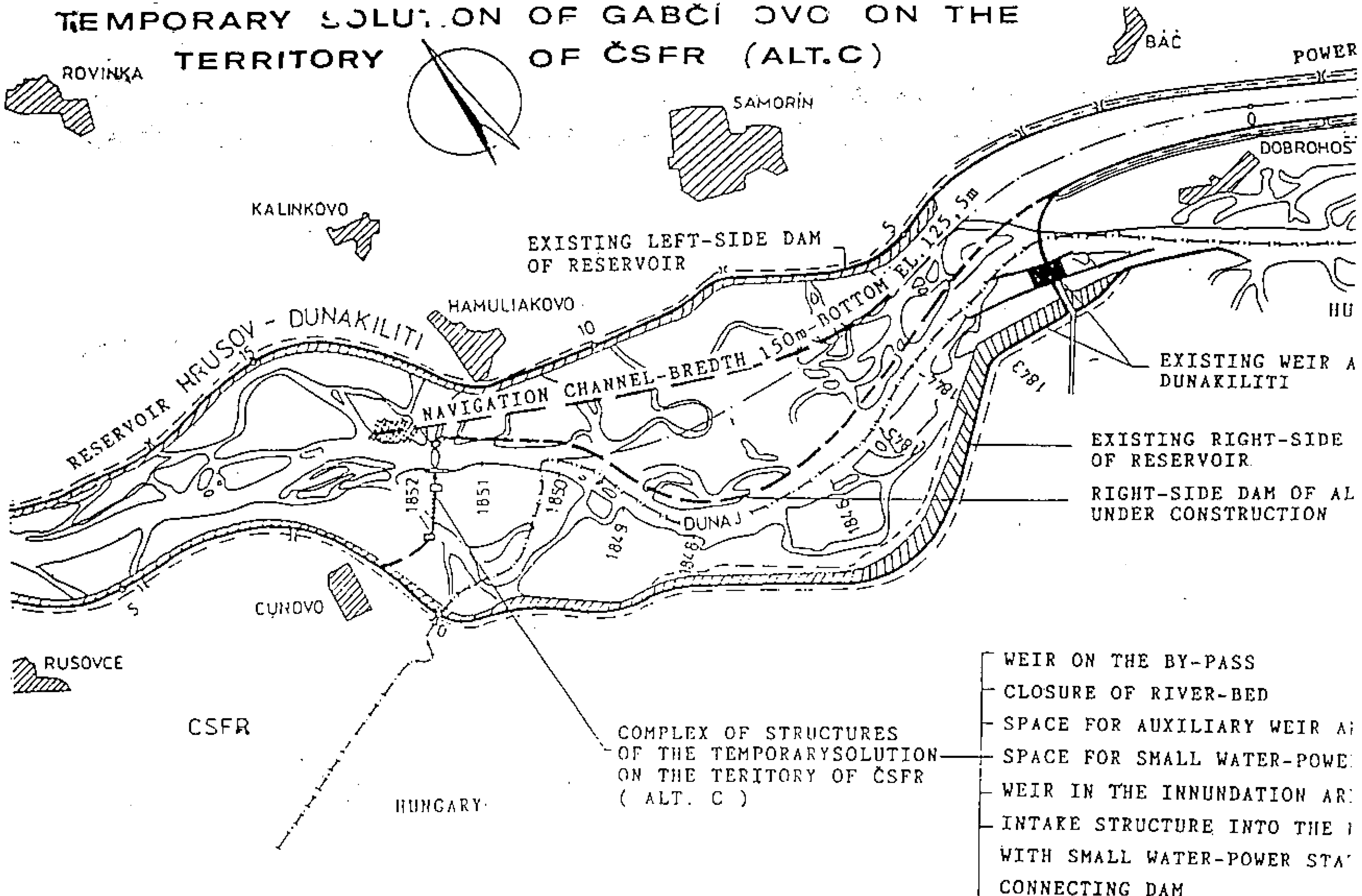

TEMPORARY SOLUTION OF GABČÍKOVO ON THE TERRITORY OF ČSFR (ALT. C)
ROVINKA
SAMORÍN
BÁČ
POWER
DOBROHOŠŤ
KALINKOVO
EXISTING LEFT-SIDE DAM OF RESERVOIR
HAMULIAKOVO
RESERVOIR HRUSOV - DUNAKILITI
NAVIGATION CHANNEL-BREDTH 150m-BOTTOM EL. 125.5m
EXISTING WEIR AT DUNAKILITI
EXISTING RIGHT-SIDE OF RESERVOIR
RIGHT-SIDE DAM OF AL UNDER CONSTRUCTION
DUNAJ
CUNOVO
RUSOVCE
CSFR
HUNGARY
COMPLEX OF STRUCTURES OF THE TEMPORARYSOLUTION ON THE TERITORY OF ČSFR (ALT. C)
WEIR ON THE BY-PASS
CLOSURE OF RIVER-BED
SPACE FOR AUXILIARY WEIR A
SPACE FOR SMALL WATER-POWE
WEIR IN THE INNUNDATION AR
INTAKE STRUCTURE INTO THE
WITH SMALL WATER-POWER STA
CONNECTING DAM

Fig. 1.1

APPENDIX F

Discharge capacities of Variant C structures

DISCHARGE CAPACITIES [m^3/s] OF VARIANT C.

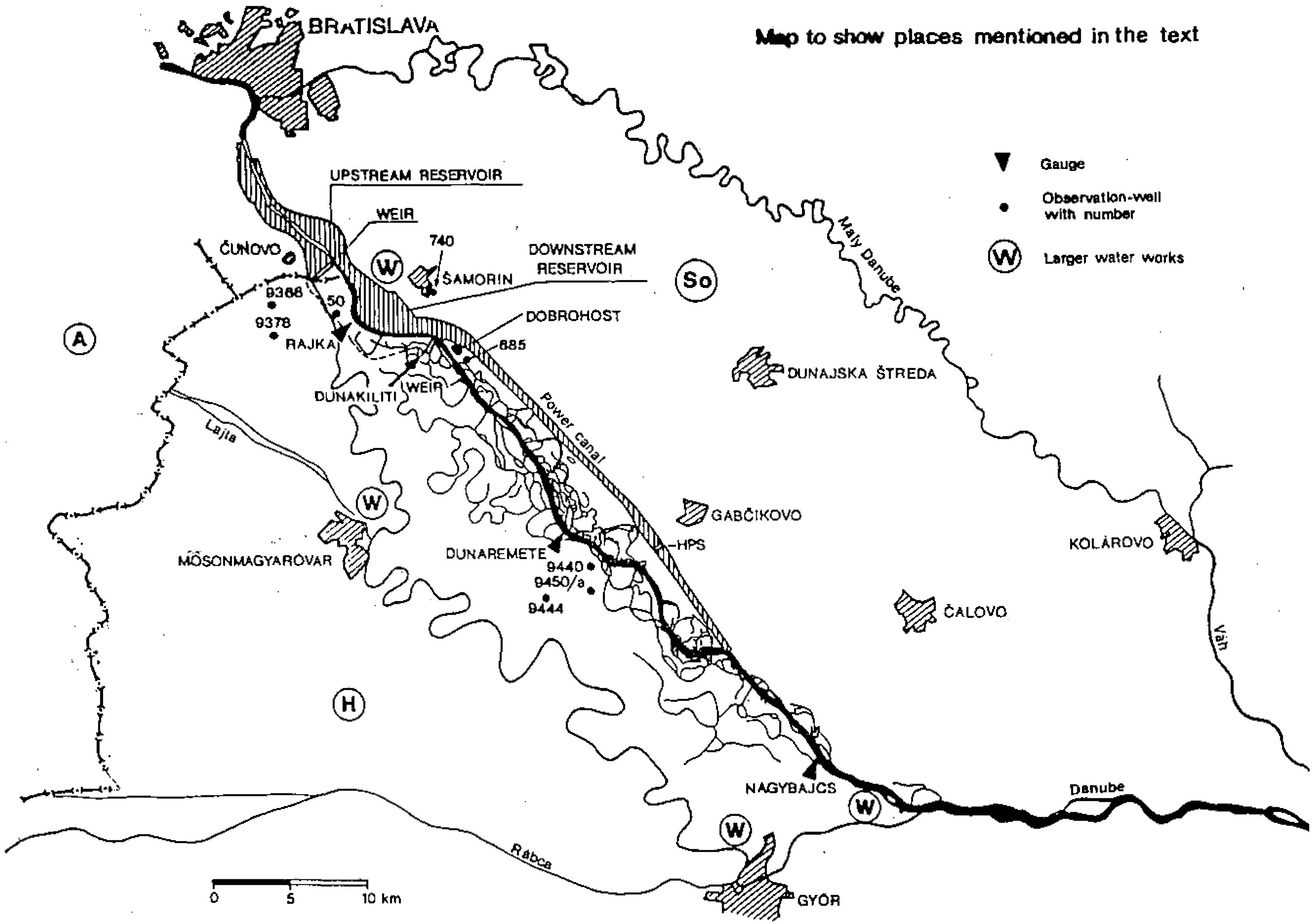
(according to the scheduled completion and stated water levels)

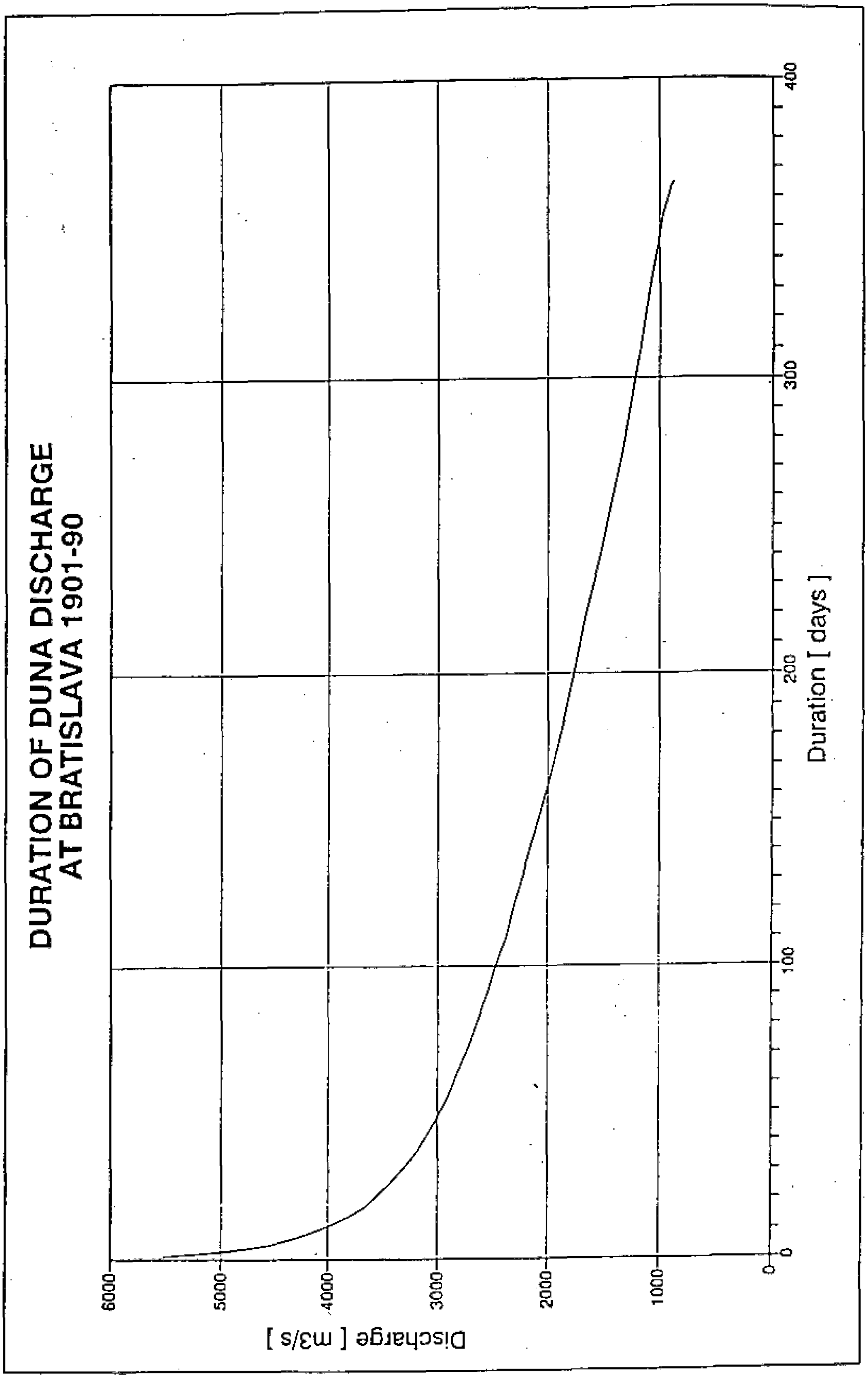
PERIOD	30-10-92	30-10-92	21-11-92	01-01-93	31-12-95
WATER LEVEL m asl	129.0	131.1	131.1	131.1	131.1
GABCIKOVO COMPLEX					
Ship locks	1500 *	1970	1970	5200	5200
Power station	500 *	610	1220		
Water intake in dike		250	250		
ALTERNATIVE C PHASE 1					
By-pass weir	300 *	300	650	1460	1460
Floodplain weir	500 *	2340	2500-4000#	4600	4600
Mosoni weir	20	25	25	25	25
ALTERNATIVE C PHASE 2					
Locks,weir and HEP					6300
TOTAL	2820	5495	7915-9415	11500	19385
DESIGN FLOODS					
$Q_{1\%, winter}$	6000	6000	6000	6000	
$Q_{1\%, year}$					10600
$Q_{0.01\%, year}$					15000

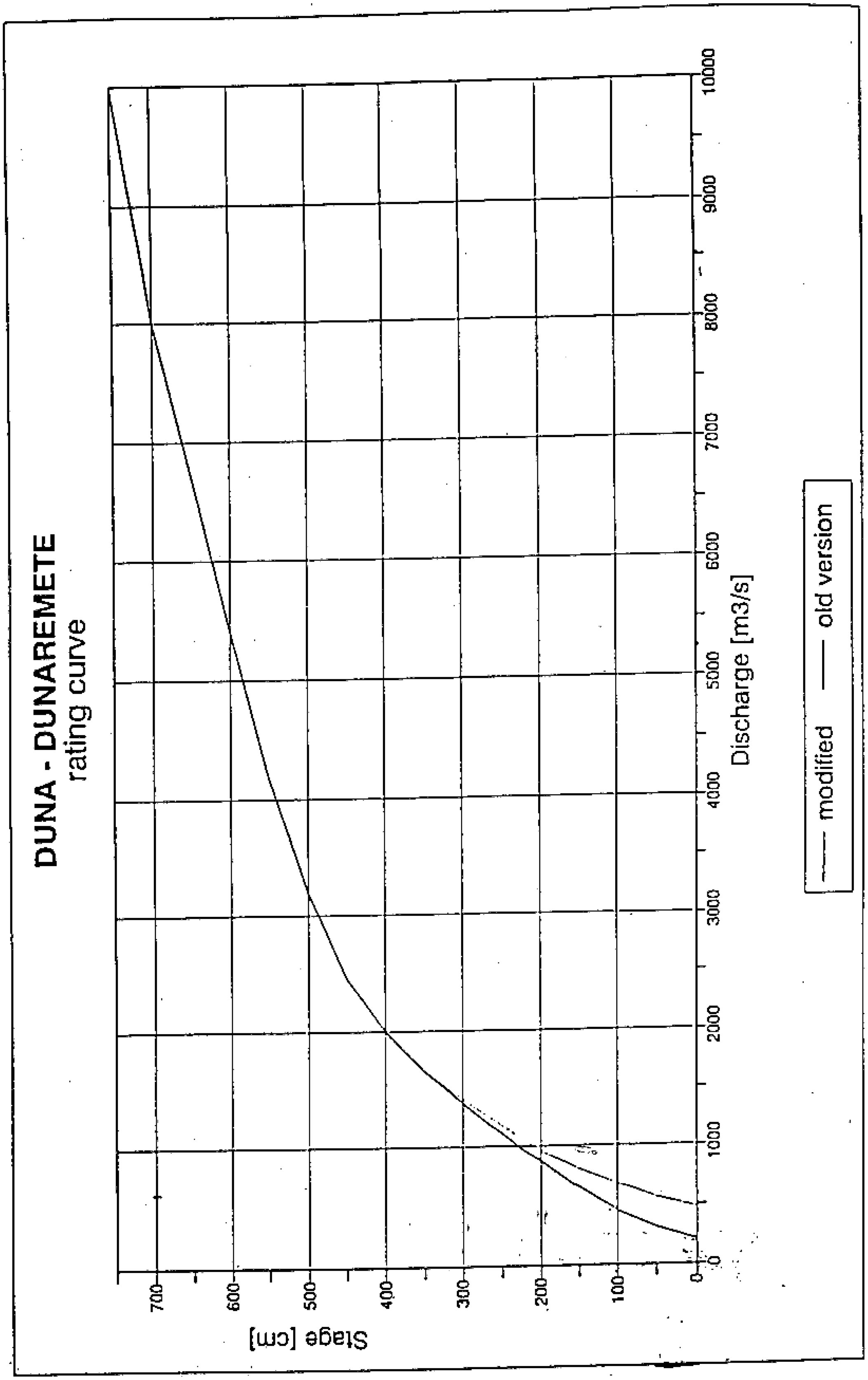
Notes: * : estimated values
: under continous change during construction

APPENDIX G

Figures illustrating the present (pre-dam) state and trend in the area

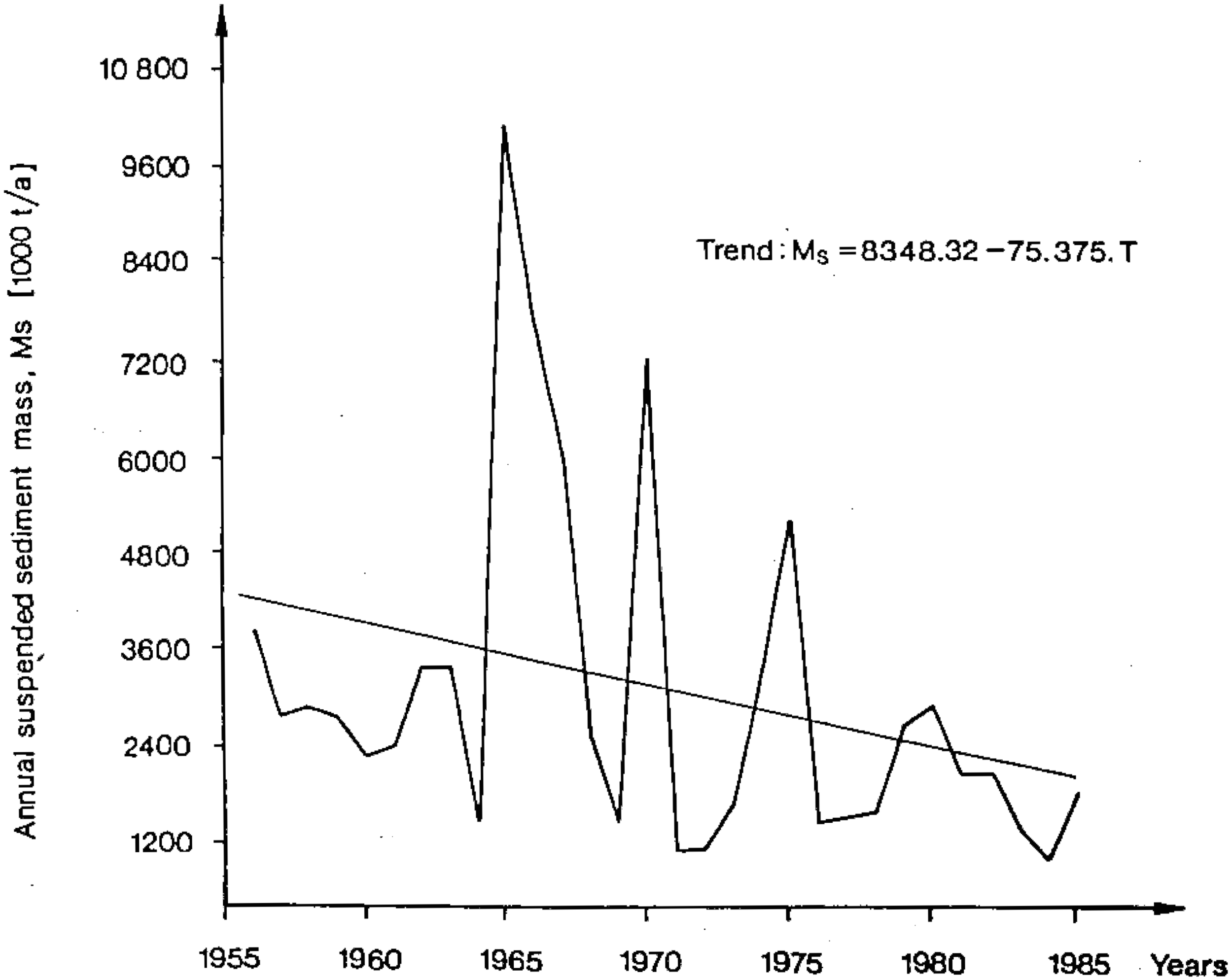

Map to show places mentioned in the text
BRATISLAVA
UPSTREAM RESERVOIR
WEIR
ČUNOVO
740
ŠAMORIN
DOWNSTREAM RESERVOIR
So
W
A
9368
9378
50
RAJKA
DOBROHOST
685
DUNAKILITI
WEIR
DUNAJSKA ŠTREDA
Malý Danube
Power canal
Lajta
MOSONMAGYARÓVAR
GABČIKOVO
HPS
DUNAREMETE
9440
9450/a
9444
KOLÁROVO
ČALOVO
Váh
H
NAGYBAJCS
Danube
Rábca
GYÖR
0
5
10 km
Gauge
Observation-well with number
Larger water works


DURATION OF DUNA DISCHARGE
AT BRATISLAVA 1901-90
Discharge [m3/s]
6000
5000
4000
3000
2000
1000
0
Duration [days]
0
100
200
300
400



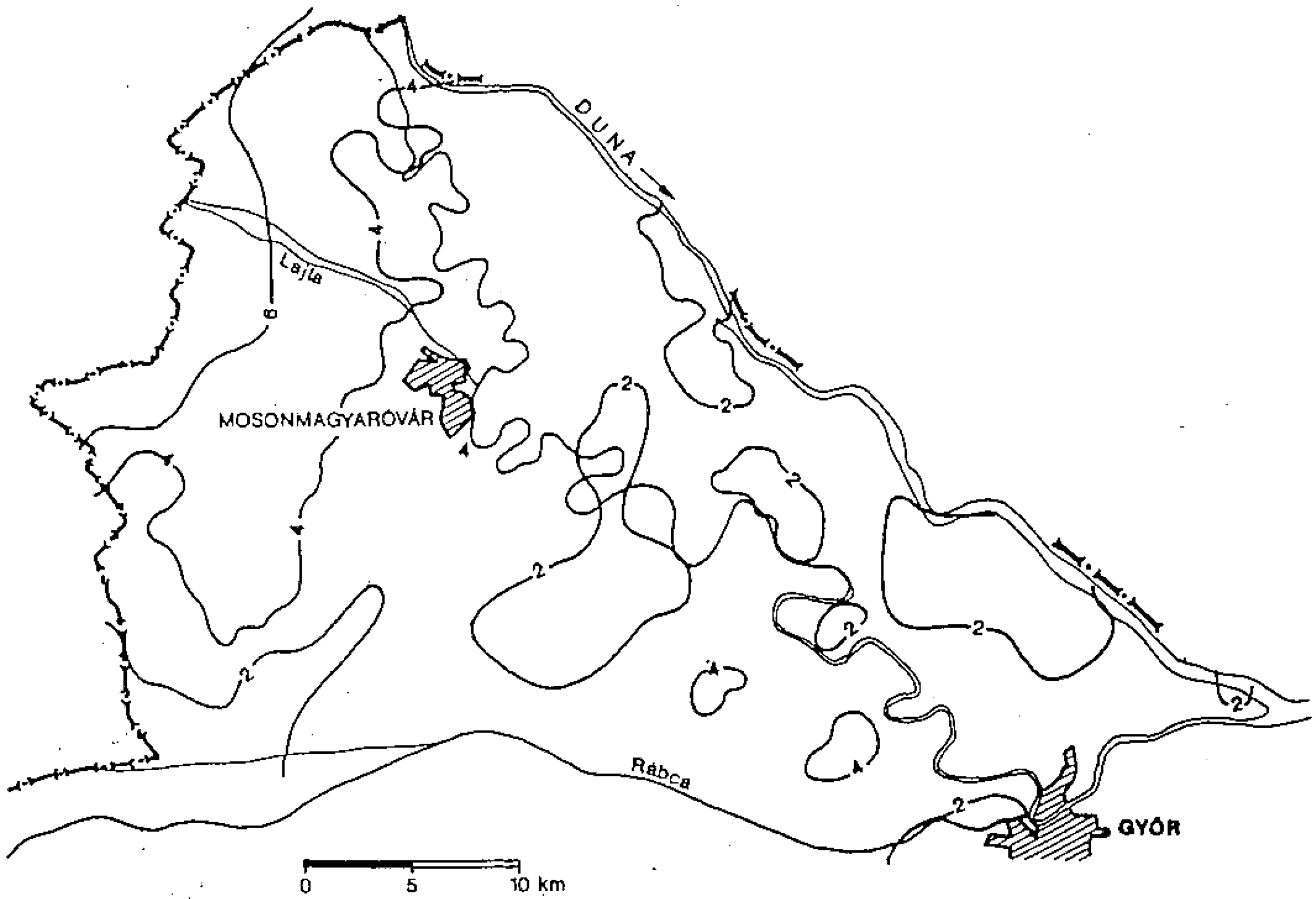
DUNA - DUNAREMETE
rating curve
Stage [cm]
Discharge [m3/s]
modified
old version
0
100
200
300
400
500
600
700
1000
2000
3000
4000
5000
6000
7000
8000
9000
10000

TREND OF ANNUAL SUSPENDED SEDIMENT MASSES AT RAJKA BETWEEN 1956 AND 1985

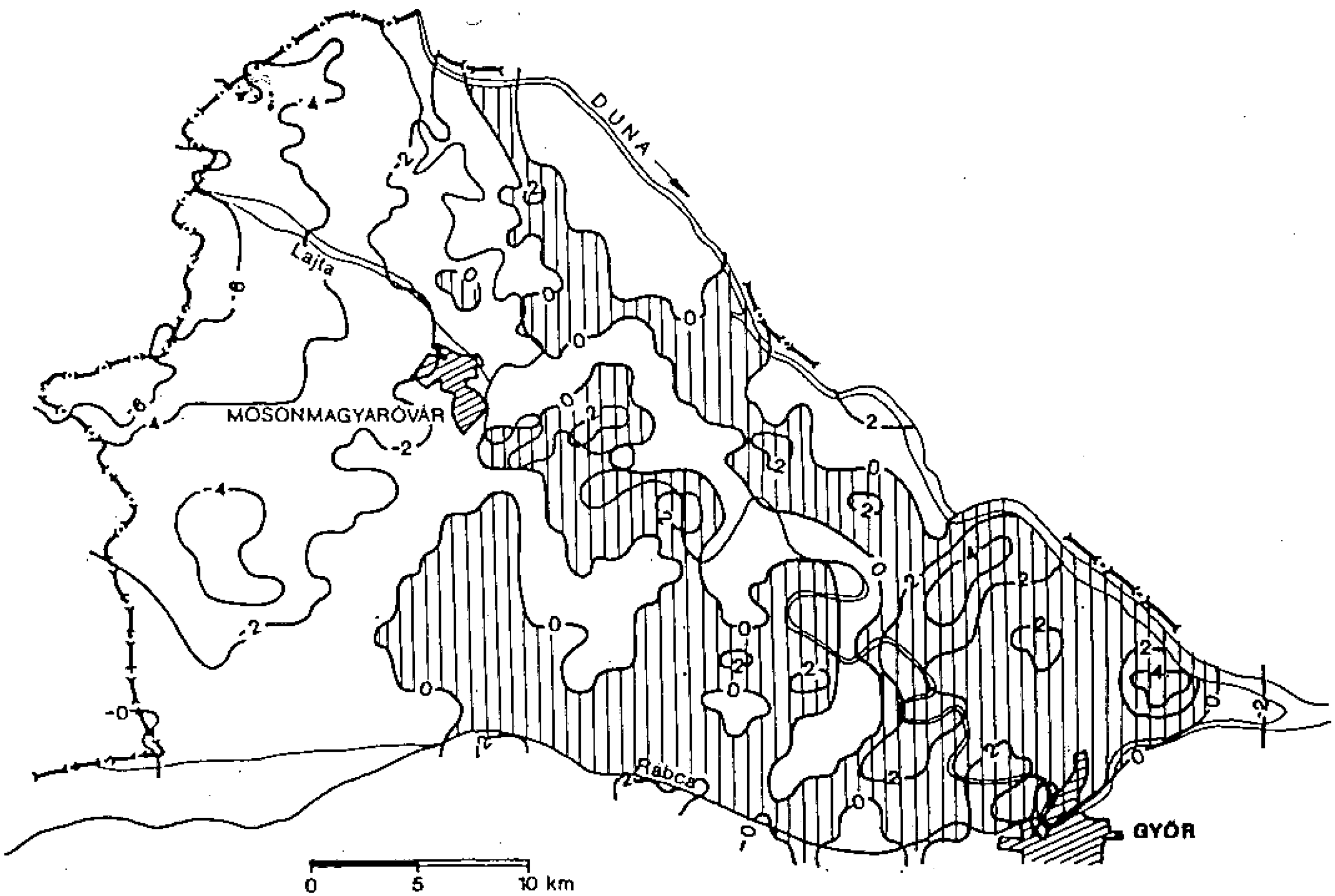


Depth of groundwater table below the surface [m]

Original state



Depth of groundwater table compared to the base of the top-layer [m].
Original state



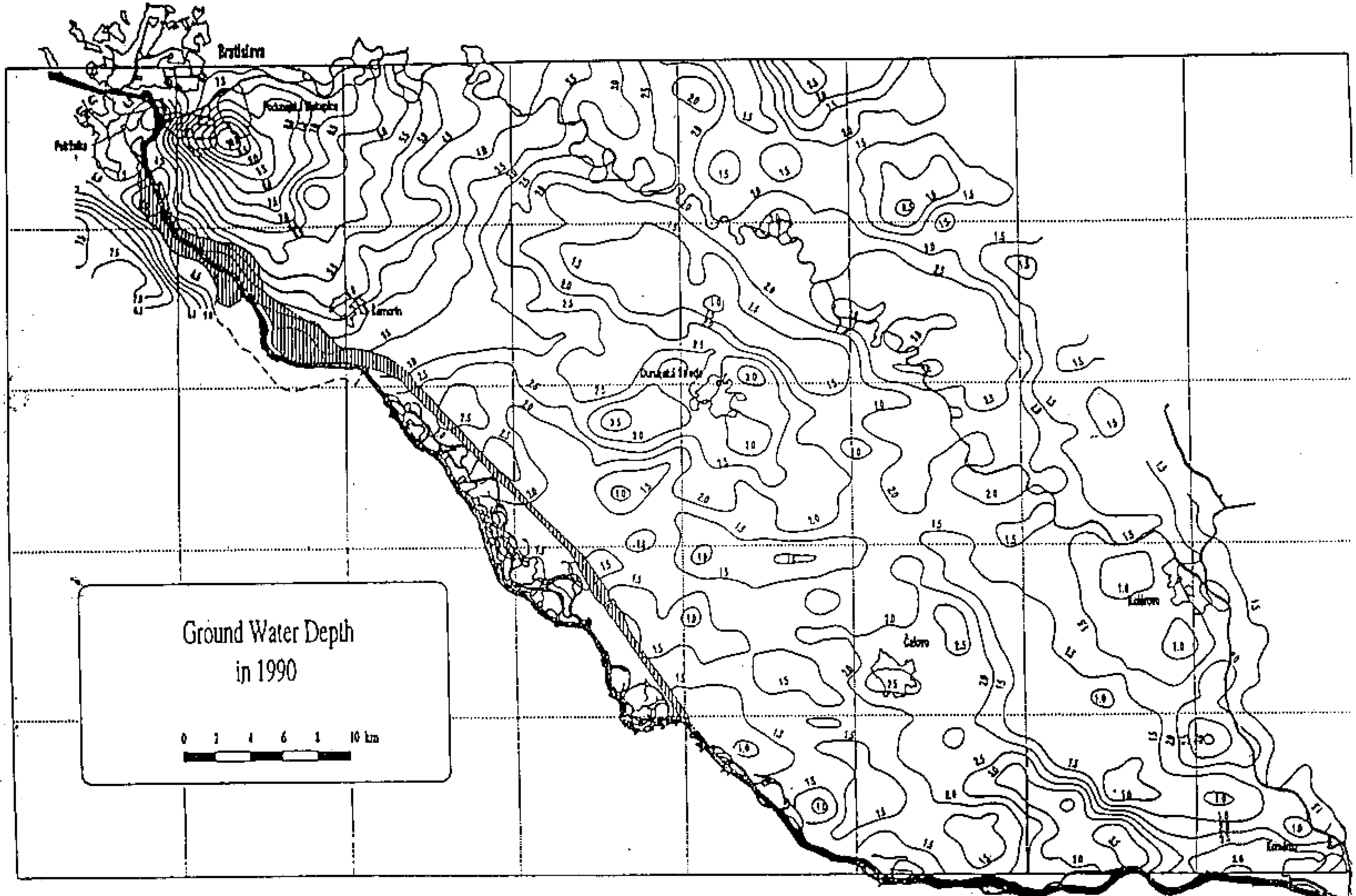
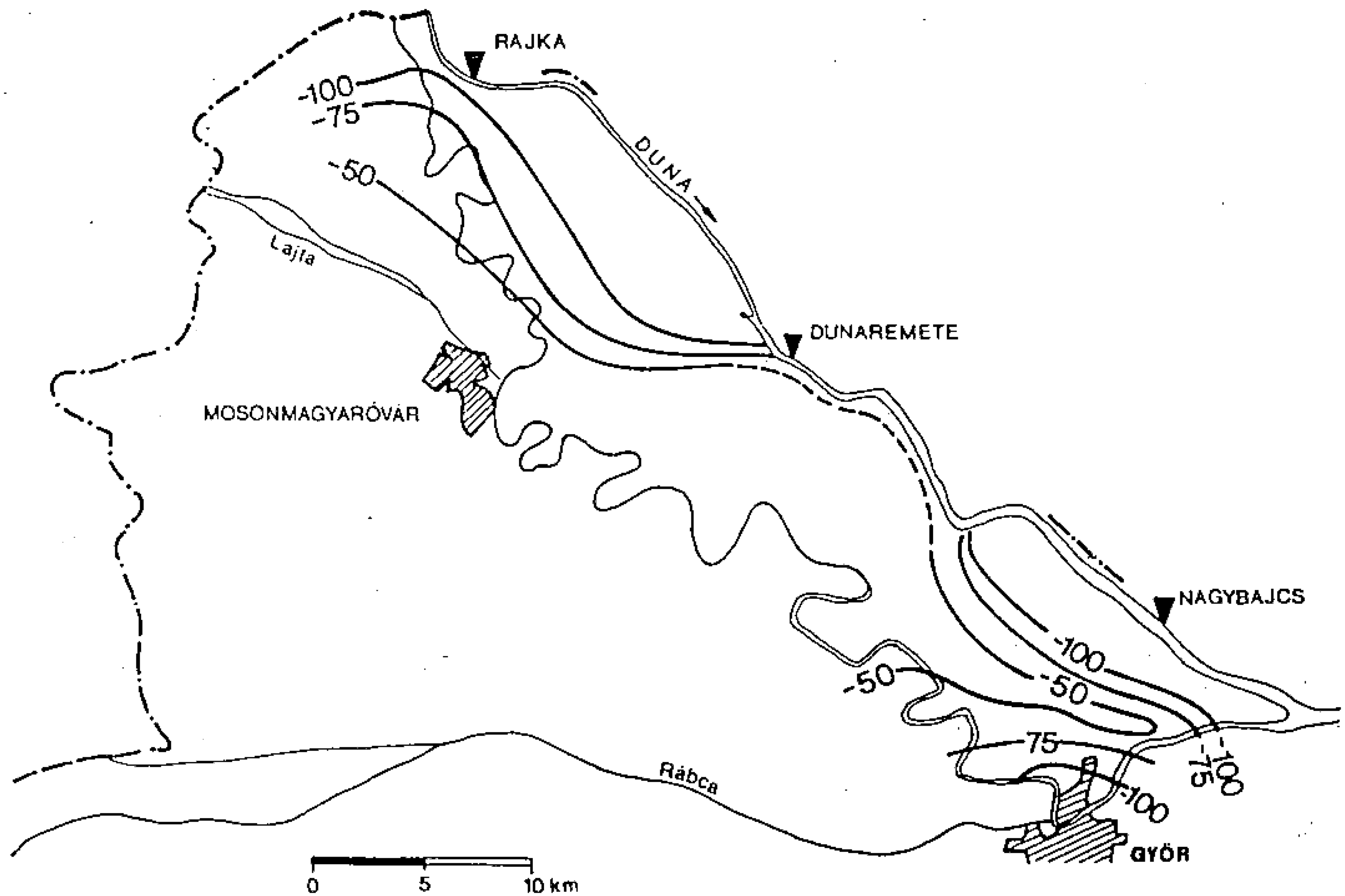


Fig. 5.19:Ground water level depth lines in 1990.

Difference of the average groundwater levels between the periods 1956-60 and 1986-90 [cm]



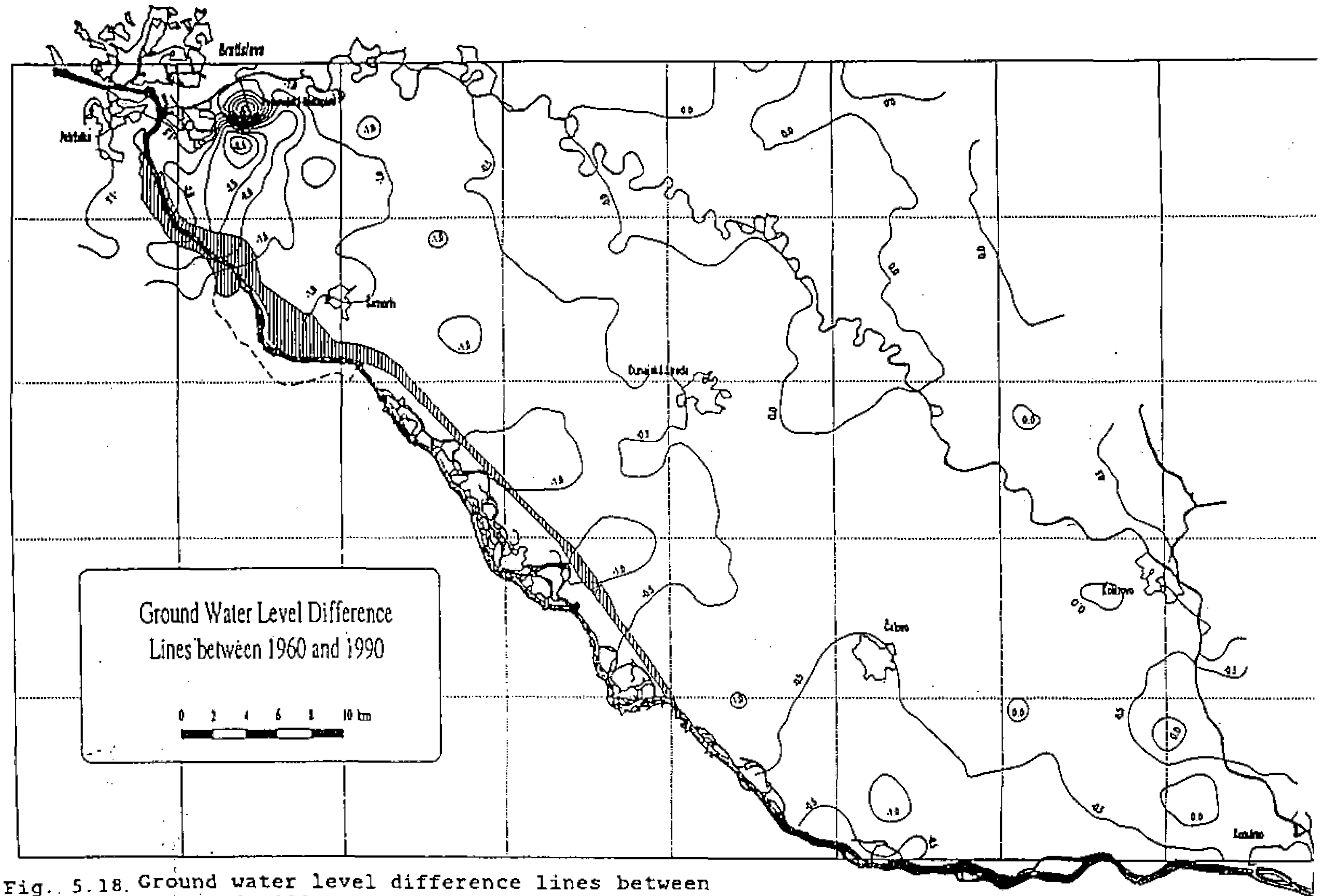


Fig. 5.18. Ground water level difference lines between 1960 and 1990.

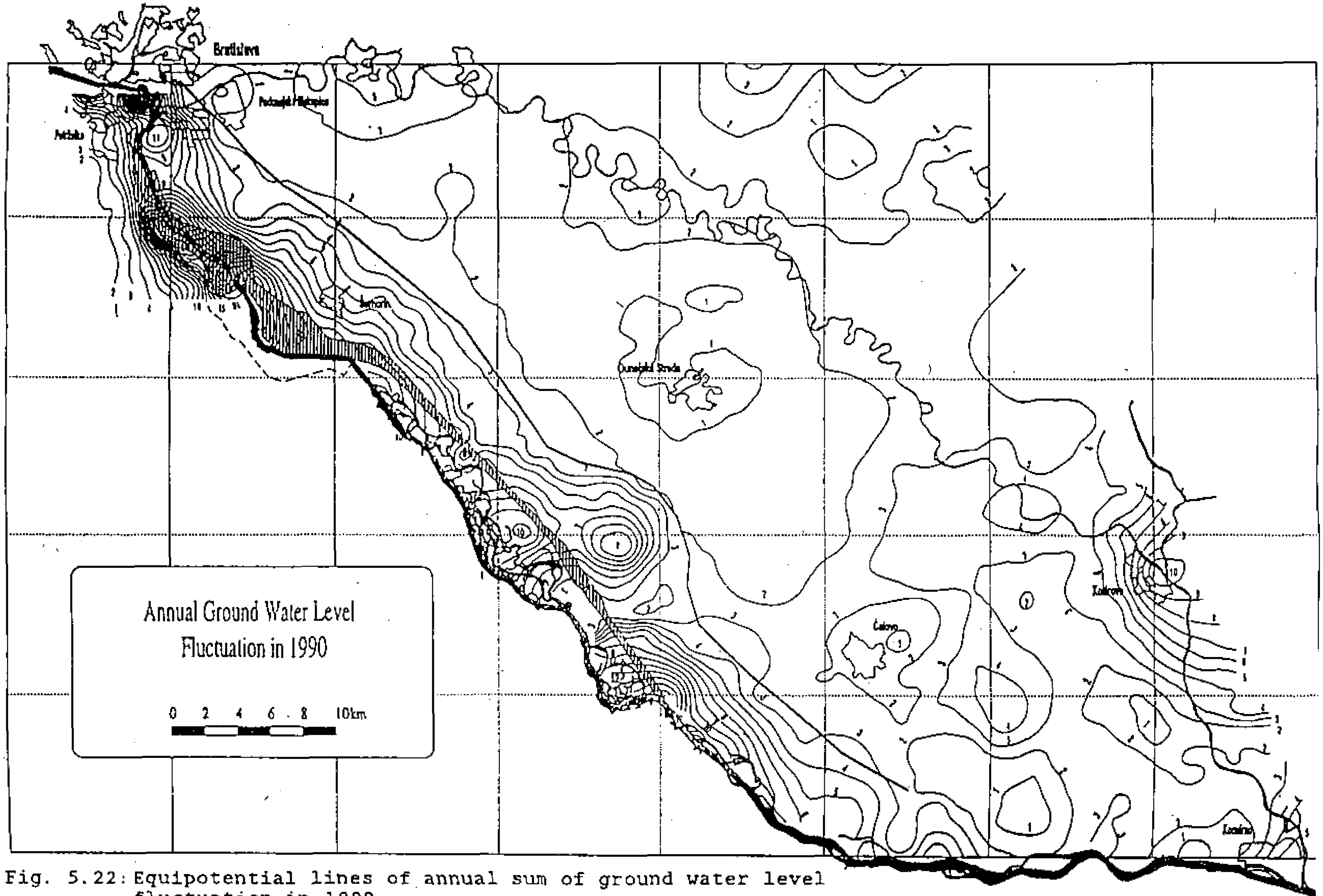


Fig. 5.22: Equipotential lines of annual sum of ground water level fluctuation in 1990.

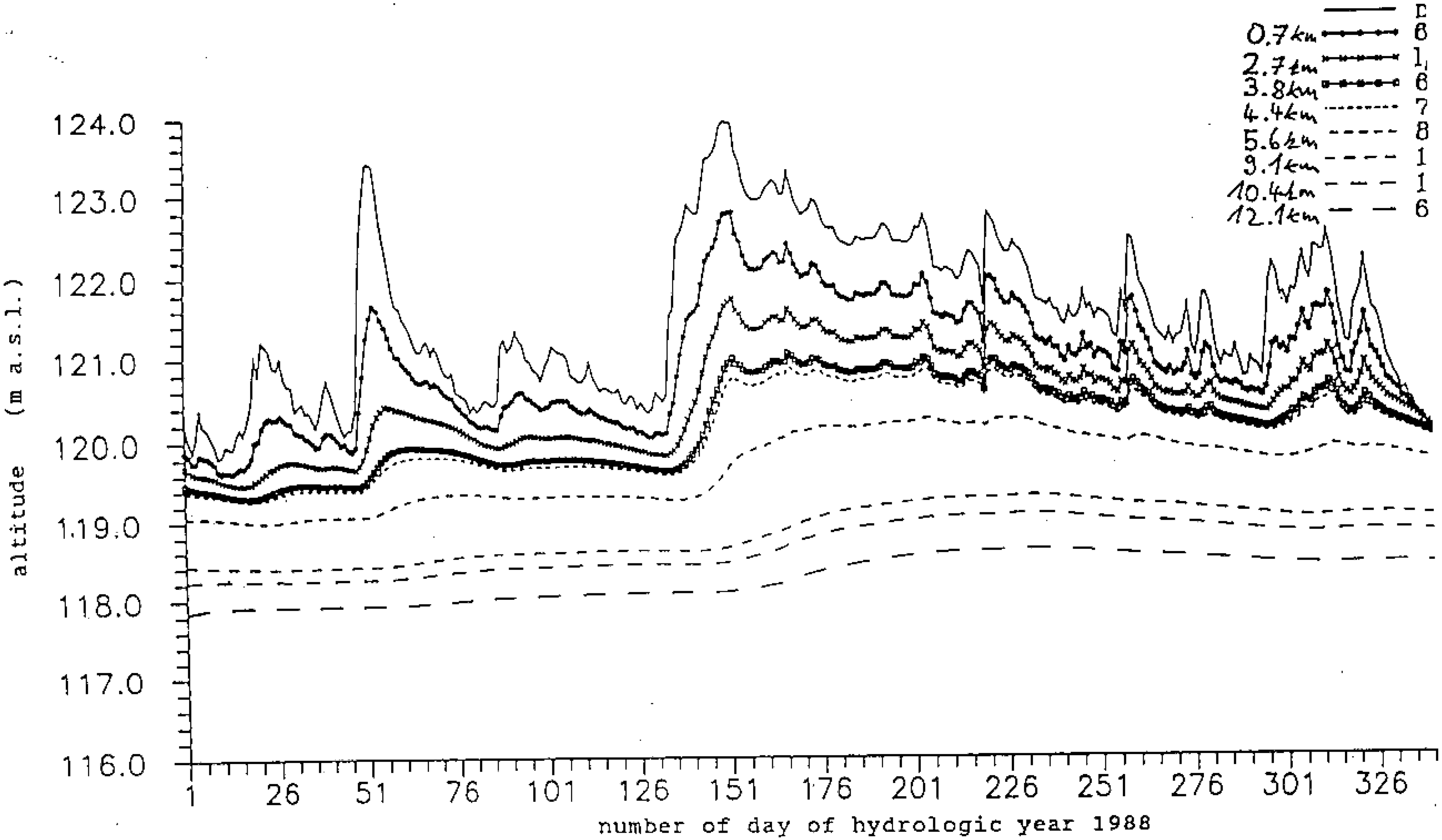
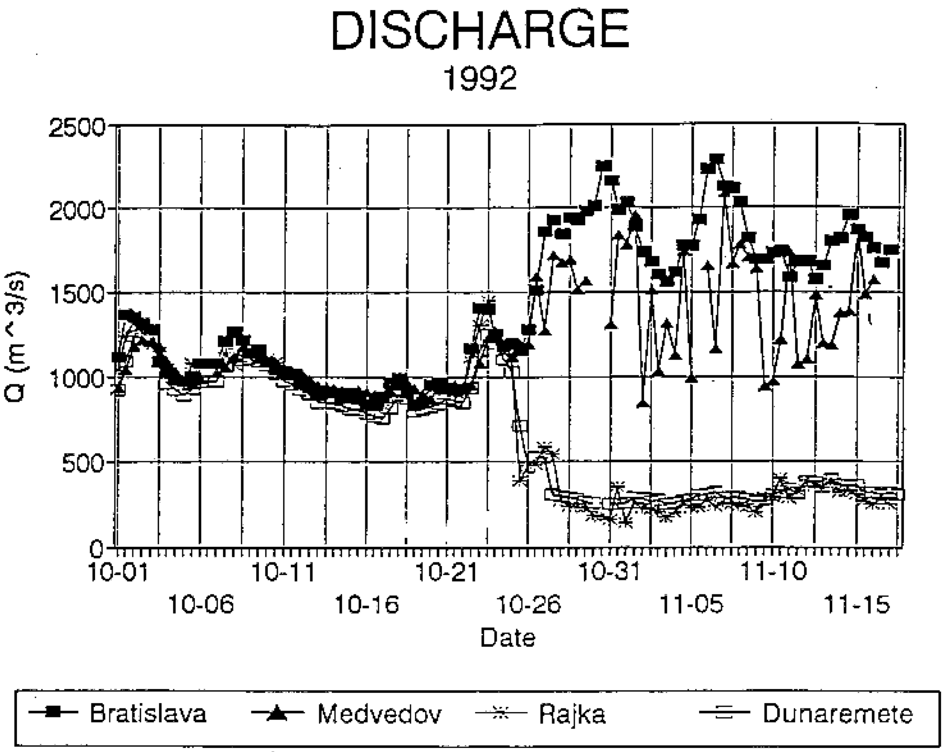
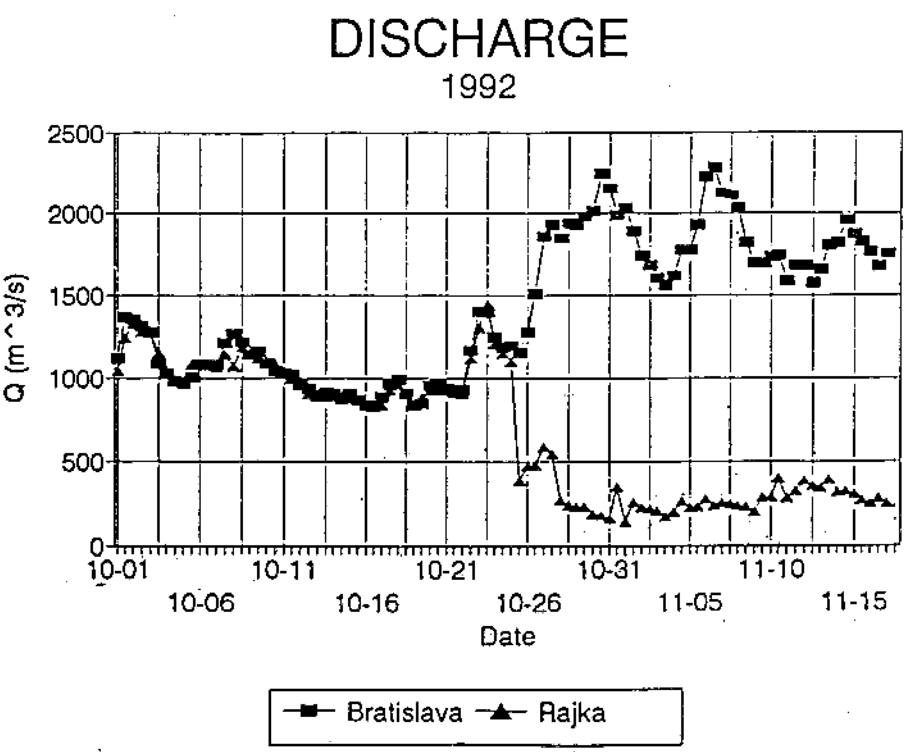


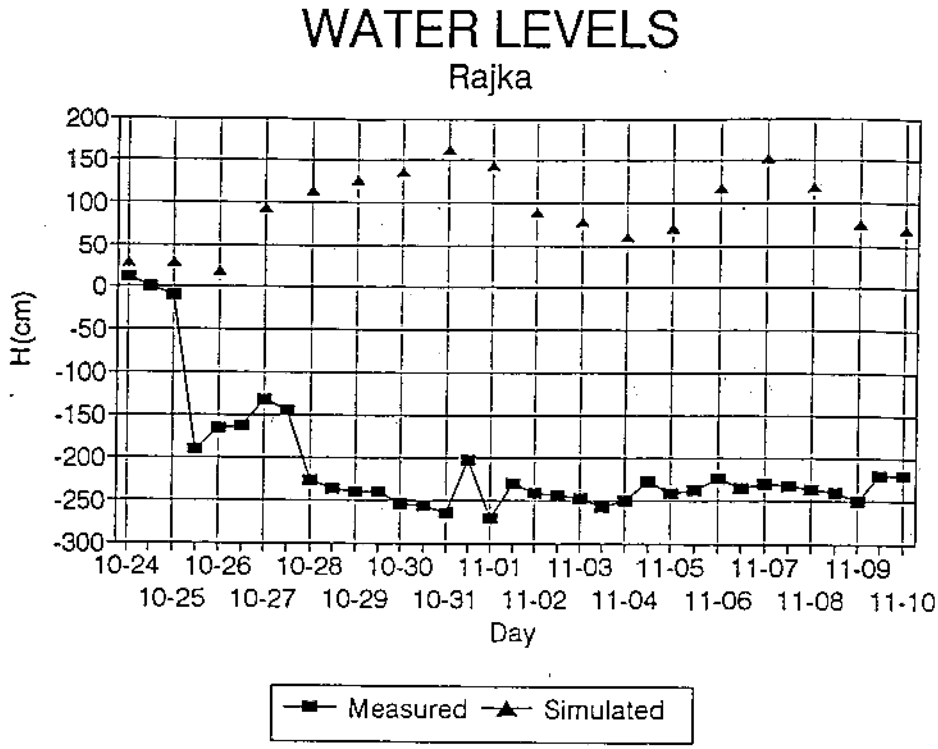
Fig. 5.25: GWL fluctuation in piezometers in various distances from the Danube (profile situated on Fig. 5.24)

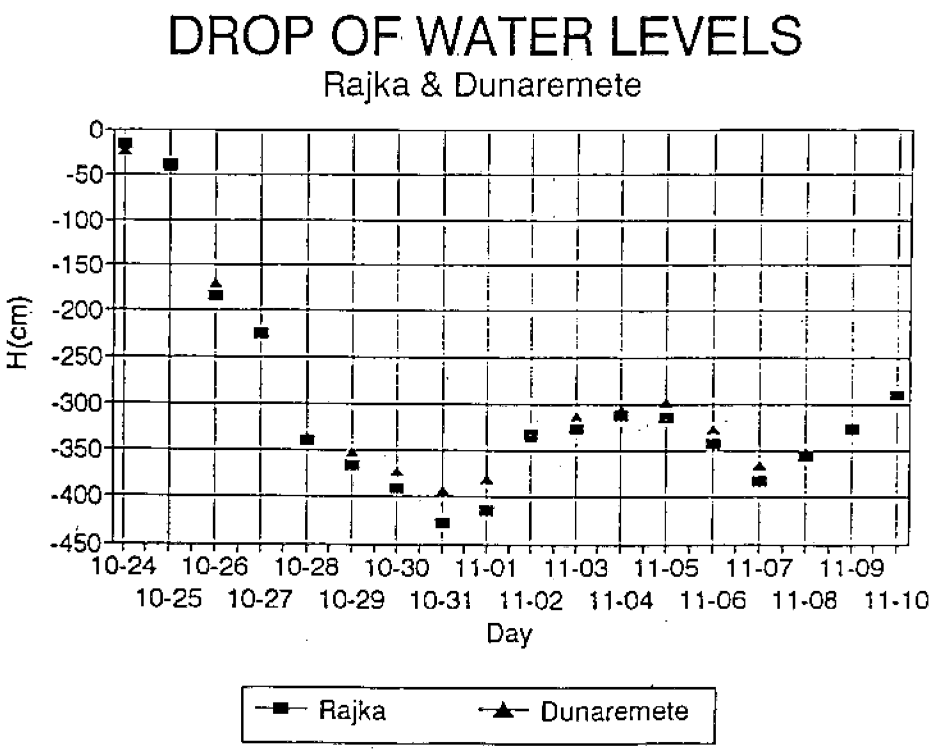
APPENDIX H

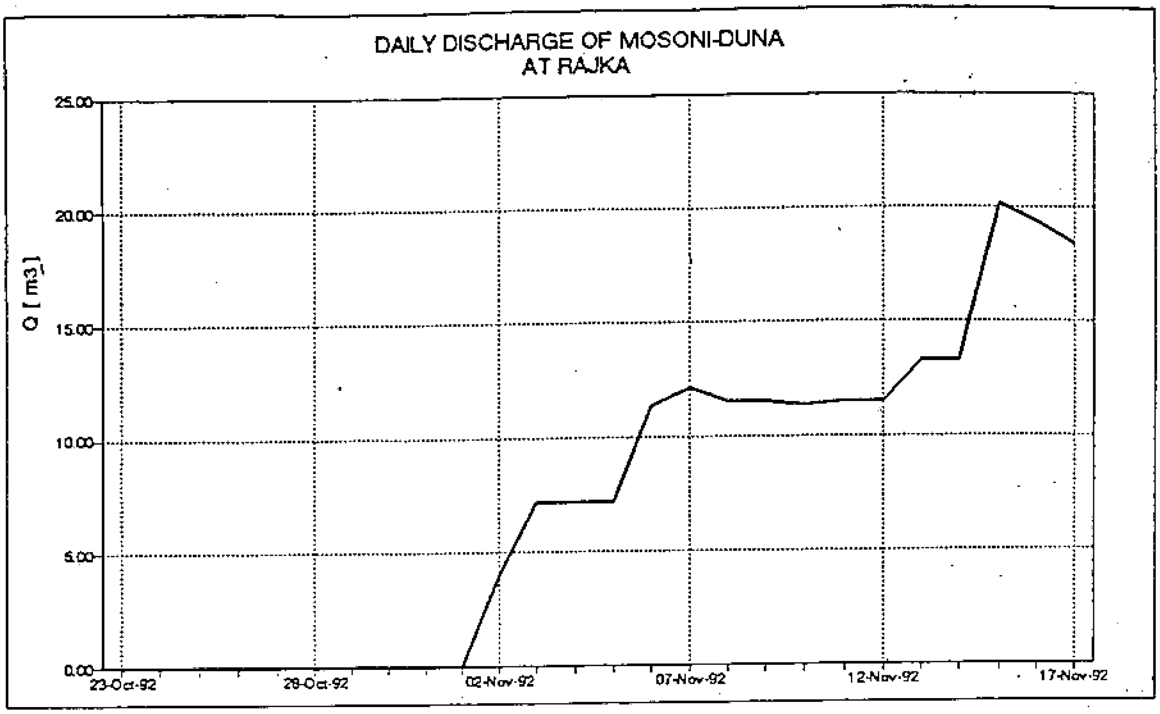
Figures illustrating the observed immediate impacts

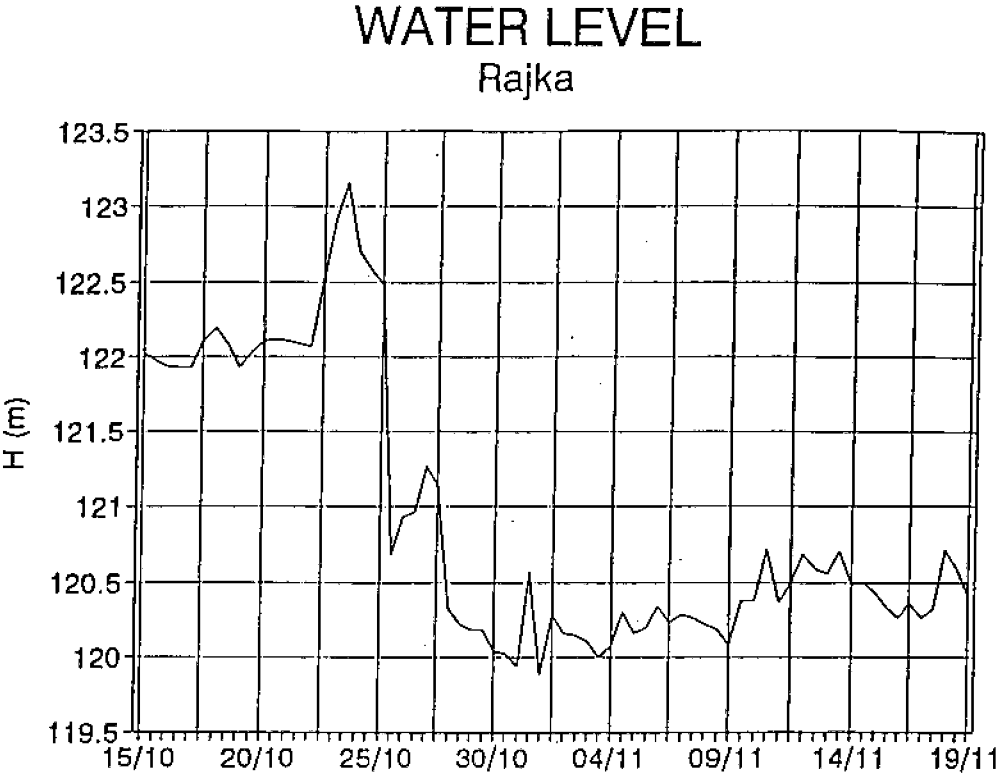

DISCHARGE
1992
Q (m^3/s)
2500
2000
1500
1000
500
0
10-01
10-06
10-11
10-16
10-21
10-26
10-31
11-05
11-10
11-15
Date
Bratislava
Medvedov
Rajka
Dunaremete

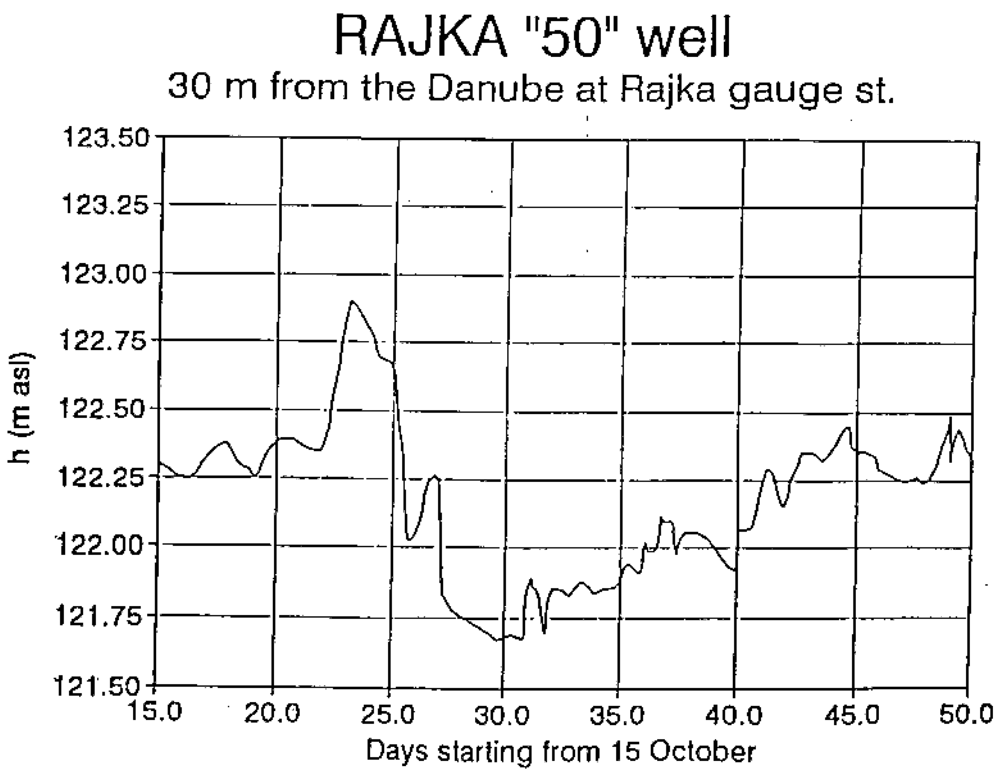

DISCHARGE
1992
Q (m^3/s)
2500
2000
1500
1000
500
0
10-01
10-06
10-11
10-16
10-21
10-26
10-31
11-05
11-10
11-15
Date
Bratislava
Rajka

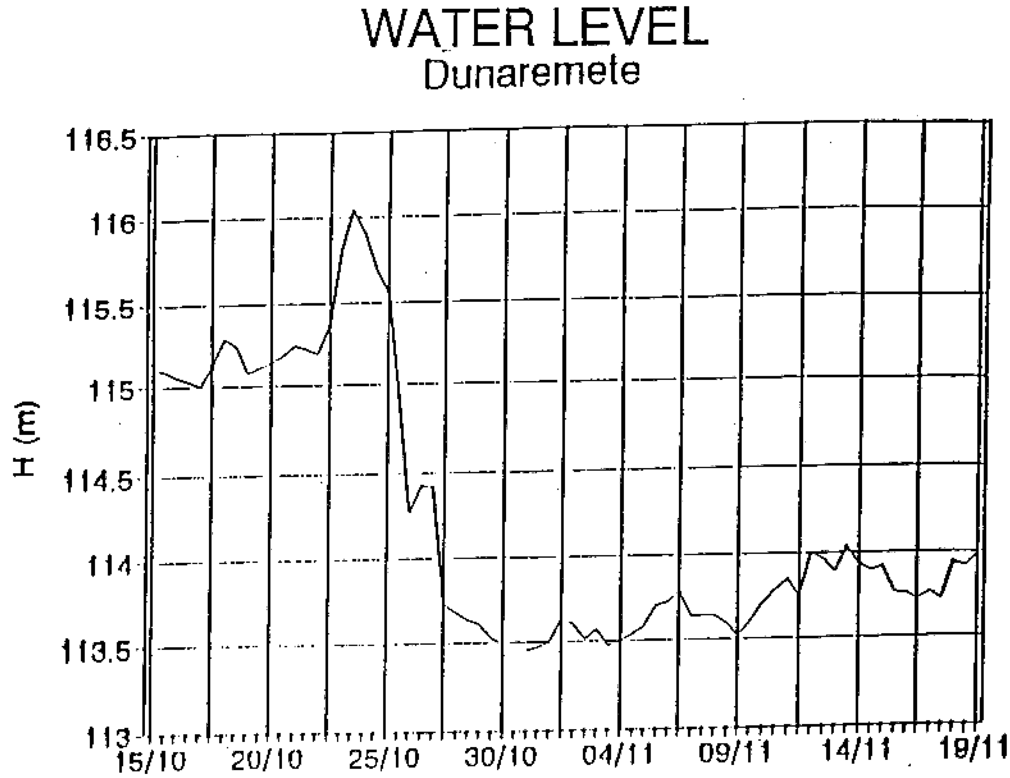

WATER LEVELS
Rajka
H(cm)
200
150
100
50
0
-50
-100
-150
-200
-250
-300
10-24 10-26 10-28 10-30 11-01 11-03 11-05 11-07 11-09
10-25 10-27 10-29 10-31 11-02 11-04 11-06 11-08 11-10
Day
Measured
Simulated

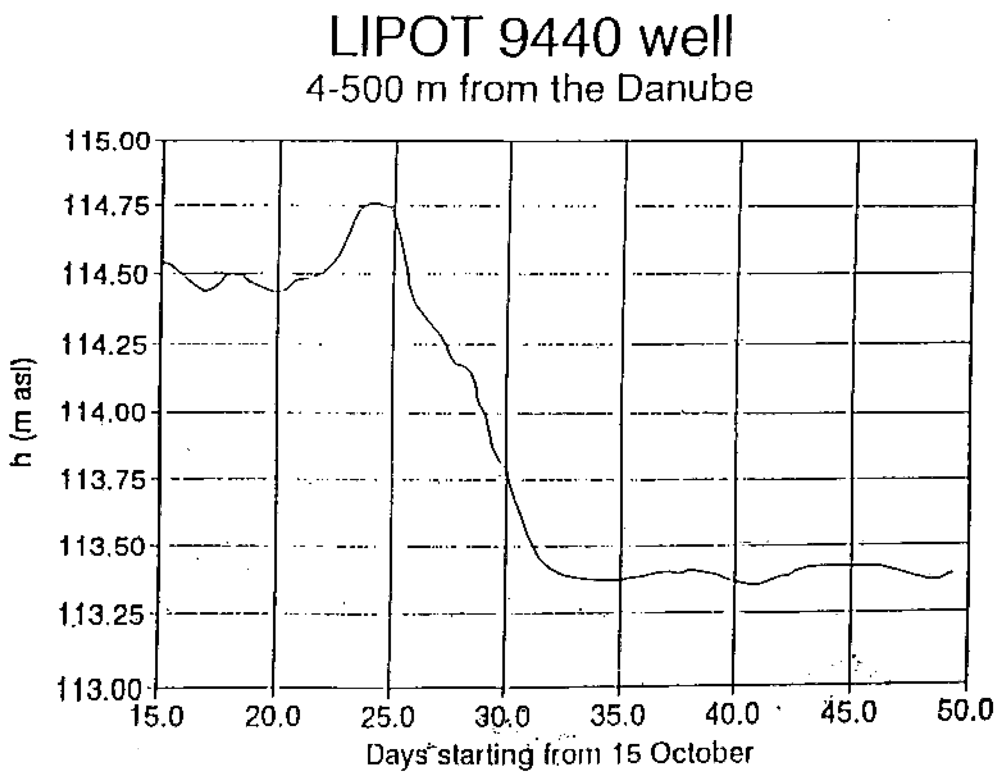

DROP OF WATER LEVELS
Rajka & Dunaremete
H(cm)
0
-50
-100
-150
-200
-250
-300
-350
-400
-450
10-24 10-26 10-28 10-30 11-01 11-03 11-05 11-07 11-09
10-25 10-27 10-29 10-31 11-02 11-04 11-06 11-08 11-10
Day
Rajka
Dunaremete


DAILY DISCHARGE OF MOSONI-DUNA
AT RAJKA
Q [m3]
25.00
20.00
15.00
10.00
5.00
0.00
23-Oct-92
28-Oct-92
02-Nov-92
07-Nov-92
12-Nov-92
17-Nov-92


WATER LEVEL
Rajka
H (m)
123.5
123
122.5
122
121.5
121
120.5
120
119.5
15/10
20/10
25/10
30/10
04/11
09/11
14/11
19/11


RAJKA "50" well
30 m from the Danube at Rajka gauge st.
h (m asl)
123.50
123.25
123.00
122.75
122.50
122.25
122.00
121.75
121.50
15.0
20.0
25.0
30.0
35.0
40.0
45.0
50.0
Days starting from 15 October


WATER LEVEL
Dunaremete
H (m)
116.5
116
115.5
115
114.5
114
113.5
113
15/10
20/10
25/10
30/10
04/11
09/11
14/11
19/11


LIPOT 9440 well
4-500 m from the Danube
h (m asl)
115.00
114.75
114.50
114.25
114.00
113.75
113.50
113.25
113.00
15.0
20.0
25.0
30.0
35.0
40.0
45.0
50.0
Days starting from 15 October

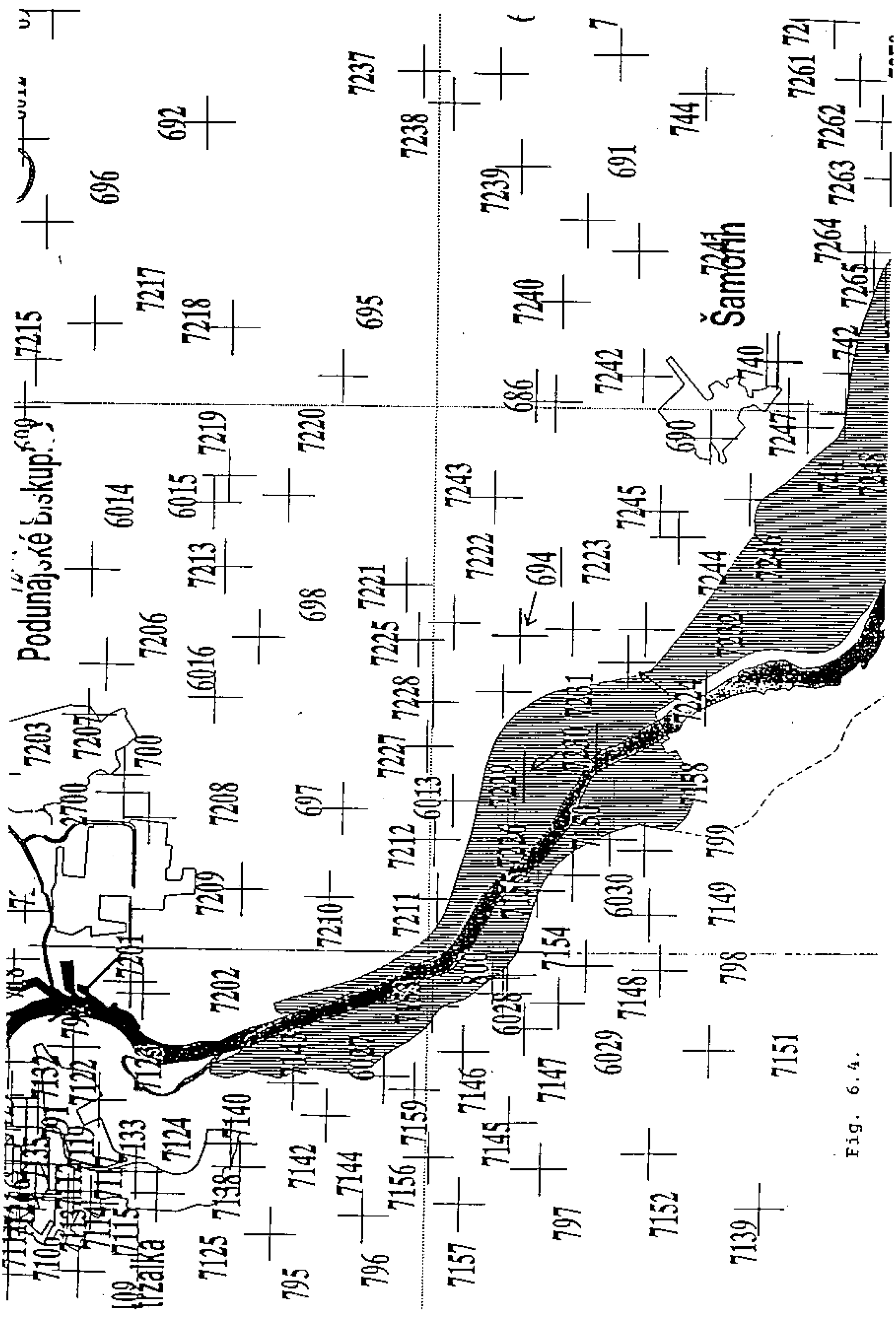


Fig. 6.4.

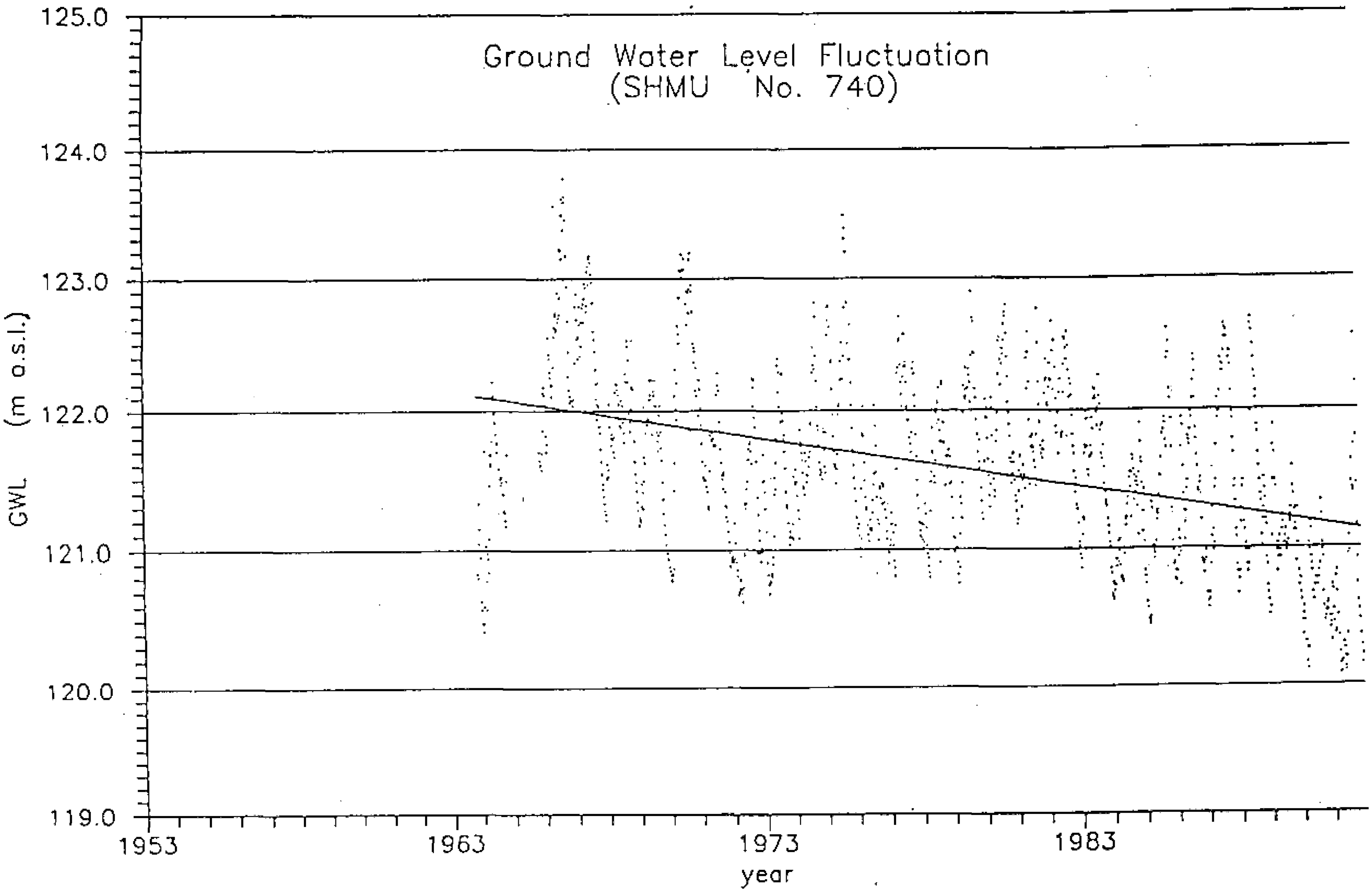

Ground Water Level Fluctuation
(SHMU No. 740)
GWL (m o.s.l.)
125.0
124.0
123.0
122.0
121.0
120.0
119.0
1953
1963
1973
1983
year

Fig. 6.4.4a

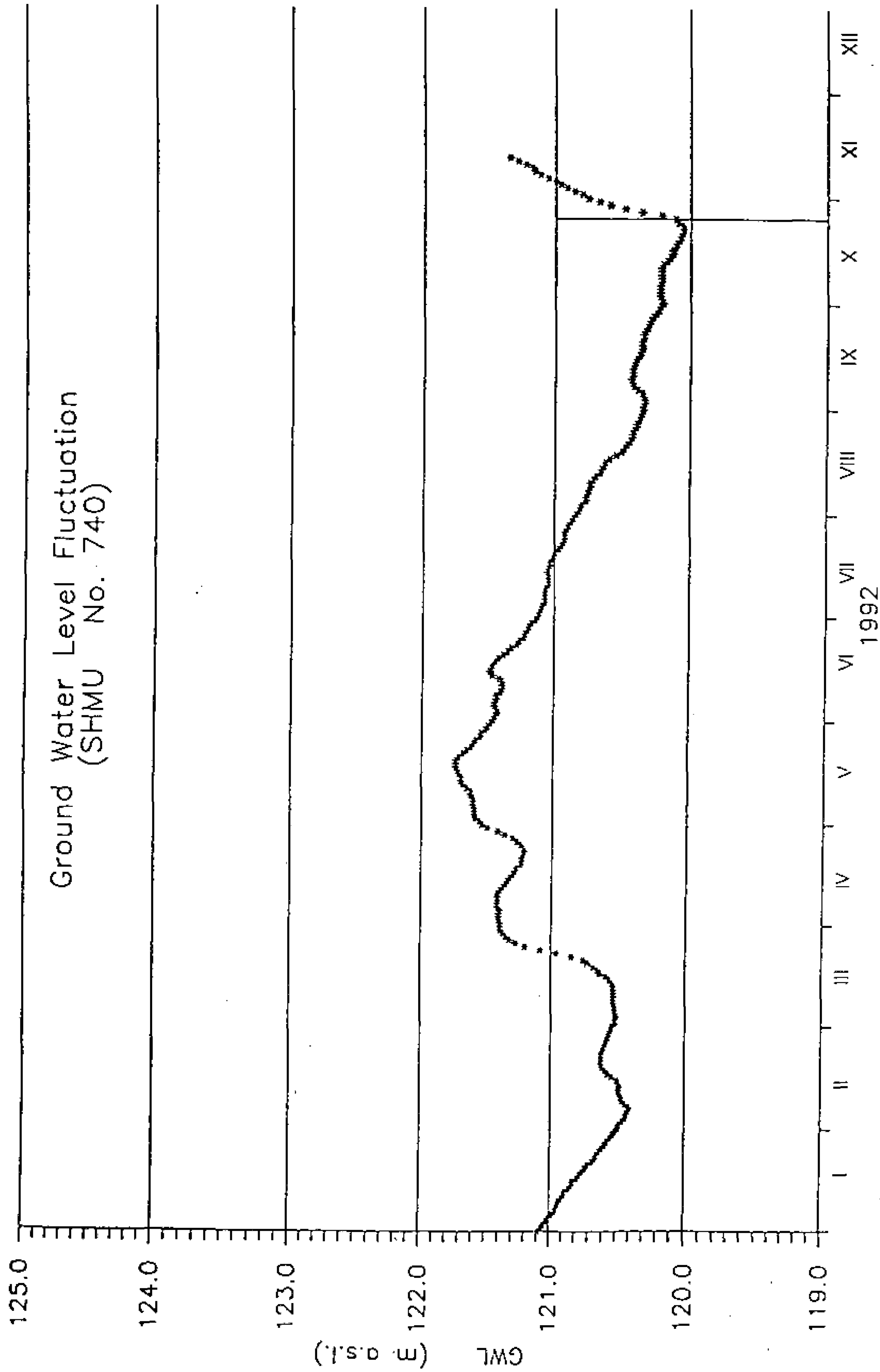

Ground Water Level Fluctuation
(SHMU No. 740)
GWL (m. a.s.l.)
125.0
124.0
123.0
122.0
121.0
120.0
119.0
I
II
III
IV
V
VI
VII
VIII
IX
X
XI
XII
1992

Fig. 6.4.4b

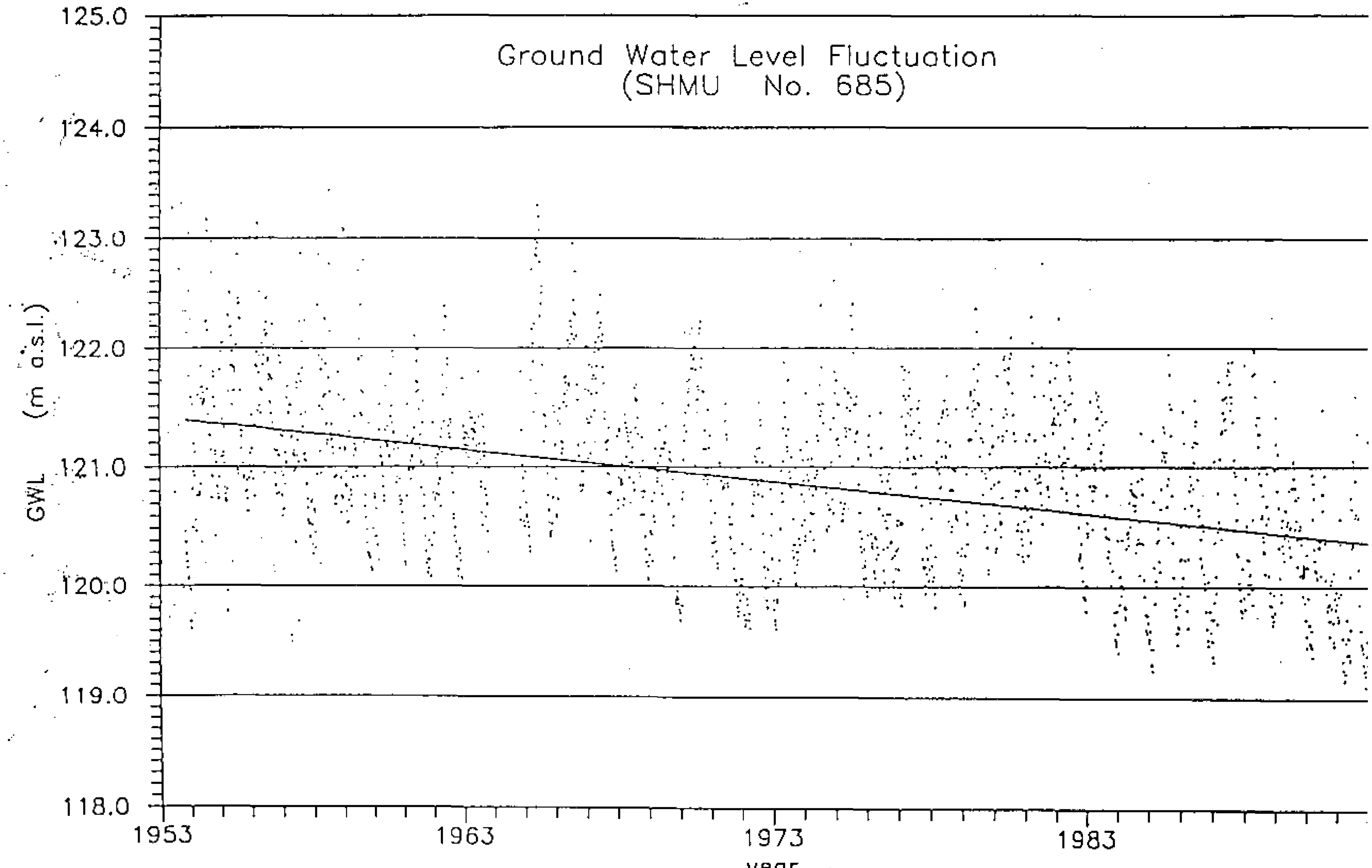
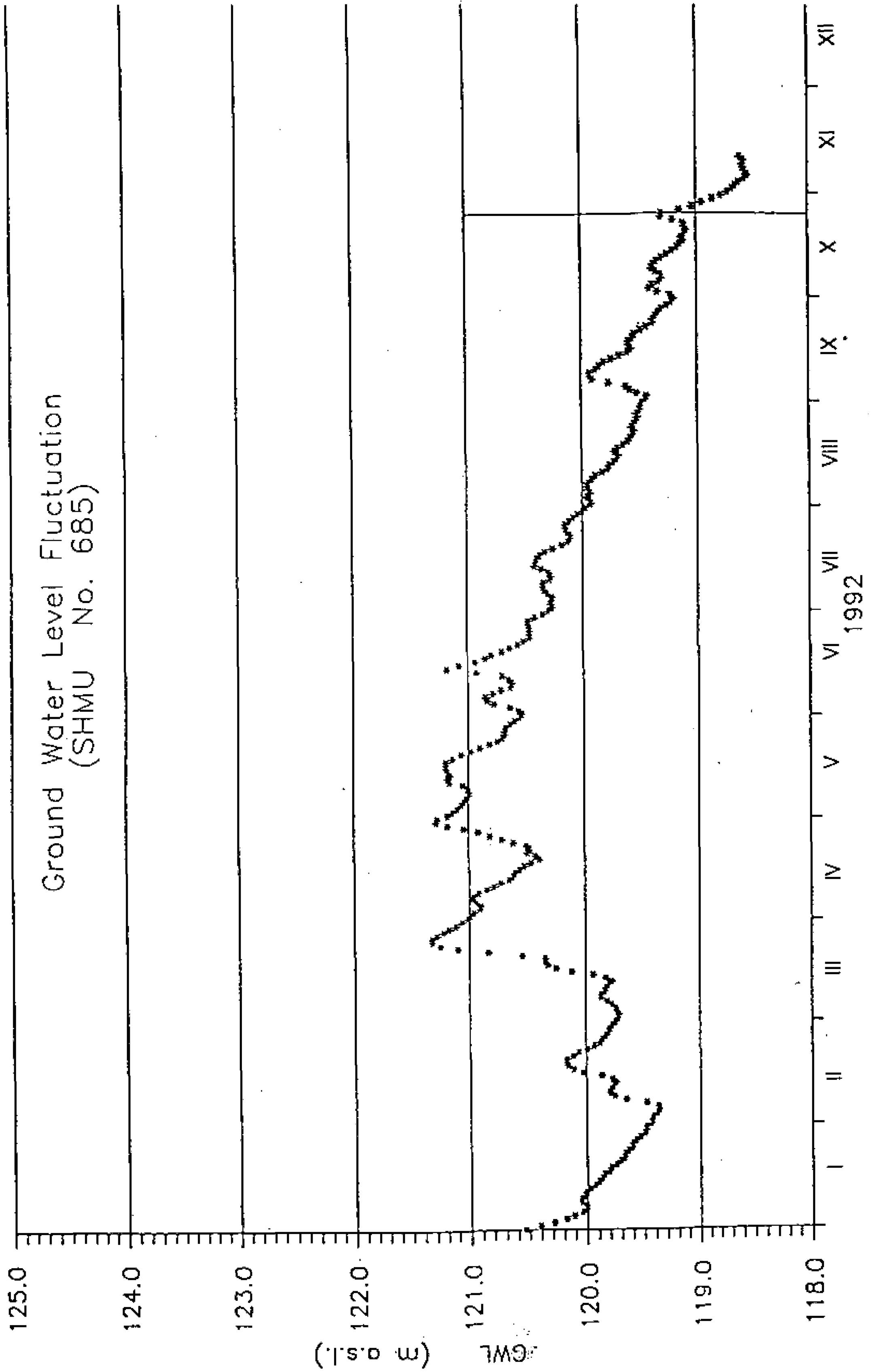

Ground Water Level Fluctuation
(SHMU No. 685)
125.0
124.0
123.0
122.0
121.0
120.0
119.0
118.0
GWL (m a.s.l.)
1953
1963
1973
1983
year

Fig. 6.5.3a



Ground Water Level Fluctuation
(SHMU No. 685)
GWL (m a.s.l.)
125.0
124.0
123.0
122.0
121.0
120.0
119.0
118.0
I
II
III
IV
V
VI
VII
1992
VIII
IX
X
XI
XII

Fig. 6.5.3b

APPENDIX I

Summary of impacts for different scenarios

Water level statistics for different scenarios
Based on Dunamerete 1980-89

Flow/water level characteristic		Pre-dam condition (historical data)	Scenario A	Scenario B	Scenario E (See Note 1)
Number of days per year with water level above certain levels	**Water level**				
Flow largely confined to groynes in main channel	2.30 m	353	334	3	342
Flow in main channel	3.71 m	211	181	0	197
Flow in few river arms	4.53 m	89	70	0	95
Flow in many river arms	5.15 m	21	16	0	22
Complete inundation of floodplain	5.62 m	4	3	0	3
Deep inundation of floodplain	6.23 m	1	1	0	0
Water level regime					
Maximum	(m)	6.56	6.51	3.43	6.37
Average	(m)	3.82	3.63	0.61	3.75
Minimum	(m)	1.90	1.60	0.61	1.52
Annual sum of water level fluctuations					
Daily	(m)	50	54	13	55
5-daily average	(m)	23	35	1	25
10-daily average	(m)	14	15	0	15
Number of days per year with water level fluctuations within intervals					
0 - 10 cm		172	172	364	168
10 - 20 cm		119	115	0	112
20 - 30 cm		41	41	0	46
30 - 40 cm		14	17	0	18
40 - 50 cm		8	8	0	8
50 - 60 cm		3	4	0	4
60 - 70 cm		2	2	0	3
> 70 cm		6	6	1	6

Note 1): The water level statistics for this scenario was calculated assuming a constant reduction in discharge of 500 m³/s and a new rati curve changed according to the estimated functioning of the under-water weirs.

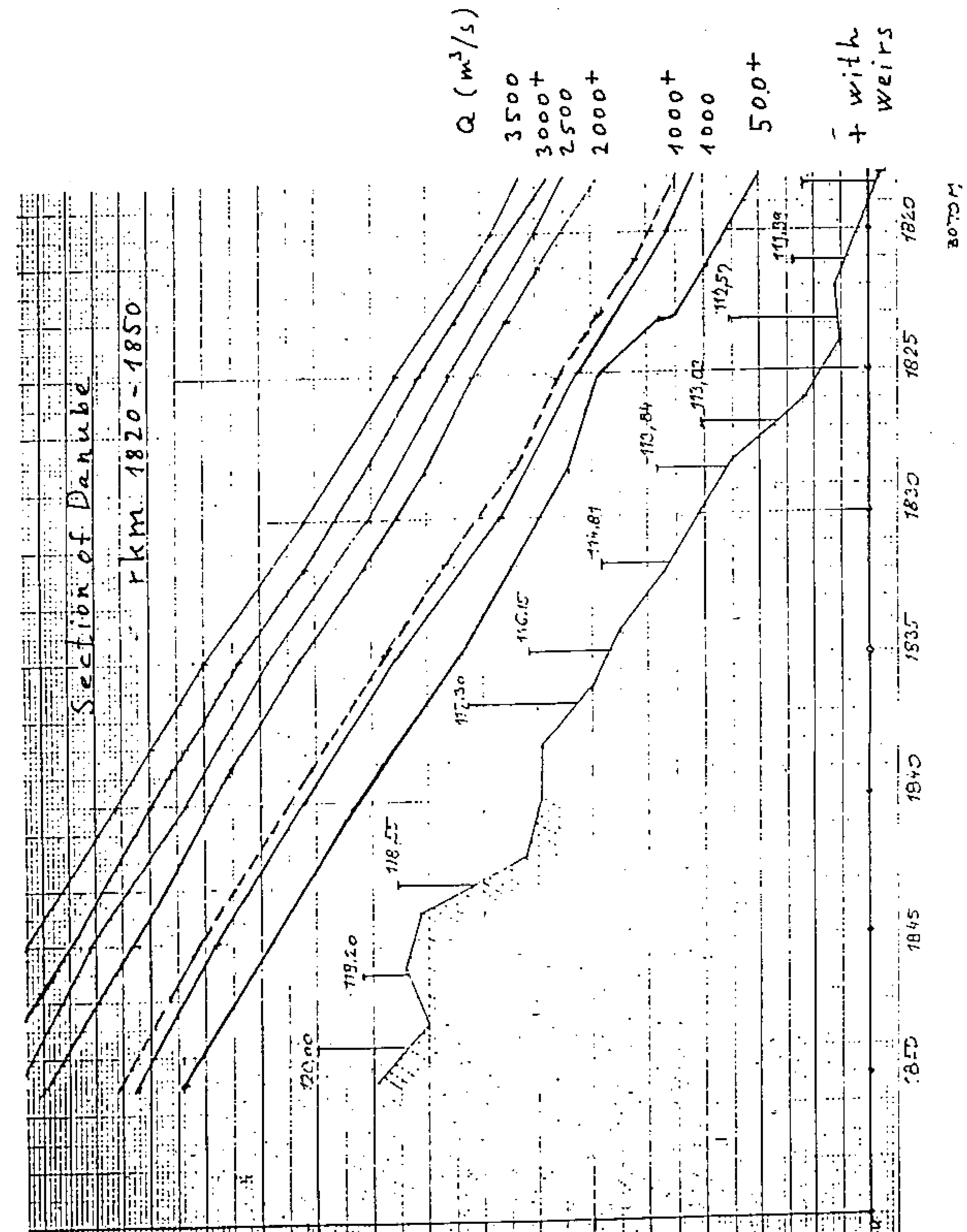
SUMMARY OF IMPACT ASSESSMENTS FOR SCENARIOS*

Key parameter	Scenario A	Scenario B	Scenario C	Scenario D	Scenario E (Phase 1)
Date for possible start of specified water management operation	January 1993	November 1992	1993-95	November 1993	July 1993
Surface water regime					
- Danube average water level	0/-	-	- => +	0	- => +
- Danube w.l. fluctuations	0	-	-/0	0	0
- Danube velocities	0	-	-	0	-
- floodplain dynamics	0/-	-	- => +/?	0	0
- Mosoni Danube discharge	+	+	+	0	+
Effects of sedimentation/erosion					
- near Bratislava	+	+	+	0	0
- in reservoir	-	-	-	0	-
- between dam and Palkovicovo/Sap	-	0/-	0/- => +/?	0	- => +
- Downstream Palkovicovo/Sap	+	+	+	0	+
Surface water quality					
- upstream part of reservoir	?	?	?	0	?
- downstream part of reservoir	-	?	?	0	?
- Danube	- => ?	-	- => ?	0	- => ?
Ground water regime					
- near reservoir	+	+	+	0	+
- within floodplain	0/-	-	- => +	0	- => 0
- area behind	0	-	- => 0/+	0	- => +/0
Ground water quality					
- general	0	-	0	0	0
- near reservoir	-	0/-	0	0	-
Agriculture and forestry					
- agriculture near reservoir	+	+	+	0	+
- agriculture further downstream	0/-	-	- => 0	0	0
- floodplain forestry	0	-	0	0	0
Navigation (excl phase 2)					
- navigation canal	+	+	+	0	+
- Danube	-	-	-	0	-
Hydropower	0	+	+	0	+

Legend:
+ better/more than in pre-dam conditions
- worse/less than in pre-dam conditions
0 approximately same as in pre-dam conditions
? extraordinarily large uncertainty in assessments

APPENDIX J

Figures illustrating Scenario C

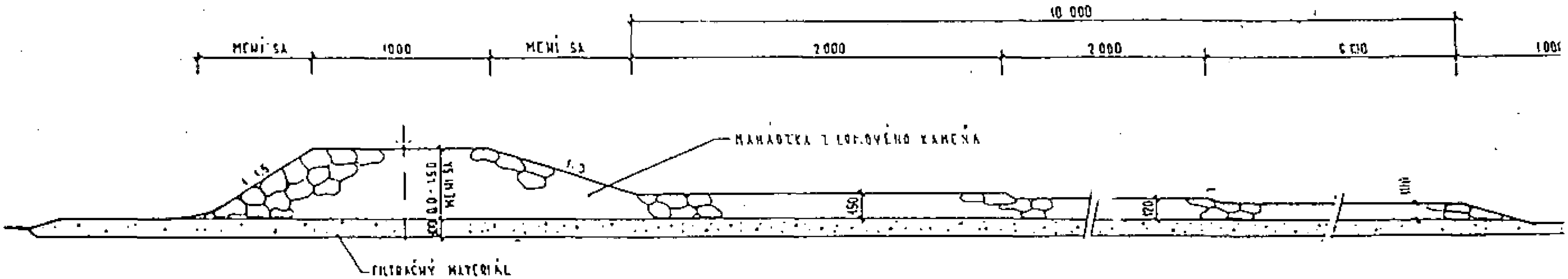

Section of Danube
rkm 1820 - 1850
Q (m³/s)
3500
3000+
2500
2000+
1000+
1000
500+
– with
+ weirs
m a.s.l.
120
115
120,00
119,20
118,55
117,30
116,15
114,81
113,84
113,02
112,57
111,39
1850
1845
1840
1835
1830
1825
1820
BOTTOM

Velocity curves between underwater weirs

rkm	1823.700	1824.300	1826.250	1827.450	1833.350	1836.500
0	0	0	0	0	0	0
500	0.535	0.569	0.539	0.566	0.644	0.752
1000	0.938	0.998	0.895	0.926	0.951	0.997
2000	1.351	1.430	1.323	1.207	1.343	1.349
3000	1.698	1.812	1.706	1.513	1.663	1.640
4000	1.973	2.172	2.05	1.709	2.018	1.683
5000	2.134	2.418	2.275	1.804	2.406	1.688
6000	2.259	2.597	2.446	1.910	2.672	1.762

Velocity curves at underwater wiers

rkm	1821.150	1823.200	1826.750	1831.700	1834.800	1838.600
0	0	0	0	0	0	0
500	1.419	2.267	0.889	1.294	1.154	1.081
1000	1.557	1.738	1.344	1.460	1.246	1.345
2000	1.713	1.860	1.714	1.776	1.574	1.731
3000	2.043	1.973	2.053	2.063	1.863	1.696
4000	2.002	1.999	2.358	2.211	2.180	1.700
5000	1.972	1.988	2.449	2.172	2.366	1.800
6000	1.949	1.966	2.547	2.131	2.459	1.936



Profile of under water wair

APPENDIX K

Hungarian proposals for redirecting the Danube to the former river bed

Sub-scenario D1

Removal of the closure of the Danube. Under the present situation it is possible to remove the closure of the Danube by the following measures:

= building a protective dam on the downstream side of the closure (the discharge in the Danube may be reduced to 350-500 m^3/s for the most critical period of the operation).

= Removing the big concrete/rock blocks from the downstream side of the closure (it can be done under dry conditions),

= Removing the top section of the closure (above 128-129 m asl),

= Opening a canal in the middle of the closure to let the water wash away the closure,

= Removing the remnants of the rip-rap and dredging the fairway downstream of the closure as needed.

Sub-scenario D2

= Excavation and removal of the material of the central section of the closure while using the resulting upstream and downstream dams - parts of the closure - as protecting dams (the hard core of the dam can be loosen up by carefully directed explosions if necessary). The gravel removed can be used for the construction of a temporary protective dam downstream.

= Simultaneously, the removal of the downstream and the upstream rip-rap and concrete blocks and the preparation of bore holes for explosives on the remaining parts of the dam can be done.

= After having finished the removal - respectively weakening - of the stony protection upstream and downstream the remaining rocky material of the dams can be demolished by thoroughly directed explosions.

= The material washed away by the river can be dredged and the original fairway can be restored.

If the preparation of the work is appropriate and there is a sufficient number of machines and vehicles present - 2 high capacity boring machines, 4 excavators with a minimum 4 m^3 capacity each and truck in appropriate number - then the time demand of the restoration on the water way requires not more than 2 months.

Sub-scenario D3

Building a new bed/path for the Danube by:

= Opening an about 200 m wide canal at the place of the future power plant, weir and ship lock at Cunovo. It requires the correction of the main bed between the 1853 and 1850 rkm.

Sub-scenario D4

= Opening the left bank dyke of the Danube (the newly built dyke between Dunakiliti and Cunovo on the left bank of the Danube). It requires the removal of about 2 km long dyke and the diversion of the Danube between 1854 and 1850 rkm.

Sub-scenario D5

= Opening an about 300 m wide canal between the weir in inundation and the right bank of the reservoir at Cunovo. It requires the removal of the water intake for the Mosoni Danube and the diversion of the Danube bed between the 1855 and 1848 rkm.

SEPARATE STATEMENT OF HUNGARY

To the best of my knowledge most of the technical-scientific statements presented in the Working Group Report are on the whole correct. However, considering the enormous range of scientific and technical details and the shortage of possibilities to discuss and consult with my colleagues, I do not guarantee or take the responsibility for the correctness of the text.

I also attach different importance to some aspects treated in this report. Riverbed erosion is a minor problem as compared to ecological questions. I cannot share the optimistic view on the surface and groundwater quality in connection with the reservoir. The uncertainty and the risk of unforeseen aspects are too great to accept a simple modelling monitoring strategy. Consequently, the only acceptable strategy should, in my opinion be to return to the pre-dam condition as described under scenario D. All the other scenarios are of highly unpredictable outcome.

Some more specific problems are as follows:

A) Flooding risk

We do not understand why are we not allowed to study (on the written command of Mr. Pablo Benavides) the question: Was it really inevitable to complete the closure of the Danube in face of the flooding risk as declared by the Czecho-Slovak Party on the 22nd of October (thousands of people hazarded).

B) The impossibility of maintaining the "whole" quantity of water in the former reverbed as agreed in the London Agreement.

The unsuitable closure of the Danube is clearly reflected by the various incomplete structures. The break-downs and heavy losses that occured are partly due to these. All these make it impossible to replace the Danube-water accepted under the London Agreement.

From among the break-downs of the weir consisting of four tainter gates the Czecho-Slovak Party stresses that this is mainly due to unknown geological circumstances – this reasoning is stated in the document. According to my opinion, it is entirely due to shortcomings of the planning. These have already caused some severe problems:

- Approximately at a 25 km section the water level of the Danube decreased by 3 meters on the average.

- Consequently, several fish specie have probably become extinct. The final assessment of the heavy damage caused can only be made in the vegetation period of the next year.

- Owing to the directed incomplete structures incapable of functioning the risk of flooding is great, much greater than before closure. Outstanding role is played by the unsuitable planning and constructions of the weir consisting of four tainter gates.

- The lowest ever recorded groundwater table between Dunakiliti and Ásványráró has further sunk by 0,5-1,5 metres.

C) The problem regarding the seismic safety of the dikes

According to the statement the asterisk 2 on page 1 the seismic risks of variant C has not been studied by the Working Group in spite of the Hungarian request. With regard the construction of the dikes in the area the value of seismic risk is higher than that of flooding, because the sizing of the dikes of the water reservoir and the upstream channel disregarded the European standards and recommendations (e.g. *IAEA Safety Series No. 50-SG-S1*).

These concerns were strongly highlighted not only by the Hungarian Party but in the Study Report carried out by *Hydro-Quebec International* (1990) on behalf of the Czechoslovakian contractor. These problems are two folded:

- * Underestimation of seismic risk in the area
- ** Intensity - acceleration relationship, lack of site effect studies

In 1990 the *Geophysical Institute of the Hungarian Academy of Sciences* and *Seismic Department of Geofyzika Brno* proposed a joint investigation of the seismic risk in the Dunakiliti - Gabcikovo area. This recommendation failed at the Czechoslovakian Party therefore we carried out a preliminary investigation in the questioned subject and resulted the following conclusion:

* The expected maximum intensity for
100y period -- 7.5 MSK
500y period -- 8 MSK
1000y period-- 8.5 MSK
The original plans were prepared by assuming an intensity of 6-7 MCS.

** The expected horizontal acceleration -- 0.200 - 0.280 g
The original plans (1965) were prepared for 0.010 - 0.025 g
revised (1987) for 0.035 - 0.075 g

The hazard issuing from the underestimated seismic risk was not dealt with by the Working Group in spite of the fact that when determining temporary precautions these must be considered.

D) About scenarios

The report includes two antagonistic water scenarios i.e. whose basic approaches are different.

One is to re-establish the original state of the Danube (scenario D), while all the other variants aim to retain the already constructed structures with the various functions and the study of effects caused. The Danube and the self-regulating natural system around it are irreplaceable values of Hungary. This system as a whole cannot be regulated by human means, on the other hand, the various scenarios promising proper management refer to partial elements only, and what is more, the regulating means are not in the hand of Hungary.

During the sessions of the Working Group the following effects and factors of primary importance could not be discussed, i.e.

- the feasibility of the ideas in the scenarios,
- the endurability of the described hazards,
- the risks arising from the drawbacks of researches.

All these can only be performed and evaluated with the Environmental Impact Assessment accepted in the countries of EC.

Ecological evaluation:

- In our opinion the ecological aspects are the primary factors concerning the future of the Szigetköz region.

- None of the presented biological "models" describing the ecological status of the area can be considered a coherent system, they all consist of a series of unanswered questions or simulated processes, and hence they have never been tested. Ecological modelling is intrinsically complex with non-linear dynamics the outcome of which results in chaotic behaviour, thus, it is unpredictable.

- The above-mentioned "models" only deal with the area inside the dikes, but the ecological processes of the Szigetköz region cannot be discussed without the areas outside the dikes. On the other hand, we must bear in mind that a significant proportion of the natural values and the ecological potential of the Szigetköz is actually outside the dikes.

Ad 6.6 This area is exceptionally important for the overwintering waterfowl. For this very reason the inclusion of the Szigetköz into the Ramsar Convention is in progress.

Ad 8.3.8. Scenario C based only on the control of the periodical water fluctuation and water table level, while the natural ecosystems are controlled by many other factors, as well. Furthermore, if the natural optimum of the artificially controlled values is unknown man-made optimization is impossible. Consequently, the effects of scenario C on the flora, fauna and habitats are wholly unpredictable.

G. Vida

Gábor Vida
Hungary

APPENDIX M

Statement by the CSFR representative

M - 1

From M-1 to M-21.

SCENARIO BASED ON TREATY BETWEEN REPUBLIC OF HUNGARY AND CZECH AND SLOVAK FEDERAL REPUBLIC

1. Objectives and priorities

Objective to be achieved in this scenario is to fulfill the Treaty between Republic of Hungary and Czech and Slovak Federal Republic. Priorities are the same as in Scenario A.

This proposal is based on treaty between Republic of Hungary and Czech and Slovak Federal Republic on 16 September 1977 and registered by Hungarian side at United Nations Organization in frame of United Nations Treaty Series. This Treaty came into force on 30 June 1978 (United Nations, vol. 1109,1,17134).

Joined Treaty was elaborated on basis of wide range of studies, investigations and observations including:
- geological and seismic conditions, also hydrological situation in river Danube and surrounding area (Danubian Lowland),
- pre-dam regime of ground water and prognosis for after-dam regime including unsaturated zone,
- possible influence of water structure operation on ground water quality (resources of drinking water),
- river bed ecological situation, area of flooding and inundation,
- comprehensive area protection against flood,
- navigation problems solution,
- usage of hydroenergetic potential of the Danube between Bratislava and Budapest.

Joined Treaty elaborated in 1977 includes following mai[n] structures:

A/ Water structure system Gabcikovo
- Hrusov - Dunakility reservoir (system of dikes, seepag[e] canals, etc.),
- weir Dunakility,
- power canal,
- structure Gabcikovo (navigation locks and power station),
- spillway canal,
- dredging of river bed downstream of Palkovicovo,
- modifications in old Danube river bed to stop lowering o[f] ground water table.

B/ Water structure system Nagymaros
- protection measures on CSFR territory related to Nagymaros structure system construction,
  - protection embankment of Danube and left side tributaries including underground sheet piling,
  - dewatering system on protected area (from flood), including pumping stations,
- protection measures on Hungarian territory,
  - protection embankment of Danube and right side tributaries,
  - dewatering system on protected area (from flood), including pumping stations,
- structure Nagymaros (weir, navigation locks and power station),
- dredging of river bed downstream of Nagymaros.

Except above listed structures following problems were solved on basis of national investments:
- branch network system in area of power canal on left and right sides of the Danube inundation area,
- ecological optimization of use of Danubian Lowland area affected by construction of Gabcikovo - Nagymaros Barrage System (Bioproject) elaborated in 1978, dealing with Czecho-Slovak territory,
- wide area monitoring of Danubian Lowland environment affected by construction and operation of barrage system.

Works on structures realization started according to the Treaty plans on CSFR territory in 1978.

A/ Water structure system Gabcikovo

1/ constructed structures
- all structures in Hrusov - Dunakility dam except right side embankment in Szigeti Duna area of river bed on Hungarian territory,
- Dunakility weir on Hungarian territory except closure of Danube river bed in km 1842,
- all structures of power canal, including intake structure into left side river branch system,
- all structures of Gabcikovo structure, from 8 aggregates of hydropower plant, 5 are finished and 3 are in high state of construction,
- all structures of spillway canal,

- all parts of reservoir (seepage canals, dikes, etc.).

2/ not yet constructed structures
- dredging of river bed downstream from Sap (Palkovicovo),
- modifications in old Danube river bed (underwater weirs) (both these structures were supposed to be build according to the Treaty by Hungarian side).

Not constructing water work Nagymaros in the rkm 1809 - 1708 will have following negative effects:

a/ Navigation

By discharge 1200 m^3/s at the rkm 1809 - 1803 moving sand banks and fords will emerge, the depth of water will be less than 2 m and navigation width will narrow to 120 m. To ensure navigation there will be necessary to realize some additional works (e.g. dredging). For the same discharge there exists similar fords in rkm 1734 and 1722. In these locations the bottom consists of hard rocks.

b/ Flood

Not dredging of the river bed by Sap (Palkovicovo) in rkm 1820 - 1800 will cause that the flood levels will be much higher than supposed by the Treaty. Because of this there were no supposed anti-flood measures. Only for the illustration the flood wave in 1991 caused increase of water level to the altitude 117.29 m a.s.l. Discharge during this flood was the level of 50 years recovery. According to Treaty discharge corresponding to water level 117.25 m a.s.l. is 100-year's recovery flood.

B/ Water structure system Nagymaros

1/ constructed structures on CSFR territory related to water structure Nagymaros

- protection embankment of the Danube and left side tributaries including underground sheet piling,
- dewatering system on protected (from flood) area including pumping stations of which 80 % is constructed.

We have no information about level of completion of protection measures on Hungarian territory.

2/ not yet constructed structures

- water structure Nagymaros (weir, navigation locks and power station), only protection embankment and foundation pit were done,
- dredging of Danube river bed under Nagymaros.

Realization of these structures was supposed to be done by Hungarian side.

National investments structures:
- modifications of branch system according to the original

M - 4

treaty is 80% done on both sides of the Danube,
- some work proposed in Bioproject was done and for completin works 2.4 billion CSK was reserved,
- wide area monitoring system of affected territory i constructed and operational.

Legal aspects

According to the Treaty from 1977 first aggregates in wate: structure Gabcikovo should be operational in 1986.

In 1983 by Treaty between Hungary and CSFR the date wher aggregates should be operational was changed to 1990. On (February 1989 because of Hungarian side request was agreed 1(months shorter term for aggregates to be operational. Term for completing work on whole barrage system was set to 1994, including the Nagymaros water structure.

According to the Treaty discharge from Dunakility to old Danube river was constantly 50 m^3/s.

13 May 1989 Hungarian government informed CSFR government about stopping the works on Nagymaros water structure.

22 May 1990 Hungarian government informed about stopping all works done by Hungarian side on water structure Gabcikovo.

19 May 1992 Hungarian government released information about one side abolition of Joined Treaty between CSFR and Hungary from 1977 beginning 25 May 1992.

From the first day of stopping work on water structure Nagymaros took place number of meetings between governments. All proposals suggesting returning to the original treaty were unsuccessful. Federal government of CSFR by its resolution No. 794 dated 12 December 1991 after last unsuccessful meeting decided to build temporary structures only on CSFR territory which will enable operation of Gabcikovo water structure (Variant C).

2. Technical and water management aspects

Technical proposal:
a/ CSFR part insists on completing of whole barrage system according to the conditions from Treaty from 1977 (peek power production from Gabcikovo). Variant C enables completion of all works as listed in Treaty and all construction done on Variant C are then without significant effect, it is functionally temporary solution until that stage.

b/ We take into consideration situation after closure of Danube river bed in km 1851.73 and we suggest to realize supply of water into river branch network by these measures:

1/ immediate temporary solution
- flow trough under water weir in Danube river bed approximately in place of original closure of Danube river

M-5

bed at Dunakility to such level that gravitational intake is able to ensure the necessary amount of water into river branch network through Szegeti Duna river branch. Then it is possible to use all segments on Dunakility weir to optimize water level between Rajka and Dunakility,
- Dunakility can be used as a management tool of water regime.

This technical solution is possible to realize immediately with possibility to use offered help from CSFR side. Expected result of such solution and together with effect of continuous intake of water into the Mosoni Danube (20 m^3/s) will be:
- rise of ground water table,
- securing flow in river branch system with higher water levels than would be possible from the Danube in the same season,
- minimization of ecological impacts in related area.

2/ The following final solution includes construction of 8 small underwater weirs according to the updated Treaty. This technical solution will enable:
- simulate such water level by 600 m^3/s discharge in the Danube as the water level would be by 1200 m^3/s discharge,
- water interaction of both left and right sides river branch network with water levels in the Danube river (opening of closed branches),
- optimization of water levels in area affected by construction of water structure,
- to pass maximal flood discharges without flooding risk,
- enable navigation in old Danube river bed when discharge in the Danube will be higher than 2000 m^3/s and enable navigation continuously for ships with dip of ca. 1 to 1.4 m.

3. Possible time schedule for implementation

We note, that the date set for Danube river bed closure was according to the original plan set to the end of October. According to the statistical analyses in this time period lower discharges in the Danube were recorded. If Hungarian side had been willing to cooperate by Danube river closure by constructing measures planed in Treaty in old Danube river bed (see above), impacts would be eliminated. Additional measures to optimize structure and impact on ecology is welcome and can be agreed easily between the both country Representatives responsible for water works Gabcikovo - Nagymaros.

It is possible immediately to restart the common work on Gabcikovo hydropower scheme.

If this scenario will be accepted all other common disputes are to be settled according to the Treaty, chapter XII, article 27 "Settlement of Disputes". Treaty is included in enclosure.

RECOMMENDATIONS, STUDIES AND WATER MANAGEMENT

Recommendations for coming winter

Taking into account the risk of damage of existing structures, M-6

including navigation facilities, ecological damage, floodin risk, it is not possible to stop "all works" until the all dike are fortified at the projected level. By-pass weir controllin the flow into the river must be fully operational and th floodplain weir in inundation should be ready for operation. Th service roads should be ready and surrounding area tidied up. Th best optimization solution will be reached if all managemen tools are ready. This means

- intake structure into the Mosoni Danube,
- weir in the inundation,
- weir on the by-pass,
- at least five turbines at Gabcikovo,
- intake structure on power canal,
- auxiliary weir and lock.

The importance of these structures is described in Fact Findinc Mission. During the winter temporary manipulation time table is valid (until 30 March, 1993). This manipulation time table is set together that way that also 100-year's flood can pass the structures.

Measures, studies and water management for the following year

For the following year it is necessary to elaborate manipulation time table which will be valid until the block of auxiliary weir, lock and turbines is ready. This manipulation time table shall include optimization of division of water discharge.

Detailed monitoring of discharge, water levels, ground water levels and ecological factors should be carried out and evaluated to prepare background for following optimization. All measurements are carried out on both sides according to agreed monitoring system (e.g. Fig. 8.1). For evaluation of measured data it is proposed to create the common group, e.g. under the status of PHARE.

Measures, studies and water management for the longer term water management

For the long-term studies of ecology related to water resources and management we are proposing to sign the document expressing the cooperation in the framework of program PHARE attached in following pages.

M - 7

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Agreement on Joint Czecho-Slovakian and Hungarian Cooperation on the PHARE - Environment Protection

SURFACE WATER AND GROUND WATER MODEL OF DANUBIAN LOWLAND
BETWEEN BRATISLAVA AND KOMARNO:
ECOLOGICAL MODEL OF WATER RESOURCES AND MANAGEMENT

Ground water is one of the most important of supports for human life and flora and fauna in Danubian lowland, both in Hungarian and Slovak territory. The trends in the quality of ground water are worrying. Degradation and pollution of ground water is far more serious than we thought and that the quality of the ground water is deteriorating faster than has hitherto been assumed.

In order to implement a scientifically based ground water control programme in the Danubian lowland territory it is necessary that a scientific research programme will be an common programme of hugarian, slovak and international surface water and ground water specialists. This project shall help to initialize the international cooperation in Danubian lowland area and help to bring to a cooperation hungarian and slovak specialists.

The objective of the required comprehensive study is to evaluate and verify the effects of previous activities and by the new hydraulic system of hydropower development. The goal is to define the remedial actions and optimization of all mutual interferences. A permanent optimization and management model is to be developed by this project.

M - 8

Slovak, Hungarian and foreign experts will act and work together as an independent working team and will take main methodological responsibilities in the organization and execution of the project. This group will be included in coordinative and investigative group "Ground Water" which has been established at the Faculty of Natural Sciences, Comenius University in Bratislava.

Description of conditions, specific problems to be taken into account and to be solved, methodological approach is given in the "Invitation of proposals" of this project.

At the beginning of the project definition study should be prepared. This study, or so called inception report shall focus on the definition of special subjects related to the environmental and ecological effects on the Danubian lowland. This study shall prepare a working plan of required detailed studies and the integrating policy analysis study to be carried out. The main goal is the identification of the system, its components, and its boundaries with other systems within the nature and national economy. Decisions on what should be included in each system and subsystem is a part of this study. The main parts of the system are: surface water, ground water, agriculture, population, ecology and nature of Danubian lowland. Inception report should be prepared until a month after start of work.

At the end of the project an integrated modelling system is to be developed. This system should be able to run simulation models of river flow, ground water flow, ground water quality and impact of agriculture on ground water to provide better understanding of the interrelated processes involved, their interactions and basis for decision making.

Bratislava - Budapest, 26. Oct. 1990

Ing. Dominik Kocinger   Dr. George Sámsondi Kiss

Annex 15

COMMISSION
OF THE EUROPEAN
COMMUNITIES

Brussels, January 1993

Directorate General
External Relations
HCS/

Discussion Paper

Draft principles for the establishment of a Temporary Water Management Regime for the Gabcikovo System

1. *Introduction*

A water management regime, along the lines of the London Agreed Minutes of October 28, 1992, and based upon the "Report from the Working Group of Independent Experts on Variant C of the Gabcikovo - Nagymaros Project, November 23, 1992", will have to be maintained for the period before final judgement on the matter by the International Court of Justice.

The temporary regime, or the measures to be applied therefore, will in no respect prejudice the final solution following the judgement of the International Court of Justice nor impair the rights of the the two parties..

A Water Management and Monitoring Committee should be established in order to supervise the operation of the agreed regime and make recommendations for adjustments if necessary.

2. *Temporary Water Management Regime*

This paper contains only the general outline for water management regime. The technical details will elaborated in the form of a *Detailed Water Management Manual* prescribing how the water management should be carried out. The Water Management Manual will be prepared by Technical Experts before February 20, 1993 and finally agreed by the two Parties before March 1, 1993.

In order to prevent substantial negative environmental impacts on the flora and fauna in the affected area the Temporary Water Management Regime will be put into operation before March 10, 1993.

A ***Water Management and Monitoring Committee*** will be established by the two sides in order to (i) supervise and control the operation of the Temporary Water Management Regime; (ii) propose adjustment, whenever necessary or suitable, in the regime based on new information and data and (iii) launch and monitor a comprehensive Hungarian/Slovak programme of environmental monitoring, studies and modelling and (iv) assess the implications of exceptional circumstances i.e floods and ice and make recommendations for remedial measures.

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The guiding principle for the work of the Water Management and Monitoring Committee is to ensure the long term viability of the Danube and the preservation of its natural resources as well as the protection of the environment and ecological conditions both down stream and in the surrounding region, while at the same time take into account relevant considerations and legitimate interests of both parties.

The Temporary Water Management Regime will be based on the daily discharge recorded at Bratislava with the deduction of the following estimated discharges :

Maly Danube	50 m^3/s
Mosoni Danube	25 m^3/s
Drobrohost	30 m^3/s
Seepage (estimated)	20 m^3/s
Total	125 m^3/s

3. *Distribution of discharge*

Following the recommendations of the Working Group of Technical Experts it is essential to maintain the natural fluctuations, and the Water Management Regime will be operated, as a general principle, based on relative figures (% of total discharge).

The Regime will be operated based on seasonal factors according to the criteria provided below. The Regime may be varied under exceptional conditions by agreement in the Water Management and Monitoring Committee. It will be ensured that the Danube and its floodplain receives at least 2 - 3 floods every year, which will imply that in some of the flood situations almost all of the discharge will be directed to the Danube.

3.1 *Winter Season (Period November - February)*

3.1.1 *Regime*

In the months November to February the discharge will, subject to the exceptional circumstances mentioned below, be distributed with 50 % to the Danube River and 50 % to the Navigation and Power Canal.

3.1.2 *Exceptional circumstances*

According to the recommendations from the Slovak Commission of the Environment not less than 600 m^3/s should be discharged to the Danube in the winter period, and whenever the discharge falls below 1200 m^3/s, the flow to the Navigation and Power canal will be changed accordingly in order to fulfil this requirement.

3.1.3 *Provisional remedial measures*

The Water Management and Monitoring Committee will, based on the information provided by the joint monitoring and appropriate expert advice, make timely recommendations to ensure the implementation of provisional remedial measures in order to avoid environmental damages.

3.2 Summer Season (Period March - October)

In the vegetation season the discharge to the Danube will be as follows:

Total Discharge	Up to 1200 m³/s	Between 1200 - 2500 m³/s	Above 2500 m³/S
Discharge to the Danube	75 %	900 m³/s + 60 % of quantity above 1200 m³/s	1680 m³/s + 50 % of quantity above 2500 m³/s

An estimation of the actual discharge to the Danube River and the Navigation and Power canal based on the criteria described above is found in Annex A

4. *Necessary Construction and repair Work*

The construction work necessary in order to manage the Temporary Water Management Regime according to the criteria is:

A. Completion of the protection works behind the by-pass weir,

B. Completion of the gates and the protection works behind the flood plain (inundation weir)

C. Repair of damages caused by the November flood.

The Temporary Water Management Regime will be put into operation not later than March 10, 1993. However, dependent of technical feasibility a gradual implementation may be necessary. A joint Hungarian/Slovak technical mission will based on the status of the construction work prepare a detailed implementation schedule before February 15, 1993

5. *Timing*

The timing can be summarised as follows:

Not later than February 20, 1993	Technical Experts finalise the Detailed Water Management Manual
Not later than March 1, 1993	Final accepeptance by the two Delegations of the Detailed Water Management Manual
Not later than February 20, 1993	First official meeting of the Water Management and Monitoring Committee
Not later than March 10, 1993	Temporary Water Management Regime is put into operation. Dependent of technical feasibility a gradual implementation may be necessary. A joint Hungarian/Slovak technical mission will based on the status of the construction work prepare a detailed implementation schedule before February 15, 1993

File:HCS/REGIONAL/DANUBE/regime

ANNEX A

Estimate of the actual discharge to the Danube and the Navigation and Power Canal

On the basis of the distrubution rules outlined in chapter 4, the division of water between the Danube River and the Navigation and Power Canal can be calculated. In order to calculate the average monthly and annual figures it is necessary to take into account the large discharge variations within a month. This result (in the summer season) that different precentage figures (50/60/75) have to be applied to different days within the same month.

The Commission does not have a long time series with daily discharge values which is necessary for the exact calculation. The figures given in the two tables below are based on monthly average discharge (1901-50 series), the discharge duration curve (1901-90 series) and a gross estimate of the importance of the daily variations.

Table 1 Estimated monthly and annual discharge to the Danube and the Navigation and Power Canal

Months	Average discharge with deduction of discharge to Mosoni and Maly Danube, Dobrohost and seepage (m^3/s)	Estimated average discharge to the Danube River		Estimated Average discharge to the Navigation and Power canal	
		m^3/s	%	m^3/s	%
January	1443	721	50	721	50
February	1460	730	50	730	50
March	1832	1252	68	580	32
April	2233	1483	66	750	34
May	2575	1675	65	900	35
June	2660	1730	65	884	35
July	2508	1638	65	870	35
August	2146	1436	67	710	33
September	1829	1249	68	580	32
October	1443	1023	71	420	29
November	1355	678	50	678	50
December	1316	658	50	658	50
Year	1900	1189	63	711	37

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Annex 16

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THE DANUBE...
FOR WHOM AND FOR WHAT?

FINAL REPORT
March 1993

PARTS 2, 2, & 4 OMITTED

EBRD Agreement, November 1991

Equipe Cousteau

Pursuing and expanding the experience of the "Cousteau Society", founded in the United States in 1974, in March 1981 tthe "Fondation Cousteau" was created in France. On January 1st, 1992, its name was changed into "Equipe Cousteau".

This non-profit organization, presided by Captain Jacques-Yves Cousteau, is devoted to studying the complex relationship between human populations and the aquatic system. Through expeditions led on the largest rivers of the world -- the Nile, the Saint-Lawrence, the Mississippi and the Amazon, the Cousteau teams acquired a significant knowledge of river ecosystems.

At the beginning of the 1980's, with the energy crisis imposing new research in renewable energy sources, the Equipe Cousteau developed a wind propulsion system, the Turbosail ©, on the ships *Moulin à Vent* and *Alcyone.*

The Equipe Cousteau is currently leading a campaign for the Rights of Future Generations to an uncontaminated and undamaged Earth.

European Bank for Reconstruction and Development

The European Bank is an International Institution with a capital of ECU 10 billion. Its members comprise forty countries, the European Economic Community and the European Investment Bank. The bank's objectives are to provide loans and equity investment to qualified applicants so as to foster the transition toward open market-oriented economies and to promote private initiative in the countries of Central and Eastern Europe committed to multi-party democracy and pluralism.

We welcome any additional information or statistics relevant to this document.

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F O R E W O R D

The Danube River receives water from more than a hundred tributaries, drains sediment and waste from a huge basin encompassing 76 million people from ten nations. The Danube's main watervay passes through ten cities of more than !00,000 inhabitants.

Conflicts of interest have always been smoulde-ng between communities and varieties of users, ut they have become more acute since the col-ipse of the Soviet authority: the development of ydroelectricity requires the construction of dams; avigation relies on a steady flow through calibra-d channels; but irregular flow and even floods e indispensable for alluvial ecosystems, for hing and agriculture; farming needs quantities of ean water, urban and rural propulations also ed potable water while industrial production, ermal and nuclear power plants draw on the er for cooling, and pollute the same river. eedless to say, all these conflicts become more ere because they are by essence, international. As early as September 1990, less than one ar after the collapse of the Soviet empire, I de a preliminary survey of the Danube, flying n its source to its delta. From my helicopter, it s obvious that the three main and characteris-problems of the Danube were the Gabcikovo n, the Kozloduy nuclear plant, and the delta lf.

The Gabcikovo dam, seen from the air looks like a huge scar, cutting across a splendid alluvial forest. The problem raised by this monstruous project is exemplary. It involves energy production — water resources — fishing — forestry — national boundaries and the protection of natural ecosystems. It illustrates the complexity of environmental problems: systematic analysis of water is, today, insufficient. Wholistic ecology includes all issues, environmental, political, economic, social, analized not only in the short term, but also in the long and the very long term.

The Kozloduy nuclear power plant in Bulgaria includes six reactors; four of them are of obsolete design, poor condition, and respresent for all Europe a potential, closer and more drastic threat than the Chernobyl disaster. It's study was exemplary, because it revealed that, in the Eastern European countries, energy was wasted to such a degree that, if energy saving was comparable to the German level, those countries could afford several years of rapid development without needing new sources of energy.

The third critical area is the vast delta of the Danube, where the river's waters split in three main branches, enclosing a rich province of marshes, lakes, canals and woods gifted originally with a great variety of fish and serving as nesting grounds for hundreds of thousands of migrating birds such as pelicans and swans. This unique natural park has been subject to damaging enterprises: digging transverse canals which obstruct the normal flow of water, a tentative polderisation, attracting foreign hunters, mining non existent minerals, harvesting reeds for a paper mill that proved abortive, etc. However, the delta still remains unique and require energetic but reasonable protection. It has been proposed that UNESCO declares the delta part of the human kind's heritage.

There is a striking contrast between the reasonable and picturesque way the river banks are doted in Germany with both historic castles and clean factories and further east, with old fashioned, polluting industrial "combinats". Urgent and elementary environmental protection measures must be implemented without delay. The international community has the responsability to provide efficient aid to all the countries undergoing the difficult transition between state-planned and free-market economies.

As early as 800 AD, Charlemagne wanted to dig a navigable canal joining the Rhine and the Danube. The idea of a fluvial navigation system between the North Sea and the Black Sea was revived recently, and the canal Rhine-Main-Danube (RMD) was inaugurated in 1992. Earlier, the Constanza canal, bypassing the delta had been opened to barges and seagoing vessels. It remains to be seen what proportion of the freight will use fluvial, road, rail or air transportation.

Facing the above mentionned incomplete list of conflicts, Equipe Cousteau and its partners, after two years of thorough investigations, now propose constructive and practical solutions: optimum exploitation of renewable energy sources and maximum energy efficiency — protection of the alluvial floodplains and of the delta considered as part of the world's heritage — realistic management of fluvial transportation — improvement od the water quality of the Danube. All such measures must be taken in the perspective of long (or very long) term.

Finally, we propose the creation of a Supreme Council of the Danube. This international body would collect all available data on the environment in each Danubian country, it would issue proposals in fields as diverse as energy, transport, natural parks, tourism, water, atmospheric and soil pollution. These recommendations would help each government to decently protect the rights of Futures Generations in this part of the world.

Jacques-Yves Cousteau

T H A N K S

This report has been prepared by a multidisciplinary team led by Denis Ody and François Sarano assisted by Brigitte Vannier and Grégoire Koulbanis.

The work was carried out under the general direction of Bertrand Charrier.

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We are very grateful to the official authorities from all the countries crossed by the Danube without which nothing could have been possible.

This work must be considered as being a contribution of the Environmental Programme for the Danube River Basin coordinated by David Rodda and Richard Holland from the Commission of the European Communities.

Artistic Design: Anne Bert, Paris.

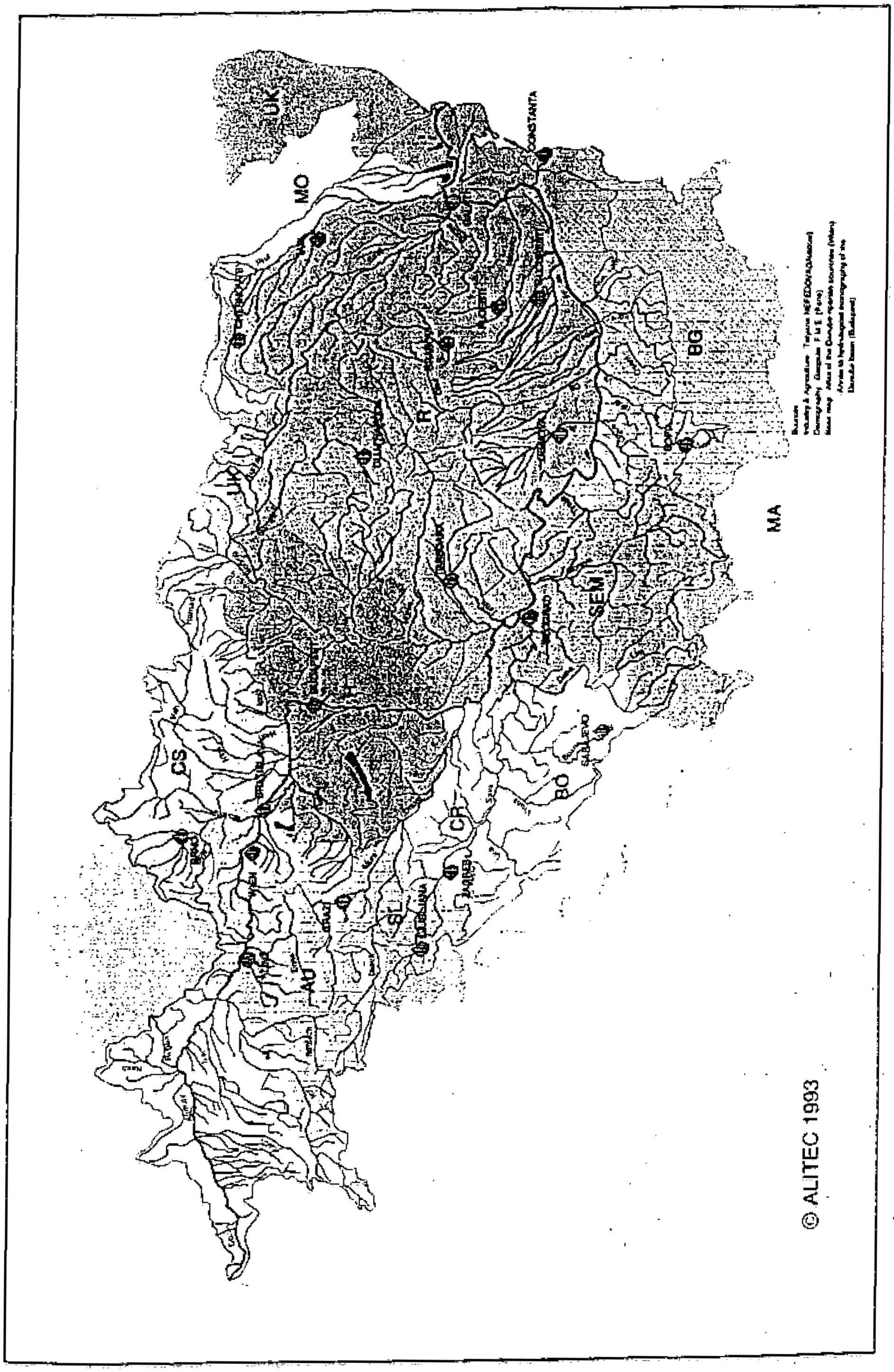
ACRONYMS AND INITIALS

CEC	Commission of the European Communities
CIS	Commonwealth of Independent States
CMEA	Council for Mutual Economic Assistance
CNRS	Centre National de la Recherche scientifique (France)
GDP	Gross Domestic Product
IAEA	International Atomic Energy Agency
IUCN	International Union for Conservation of Nature and natural Resources
OECD	Organization for Economic Cooperation and Development
UNEP	United Nations Environmental Programme
UNESCO	United Nation Education, Science and Culture Organization
WANO	Word Association of Nuclear Operators
t	ton (metric)
Mt	million tons
toe	ton of oil equivalent
ktoe	1000 toe
Mtoe	million toe
MW	MegaWatt (10^6W)
kWh	kiloWatt.hour
GWh	GigaWatt.hour (10^9Wh)
TWh	TeraWatt.hour (10^{12}Wh)
DDT	Dichloro-diphenyl-trichloro ethane
PCB	Polychlorinated bipheny
PAH	Polycyclic aromatic hydrocarbon
HEOM	Hexane extractable organic material
Bq	Becquerel
Ci	Curie
Gy	Gray
Sv	Sievert
Bucharest Declaration:	Declaration of the cooperation of the Danube countries on water management and especially water pollution control issues of the River Danube, accepted in Bucharest, December 13, 1985.
Ramsar Convention:	Convention on Wetlands of International Importance especially as Waterfowl Habitat, known as the Ramsar Convention from its place of adoption in 1971 in Iran (entry into force late 1975).

CONTENTS

CONTENTS

CONTENTS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MAIN RESULTS AND RECOMMENDATIONS

PART 1
WET ZONES OF THE DANUBE ALLUVIAL FLOODPLAINS AND DELTA

The Equipe Cousteau, acting on the basis of two year's exploration and field study of the great alluvial plains of the Danube, has carried out an interdisciplinary and international research programme with the aim of developing a proper comprehension of how these river systems work and highlighting their role in order to envisage complete overall management enabling them to be conserved. This research work, which is based on the synthesis of knowledge acquired concerning western European and American rivers, had the objective of extrapolating lessons from mistakes in the management of developed rivers in industrialized countries and of stimulating experience transfer between Eastern and Western countries in order to prevent the types of irreversible mismanagement that caused the disappearance of the alluvial forests which formerly lined all the western European rivers.

ALLUVIAL FLOOPLAINS

The alluvial zones of the Danube basin constitute a unique heritage which is necessary to the river's life and to quantitative and qualitative maintenance of the groundwater tables, and consequently to the quality of drinking water for millions of people. They are the richest natural regions in Europe in terms of biodiversity, biomass and productivity.

Alluvial floodplains play a key role in the life of the river, to which they are closely linked: a large part of the fauna reproduce and develop in these plains, and they serve as a refuge from pollution and flooding. They are also used by animal and plant species as migration and travel corridors.

Alluvial floodplains, but mainly alluvial forests, provide a most efficient system for purifying water and recycling organic matter. The assimilation of nutrients (phosphates, nitrates) by terrestrial and aquatic plant life in the alluvial plain offers an important low-cost and efficient mean to purify not only the water of the river but also the groundwater.

Alluvial plains also offer protection against flooding, by slowing the flow and giving the water space to spread out. In addition, the vegetation along the riverbanks and the plain generates friction that further slows water speed, and seepage decreases flood level. The present trend of canalization, on the contrary, increases the power and propagation speed of a flood.

These alluvial floodplains are threatened and run the risk of being definitively lost if immediate measures are not taken for their conservation. The drying out of the Hungarian Szigetköz and of the Slovakian Csallóköz caused by diverting the Danube to fill the Slovakian Gabcikovo dam and the destruction of the alluvial forest of Kopacki Rit by the war in Yugoslavia are serious warnings.

RECOMMENDATIONS

The wet zones of the Danube constitute a unique heritage and it is the duty of national and international authorities to preserve them for future generations. All efforts that have already been made to protect these natural zones, which ought all to be classified by UNESCO, will be in vain if the social and economic situation of the countries through which the Danube flows does not improve.

• Experimental project for the restoration of the Gemenc alluvial forest

The Gemenc alluvial forest in Hungary is thus now the last great alluvial zone of the Danube still intact. It has recently been classified as a "wet zone of international significance" under the Ramsar Convention. Although the Gemenc is not entirely unscathed, it does constitute a prime site for successful completion of an interdisciplinary and international research programme and a pilot project devoted to restoring an alluvial plain.

The work could serve as a model for all such attempts made on the Danube or other rivers in temperate regions.

• Creation of a "green corridor" along the Danube banks

To ensure long-term protection, a "green corridor" should be created along the banks of the Danube which will connect alluvial floodplains to each other. Except in towns, the riverbanks must be allowed to revert to their natural state in order to expand the gene pool of alluvial plain species which are now isolated.

The banks of the Danube must be redeveloped by:

- relocating the dikes by about several hundred meters on each side of the low water bed,
- reinstating connections between the main river channel and secondary channels,
- destroying certain groynes which concentrate water flow in the direction of the navigation channel at the expense of the alluvial zones.

• Maintaining river flow irregularities.

High-low water alternations are vital. The construction of any new dams must therefore be prevented.

• Classification of wet zones by international institutions

Like the Danube delta, the alluvial floodplains must be the beneficiaries of international classifications from UNESCO or Ramsar for example, which recommend management and protection regulations.

THE DANUBE DELTA

The Equipe Cousteau has been conducting field studies in the Danube Delta in cooperation with inhabitants, scientists and officials. The Cousteau team spent several weeks in the heart of the delta, both in winter and in summer. The team used all available means (helicopter, Zodiac, rowboat...), to explore the delta including its hardest-to-reach areas. Numerous meetings were organised with local people and special attention was paid to their vision of past and future changes in their region. The methodical grid-pattern helicopter survey of the delta played an essential part in the generalization of accurate but spotty field-collected information.

The Danube delta is still an unusually rich natural area, despite the sometimes heavy deterioration it has undergone in places. It constitutes an exceptional heritage recognized by the international community; as a UNESCO "Biosphere Reserve" its protection must receive absolute priority. Consequently, the Equipe Cousteau paid particular attention in compiling an inventory of the ecosystem and in proposing a management plan which enables the inhabitants of the delta to live suitably in taking advantage of the riches of the delta while protecting them.

This work, carried out in close cooperation with the Ministry for the Environment, Romania, and IUCN, was presented at the Bucharest conference "Tourism and Conservation of Deltas" (September 1992).

RECOMMENDATIONS

The wet zones of the Danube constitute a unique heritage and it is the duty of national and international authorities to preserve them for future generations. All efforts that have already been made to protect these natural zones, which ought all to be classified by UNESCO, will be in vain if the social and economic situation of the countries through which the Danube flows does not improve.

• Political driving force and legal framework

The considerable effort expended to achieve appropriate development of the Danube delta and protect this exceptional part of the world's heritage is lightly to fail if it is not supported by a visionary political driving force. This political driving force needs a legislative framework consistent with application of the management recommendations made under the ægis of the Biosphere Reserve.

The Biosphere Reserve Authority will have to ensure that relations between local people and the various agents involved in developing and managing the delta remain on a human scale, so that this unique European natural area continues developing in a harmonious way.

Conservation of the alluvial plains and delta of the Danube is not a responsibility of merely national magnitude, but indeed one of international proportions. It is the responsibility of all the countries in the Danube catchment area, which must all take an overall interdisciplinary view in space and time. It would be useless to protect the delta if structures, such as dams, which limit the flow variation are built on the Danube or if measures were not implemented to reduce pollution upstream.

Passive conservation

The reed marshes and the plaur floating island made of reeds and decomposing vegetal matter) are so immense and impenetrable that they provide excellent protection to wildlife, especially the remarkably abundant birdlife. Before launching a costly and uncertain conservation program, one should rely on the area's impressive capacity for natural regeneration and encourage passive conservation. If the delta is to be effectively preserved, some areas should remain hard to penetrate or even inaccessible. The waterway is the only access into the delta, and it must remain so. The canal network must not be extended.

• Isolating activity zones with buffer zones

The delta is large enough to allow for the creation of strictly preserved zones together with zones where traditional activities such as crafts and a controlled form of tourism (ecotourism) can develop. The delta people are practically self-sufficient and draw little benefit from major economic activities on a national scale. Their life-sustaining activities are not detrimental to the delta ecosystem, unlike the high-impact large-scale ones. If harmony between nature and inhabitants is to be maintained, it is preferable to isolate current activity zones and to prevent their extension with buffer zones, rather than surrounding preserved zones with buffer zones. This implies creating a legal framework which, while making life better for people in the delta, would prevent any large-scale alteration liable to upset its overall ecological balance.

• Ecotourism and accommodation with local people

In no case should tourism in the delta be considered, or its development planned, as a major source of currencies for Romania. Such an activity must remain moderate and be only one financial resource among others for the delta region's inhabitants.

The development of large hotel complexes which would only run counter to the interests of the reserve and above all of local people should be proscribed. On the contrary, tourist accommodation with local people should be promoted by furthering improvements in local housing (sanitary facilities, drinking water, rooms...). This policy will have the double advantage of controlling numbers of tourists and of enabling local people to benefit directly by the richness of the reserve.

• Developments: keeping things on a human scale

International banks, such as the European Bnak or the World Bank, that becouse of their size cannot provide direct services to private individuals will need to find ways, possibly using local banks and linking with the DDBRA to overcome this obstacle.

PART 2
NAVIGATION AND TRANSPORT

Eastern European traffic features an oversized freight industry and low mobility of its inhabitants. Freight transportation levels are two to four times that found in Western Europe per GDP unit. Most of this traffic consists in heavy cargo shipped by train. Since 1989, the economic transition experienced by these countries has led to a major modification in the production and trading structures. Furthermore, a demand for mobility is being increasingly felt. These changes have caused a relative and absolute increase in road traffic. For most observers, the road is considered a factor for increasing development. The growth of road traffic is unavoidable and investments in this area are very profitable.

Potential development of river traffic must be assessed in relation to the strong demand currently existing for development of road traffic. Improvement of navigation conditions is a positive factor that may enhance the competitiveness of river transportation. According to the Danube Commission, this improvement requires building eleven dams.

This type of development is highly detrimental to the environment. Experience derived from dams in Austria and at the Iron Gate (Romania, ex-Yugoslavia), as well as the more recent one at Gabcikovo, in Slovakia, has underscored their effects:

- Gradual damages to alluvial areas and forests, leading to their complete destruction in the long run.
- Contamination of groundwater tables and altered exchanges between river and groundwater.
- Modification of the overall fluvial balance (erosion/sedimentation).

The Danube, unlike the other European rivers, is only slightly developed, especially downstream of Vienna (Austria). This relative freedom constitutes the river's richness, and would come to an end if the Danube is developed.

It is therefore essential to assess the economic soundness of facilitating navigation through a development of Danube. The Equipe Cousteau was unable to find any economic or environmental study concerning these development projects, and thus had to launch its own. It was based not only on the transport statistics within the former COMECON, but also on the economic development prospects of re-structuring and opening up the Eastern countries to the world economic market.

A detailed analysis of statistics giving the number of days and the sections where the river level is lower than 2.5 meters, being the minimum recommended for navigation by deep draught barges, shows that the Hungarian/Slovakian section is the only one where frequent navigation problems occur.

It is thus unnecessary today to build the series of eleven dams recommended by the Danube Commission. The section comprised between Vienna and Budapest, a real bottleneck, including the highly controversial Gabcikovo dam, should undergo major works to guarantee the required depths. The work carried out between Vienna and Budapest would include a comprehensive project of four dams equipped with twin locks (Vienna, Hainburg, Wolfsthal and Nagymaros), according to studies carried out by the Danube Commission, and the flooding of the Gabcikovo Dam. The project can only be effective if all the dams are built; otherwise, navigation difficulties would be increased because of problems linked to incision of the river bed.

Global economic analysis of the Danubian area shows that navigation should develop around two major economic poles: modern steel industry in Linz, Austria, and the Romanian harbour of Constanza, on the Black Sea. Most of the traffic increase between today and 2020 will occur downstream from the Danubian bottleneck: roughly 21 million metric tons over the current traffic will thus transit between the Black Sea and harbours downstream from Budapest. However, the traffic increase through the Danubian bottleneck will only amount to 1.8 million metric tons if the river is developed.

Investments would consist of four dam/lock series situated near Vienna, Hainburg, Wolfstahl and Nagymaros. These works - except for Gabcikovo - will be approximately 707 million dollars at present value (up 8%). These values have been calculated for 23 x 34 m locks and for dams with the characteristics defined by the Danube Commission according to simple estimation formulas used for similar calculations in France during previous project evaluations.

These direct costs are initially to be compared with the benefits for navigation alone, estimated at $ 180 million in 2020, based on a conservative hypothesis that incorporates direct benefits. They are estimated at about $ 360 million using a more liberal basic assumption. The share of induced or new traffic volume directly linked to the improvement represents less than $ 30 mil-

RECOMMENDATIONS

Water transportation is certainly a way to limit road congestion due to transportation of heavy materials. However, one must use barges suited to the river rather than transform the river to adapt it to the barges. Such transformations would be detrimental to the preservation of the river ecosystem and are not financially justified.

• To set a transport strategic master plan

The additional investments required by the current situation in Eastern Europe must be incorporated into a master plan which is strategic in that it covers all forms of transportation combined. Only well-negotiated international planning will make it possible to better distribute the means of transportation, i.e. lessen the importance of the road networks.

The current restructuration of industry offers the opportunity for an innovative policy of land development which strongly determines transportation system. Planning and controlled building must be considered in all events, with new schemes which do not copy those of Western Europe, which display their failures more obviously as each day passes.

• To avoid the excesses and aberrations of road domination

The search for solutions favoring the use of several means of transportation (multiple-transport) would make the road network and automobiles the cornerstone which will structure the organization of the transportation system. To avoid the excesses and aberrations of Western transportation systems, we propose three orientations:

- for freight, the development of competitive combined transportation, i.e. rail/road, river/road and sea/road;
- for travellers covering medium and long distances, competitive rail transportation must be made available;
- in urban areas, strict control and mastery of automobile traffic, and a fresh boost to the development of public transport.

The current policy is hooked up to road transport pressures. It consists in tagging along after demand in order to satisfy it. It is not enough to provide incentives, as it is well-known that there is no return from road to watercourse or rail. The States must favour collective transportation, not only at the national level, but at the Europe-wide level too.

• The Danube does not become a large-gauge channel

The transformation of the Danube into a large-gauge channel must be prevented. It seems greatly preferable and far less expensive to use fleets suited to the river's irregularity, as the Romanians and Ukranians have already been doing.

Nothing at this stage justifies the building of the eleven dams planned by the Danube Commission.

• To invest next to the Danube

So as to enhance the role of river transport, either by itself or as an element of combined transportation, it seems essential and profitable to invest next to the Danube. These goods-connection priorities require large organizational investments which will particularly affect the distribution, bulking and breakbulking infrastructures.

They require that numerous port, river, sea and land infrastructures whose functionalities are inefficient or deficient be reconsidered.

Sites for harbour infrastructures should be selected according to a process that takes navigational difficulty into consideration.

lion, and it would be $ 120 million in the most favorable hypothesis. Consequently, on the horizon 2020, it appears that the benefits for navigation can be expected to represent at best about 50% of the cost of necessary works. On the other hand, if direct benefits alone are taken into account, on the improved section alone, the percentage drops to 25%.

Developing the Vienna-Budapest sector will not be directly profitable for navigation (negative internal rate of return). The impact of these investments on the overall productivity of the fleet is not negligible, but it will not generate substantial profitability. Maximum profitability will be roughly 2.5%.

The beneficiaries of this investment will of course be the fleet operators, and therefore their clients. While Romanian and Hungarian farmers will be among the indirect beneficiaries of a more productive fleet, the Linz iron and steel industry in Austria would be the only direct beneficiary if the Danubian bottleneck were developed.

It seems that both the consequences of opening the Rhine-Main-Danube canal and the possibility of switching traffic from one mode to another have been overestimated.

Actually, selecting a mode of transportation depends not only on cost, but also on benefits obtained in terms of speed, frequency, reliability.

In spite of financial advantages, the experience in Western countries has shown that there is practically no transfer from road transportation to waterways, while on the contrary road and train transportation gradually overtake the market share of waterway transportation.

PART 3

ENERGY IN THE DANUBIAN COUNTRIES

The problems of environment cannot be dissociated from energy production and use. Poor energy management, whether it is from fossil or nuclear sources, is one of the main causes of serious environmental damage in the Danube region.

The studies carried out by the Equipe Cousteau and its partners dealt with:

- Analysis of global energy indicators (energy intensity, consumption by sector, consumption distribution according to energy sources) for the Central and Eastern countries.
- Developing new energy policy proposals based on improved energy efficiency and greater use of renewable energy sources. The objectives for the Danubian countries should be to achieve with a level of energy intensity comparable with that of Western Europe as quickly as possible, that is to say, in less than fifteen years.
- Proposing concrete projects in the domains of lighting, industry, transport and building which have rapid effects on the energy and finance schedule of the nation.

Such a new policy must include necessary measures enabling unsubsidized, market pricing, regulations, incentives, responsible and human-scale institutions, clear programmes, sufficient financing.

A thorough survey was carried out about the safety of the four older nuclear reactors at the Kozloduy nuclear plant in Bulgaria, known to be the most dangerous VVER reactors still in operation in Central and Eastern Europe.

Renewable energies such as solar, biomass, waste constitute a little-exploited source of energy which we have evaluated. The new environmentally sound energy policy must give top priority to renewable energies.

The development and application of this new energy policy call for changes in thinking rather than new technology. The three-day conference in Sofia, Bulgaria, organized by Equipe Cousteau and EcoEnergetica, entitled "Citizens concerned by an energy-efficient and environment-respectful society," laid the basis for these changes.

RECOMMENDATIONS

Rational energy use, the cornerstone of any strategy for a sustainable future, has a positive impact on the environment and the well-being of the citizens of these countries. It is the responsibility of the international community, especially Western Europe, to share in the efforts and sacrifices of which the Danube countries will bear the brunt in making a successful transition toward an energy-efficient and environment-respectful society.

• To develop a new energy policy

Energy efficiency policies should be developed in all Danubian countries through:

- Planning of energy supply and demand.
- The creation of an expert group subordinate to the Prime Minister of each State, which will be in charge of the definition and follow-up of the energy efficiency policy.
- The creation of institutions at the national and the local levels to establish programmes for improving energy efficiency in the various sectors of activity and helping the appropriate partners and economic agents to implement them.
- A system of regulations to promote the rational use of energy, in particular for new buildings and electric appliances.
- An appropriate system of incentives to stimulate and promote energy efficiency improvements, initiatives, and projects, and corresponding mechanisms to facilitate financing of investments and programmes.
- National training programmes in energy efficiency for technicians, planners and engineers, managers, architects, local and municipal officials.
- A National Fund for Energy Efficiency financed by 1% of the bills paid by energy consumers on the final energy consumption to finance national energy efficiency programmes.

• To increase and to improve international cooperation

International cooperation must deal with:

- Training in energy planning methods.
- Creation of a "Danubian Center for Energy Planning" in one of the countries as a center for common training and to support needed applied research and technology innovation and adaptation.
- Institution and capacity building programmes for energy efficiency.
- Natural gas development, in particular through the laying of the Iran-Europe pipeline.

• To carry out exemplary actions

Exemplary actions must be carried out in the following fields:

- Domestic, tertiary and urban lighting: i.e. the use of economical solutions such as compact fluorescent bulbs which consume five times less than incandescent bulbs and last eight times longer.
- Household appliances, particularly refrigerators and TVs. It is now possible to obtain models that consume half as much as models currently on the market in Western countries.

• The development of hydroelectricity has to stay moderate

Hydraulic structures have serious effects both on the general equilibrium of fluvial ecosystems and on the drinking water resources associated with them (ground water tables), effects which are not always reversible. This is why:

- Exploitation of 100% of the economically operable hydroelectrical potential is not a reasonable objective. Development of hydro-electricity must be limited and moderated.
- Installation of new plants must be the object of strict and full prior consequence studies

RECOMMENDATIONS

which take the ecological, technical and economic aspects into account along with the possibility of alternative solutions.

- The building of dams in the plain regions, in particular on the Danube, must be prohibited.
- New ways of exploiting the existing dams must be envisaged. These must incorporate moderation of their consequences (sediment and water flow management in particular).

Development of small hydroelectric power plants, when kept under control, is possible if:

- The legislative framework which must be set up to accompany their development strictly imposes consideration of the consequences on rivers at both the construction design and output management levels.
- The renovation of old small hydroelectric power plants or the installation of turbines on existing constructions which fulfill other functions (e.g. water diversion for irrigation) should be favored over the building of new constructions.

• To exploit renewable energies in priority

To ensure that other renewable energies, the potential of which is estimated as at least 12% of primary energy consumption, become a priority matter in energy policies which are currently being re-defined, it is important:

- to prepare a comprehensive evaluation of the potential of the main really accessible renewable technologies,
- to set up an overall survey of industrial capacities necessary for renewable energy technologies,
- to make an analysis of the institutional and financial framework necessary to develop such policies.

• The end of nuclear energy

The application of this new energy policy is aimed at balancing energy supply and demand in all the Danubian countries without resorting to nuclear energy. Nuclear energy is not only unsafe, it is above all unnecessary. Giving it up is thus the best strategy.

PART 4

EVALUATION OF THE POLLUTION OF THE DANUBE

The decision-making process and the successful management and sustainable and environmentally sound use of natural resources requires on one hand an adequate assessment of the available resource quantity and quality and on the other hand, tools to use data collected for planning and management.

ENVIRONMENTAL RESOURCES ASSESSMENT

• CHEMICAL POLLUTION •

An important study of the Equipe Cousteau Danube programme is focused on chemical analyses of sediment samples and sentinel organisms from the river Danube for a total of over 100 parameters which reflect the current state of contamination of the river with pesticides, PCBs,

›il, combustion products, selected industrial che-nicals and sewage.

The data base includes over 10,000 measure-nents: the largest information base yet obtained or the Danube sediments. It is possible to identi-y levels and trends of contaminants in the Danube.

The Danube is not chronically polluted in its entirety. This is partly be due to the high flushing ate of the system which is, in turn, a consequence of the enormous flow rate of the river and its eason variability.

There are a large number of pollution "hot pots". These reflect the discharge of waste and ffluents from human activity and may be serious-y damaging the river environment and the quali-y of its water as well as that of the associated roundwater. With the exception of lindane, the evels of chlorinated hydrocarbons and PCBs are nferior to those measured in the more industriali-ed Western rivers. A clear gradient of pesti-ides is apparent, in some cases, evidenced by fiftyfold increase in concentrations from the pper to lower reaches of the river.

Levels of oil and oil residue are rather high in ertain hot spots but are generally inferior to ose in chronically polluted rivers. Concentration r most heavy metals overlaps that recorded in olluted Western rivers.

Danube sediments are often heavily polluted ith sewage. This is undoubtedly related to high opulation densities along the river and the lack effective urban wastewater treatment.

Any dam in the river downstream of identified urces of pollution creates a potential build-up of ntaminants and, in some cases, a future "che-cal time bomb". Today such a situation exists in e Iron gate reservoir and tomorrow, it would be e for the Gabcikovo dam.

Sediment monitoring is clearly a very useful tool detect hot spots. Although this technique and omonitoring are not to be considered as a sub-ute for systematic and regular monitoring of ater quality, suspended particules and effluents, y allow for a global vision of the river.

The results of the macrozoobenthos monitoring programme are entirely consistent with the chemical measurements of contaminants. They provide valuable evidence for chronic biological stress associated with contaminated sites: the benthic biodiversity decreases downstream of recognized hot spots such as major cities — Vienna, Budapest, Bucharest — or major industrial centres on the river or its tributaries (Bratislava, the Vah river, etc.). A more detailed study is now warranted which should consider a more statistically valid sampling scheme and seasonal measurements at selected sites. Such information, properly correlated with chemical measurements, could eventually lead to a Danube biological monitoring system as an expansion of the Bucharest Declaration.

• RADIOACTIVITY •

Aerial gamma spectrometry was used to study natural and man-made radioactivity along 2,200 km of the Danube's banks and around nine selected nuclear and non-nuclear industrial sites. The approach used here combines collation of local experts' reports from Hungary, Bulgaria and Romania with new analytical studies of environmental samples specially collected for the study.

This combined approach provides consensus results.

The Danube river and catchment is radiologically "clean" both in absolute terms and in comparison to other European rivers. It has few source-terms and fast water flow.

The only man-made radioactivity consistently observed in the river and its basin is from the 1986 Chernobyl accident and these levels are relatively low, decreasing systematically from Budapest to the Black Sea. It can generally be observed that major variations in environmental radioactivity are the result of different activity levels of natural radionuclides. Some of these variations are caused by changing shoreline geology, others by differing land-use (e.g. use of ^{40}K-rich fertilizers) and others still by industrial concentration processes. In this last category, two areas near fossil fuel power stations were mapped, one in Ruse, Bulgaria, and one in Giurgiu, Romania, at which there appears to be enhanced environmental ^{226}Ra from coal combustion residues.

The survey included the areas around of the nuclear sites at Paks, in Hungary, and Kozloduy in Bulgaria. The near-site river systems at both locations are unpolluted. At Kozloduy, an area of radiological contamination was observed, this being caused by liquid waste leakage into sewage/drainage channels. The detected contamination was produced mainly by a waste management accident in 1978 but leakage is continuing. Clearly, follow-up work is required to eliminate this leakage.

This aerial survey technique also showed its detective capabilities by pin pointing the use of an industrial radiography source in a shipyard in Galati, Romania.

An unknown contaminated zone has been identified in Romania proving the potentialities of the aerial survey technique for the monitoring of environmental radioactive contamination.

TOOLS FOR SUSTAINABLE ENVIRONMENTAL MANAGEMENT

• OVERALL EVALUATION OF POLLUTION AND HIGH RISK ZONES •

Using an upstream approach, which favours analysis of data concerning human activities generating pollutantst, we are able to estimate quantities of four determinants (organic matter, suspended matter, nitrogenous matter and phosphorous matter) discharged into 66 sub-basins covering the whole Danube catchment area, to identify the most highly polluting sectors of activity within these sub-basins, classify sub-basins by the degree of pollution pressure to which they are subjected, and to define a certain number of "high risk" zones.

The wet zones, the karst zones and the natural protected zones constitute sensitive areas in which pollution is particularly damaging. Mainly located in the plains of the north-west, Bratislava (Slovakia), of the centre, Tisza (Hungary), and in the delta region, they represent over 22% of the total basin surface area.

One quarter of the wet zones and over 10% of the natural zones are subjected to excessive pollution. This threat is affecting the drinking water resources in this region because the large groundwater tables are located in the wet zone. The delta which represents a highly sensitive and fragile ecosystem is especially in danger as it is the outlet of the whole basin and is immediately downstream of the most highly polluted basins.

All the large capitals are on the river or a direct tributary, and generally poorly served by waste water treatment plants. They constitute a major source of pollution in the sub-basins in which they are located. In some sub-basins, the impact of diffuse population is not negligible.

Industrial pollution is particularly serious in Romania and Bulgaria. It often combines with domestic pollution from the large towns as this is where the production centres are located. This particularly applies for Bucharest and Budapest.

It is in Romania that the majority of the sub-basins most globally under threat can be found. Bucharest is blighted by both domestic pollution and industrial pollution (chemical industry) and the estimated burdens of pollutant are far greater than those of the other sub-basins.

Most of the results obtained by this comprehensive pollution evaluation method based on human activities are borne out by direct pollutant measurements carried out in the context of this programme.

• GLOBAL MANAGEMENT OF THE DANUBE ENVIRONMENT •

Equipe Cousteau and its partners proposed a project to develop an advanced approach to decision-making in the field of environmental management. This Environmental Decision Support System presented is a tool which could provide a help for the Environmental Programme for the Danube River Basin, and, on a longer term perspective, for the global management of the Danube environment.

It is based on the Geographical Information System (GIS) methodologies developped to evaluate the overall pollution of the Danube river basin. In order to ensure the spread of the system throughout the Danube countries, Equipe Cousteau organized an international workshop on GIS in Environment and Water Management in Budapest from the 28th to 30th of September 1992. It gathered 43 participants and more than 30 observers coming from most of the Danube countries (excepting Germany and Romania) as well as the Netherlands and international institutions.

RECOMMENDATIONS

The requirement for control and monitoring of the Danube's environmental condition can under no circumstances justify a lack of immediate action to limit environmental contamination.

• To stop the pollution from wellknown sources

The countries' capital cities, largest towns and the industries causing most pollution must adopt a long-term comprehensive water management plan and be equipped with purification plants as a matter of priority. This measure should be accompanied by an improvement in industrial processes in order to limit the amount of polluted waste entering the Danube's waters.

Measures must be implemented as quickly as possible to reduce or eradicate the causes of pollution identified by means of hot spots and high risk areas such as the Romanian sub-basins, the delta and the wet zones of the basin's central plains.

• To protect drinking water

The groundwater of the Danube basin is particularly threatened by industrial and domestic pollution. Preventive measures must be undertaken as a matter of priority. Due to the highly probable risk of a chemical time bomb, the filling of the Slovakian dam at Gabcikovo should have been postponed and the construction of new dams along the river can no longer be considered until depollution measures have been taken and safety of groundwater quality has been proven.

• To take into account the survey and monitoring of hot spots

Diffuse pollution from agricultural sources can no longer be ignored in the Danube basin. Long-term consequences of diffuse pollution are sufficiently serious to warrant precautionary measures being implemented immediately.

• To improve the monitoring of pollution and the survey of hot spots

Sediments and sentinel organisms analysis and aerial gamma spectrometry techniques which demonstrated their efficiency, must be largely implemented in Central and Eastern Europe within a legal framework, i.e. the Bucharest Declaration (December 13, 1985). A network of laboratories will be set up to monitor and control the quality of the Danube waters.

Polluted zones, hot spots and dams must be monitored with the closest attention to follow up the effects of depollution measures.

• To develop the means for a global management of the Danube basin environment including the delta and the Black Sea

The recognized unity of Danube basin system including delta and Black Sea imposes that the monitoring of the state of the Danube environment and the drive for rehabilitation of the fluvial, delta and coastal ecosystems be interpreted in a comprehensive management programme.

The upstream approach to identifying sources of pollution by estimating of pollution-producing human activities is the main element of the project of an Environmental Decision Support System for the Danube river basin combining all the elements of the state of the art of Decision Support System and Geographical Information System and which will eventually yield a widespread Network of National Nodes.

This workshop made possible:

- Evaluation of the knowledge and experiences in the Danubian countries as well as on the Rhine within the Rhine-Danube programme concerning the Geographical Information Systems and their uses. We observe that:
  - Most of the countries had a rewarding experience with GIS in the field of environment and water management.
  - The obstacles which slacken GIS development have been identified.
  - Two levels of GIS use have been defined: the international level, namely the Danube basin scale, and the national or local level with its more specialized objectives. In the long term, these two levels, today in parallel, must be able be correlated for mutual benefit.
- Presentation of the system developed by the Equipe Cousteau and its partners.
- Initiation of the GIS network in all of the Danubian countries in relation with Western participants.
- Setting-up of recommendations to ensure the development and the use of the GIS in the Danube basin.

These recommendations have served as a basis for the draft project for the "Environmental Decision Support System for the Danube River Basin". This tool aims at integrating political, economic and social, ecological and technical data in the decision process.

The main steps of this project lasting three years in all are the following:

- Adapting the methodology developed by the Equipe Cousteau and its partners on a national level.
- Developing and harmonizing the data collection necessary for proper system operation.
- Testing the method upon a pilot zone: the Tisza basin.
- Diffusing the system throughout the Danube basin.

Fulfilment of these objectives will require the development of the network initiated during the workshop, information exchange, international cooperation, and a training effort.

PART 5
GABCIKOVO

A global approach to environmental problems taking the long term into account is the basic tenet of the Equipe Cousteau study programme on the Danube. As the unfortunate result of an approach limited to the aspects of hydraulic engineering and technology alone, the Gabcikovo dam is a striking example of how financial and environmental resources are wasted when the global approach is not used.

The body of research from the Danube environmental Cousteau programme enables to present a complete evaluation of the advantages of the dam on an economic level and of the consequences it has for people and environment.

Filling of the dam at the end of October 1992 had serious consequences for the alluvial ecosystems, attacked their value as a heritage (biodiversity) and the functions which they fulfill in the context of water purification, protection against flood, and biomass production (fisheries and forestry). It was thus clearly shown that there is massive incompatibility between operation of the dam according to the plans (which schedule outputs comparable to those observed: 200 to 300m^3/s) and survival of the ecosystems bordering the river.

The studies carried out confirm that water resources are seriously threatened by eutrophication and contaminated sediments which are being stored in the retention lake. The numerous sources of pollution identified upstream of the dam and the significant concentrations of pollutants measured in this area are conditions for a chemical time bomb. The loss or deterioration of these water resources will have serious effects at an economic and social level, since the drinking water supply for a large number of inhabitants depends on the quality of groundwater.

The energy and navigation studies show that Gabcikovo does not yield any economic benefits. The electricity produced does not respond to any real requirement for the future and is in any case very marginal. The dam does not alter the navigational conditions except in a very limited sector. The analysis shows that potential traffic increase resulting from development in the Hungarian/Slovakian sector is insufficient to justify the required investments. The recent problems at the dam do not demonstrate that it improves navigational conditions; indeed, the reverse is true.

A complete overall approach to the Gabcikovo dam problem makes it drawbacks apparent and it is clear that, if it had been used from the start of the project, Gabcikovo would never have gotten off the drawing table. The decision to build this dam is clearly the stumbling block of a system in which the decision-makers integrate only a very narrow range of criteria. No alternative solution which would have yielded the same energy or navigation services, implementing alternative resources less detrimental to the environment and more profitable for the economy, was seriously studied.

RECOMMENDATIONS

Solving the Gabcikovo problem and saving the endangered zone would be a landmark decision and an example for the future.

• To refill the Danube in priority

Most of the water in the Danube (95%) must be returned to the river bed as soon as possible and at the latest before Spring growth season.

• To apply the principle of precaution for the intermediate period

The principle of precaution must be applied in decisions concerning the dam's future, especially concerning how the water is managed, decisions due to be made for the near future. The Danube must not become a laboratory where experiments are carried out.

• To engage in a global integrated reflection guided by democratic principles

Basic reflection on the matter must be engaged in incorporating the technical, ecological, economic and social data and drawing on international experts, the public and non-governmental organizations for environment protection. It must lead to an exhaustive and detailed cost/advantages analysis of all alternative solutions. It must be carried out in a spirit of transparency and its conclusions must guide decisions concerning Gabcikovo's future.

• Courageous and reasonable solutions must be supported by Western countries

Our own analysis leads us to the conclusion that abandoning the dam and reinstating the site is the most courageous and also the most reasonable solution with a view to achieving a sustainable future. This solution must have the advantage of solid financial backing from Western countries and the large international financial institutions. Such aid is indispensable for implementing alternative solutions in the field of energy and navigation and for a site reinstatement project if these are to have credibility with the public and with political leaders.

PART 1

WET ZONES OF THE DANUBE ALLUVIAL ECOSYSTEMS AND DELTA

WET ZONES OF THE DANUBE ALLUVIAL ECOSYSTEMS AND DELTA

Two years of exploration and field work have convinced the Equipe Cousteau that the Danube is a very rich river. Its life and richness are largely due to the presence of large active alluvial floodplains. The Danube whose flow has not yet been entirely regulated nor confined with dams, still floods the vestiges of the great alluvial forests which lay alongside all the great European rivers such as the Seine, the Rhone and the Rhine some centuries ago.

The Equipe Cousteau has launched a vast study of the Danube wet zones so as to gain better understanding of their functioning and role and to propose protection and management surveys. This bibliographical synthesis has been effected by Professor Claude Amoros (Univeristy Claude Bernard, Lyon), Professor Michèle Trémolières, (University Louis Pasteur, Strasbourg) and Professor Istvan Zsuffa, (Pollack Mihaly College, Budapest).

The wet zones of a river include the alluvial ecosystems and delta. Alluvial ecosystems are both superficial and subterranean, terrestrial and aquatic and are influenced by the superficial waters and groundwaters of the main channel of the river.

These alluvial ecosystems are closely linked to the fluvial ecosystem which is not simply a discharging channel. On the contrary, the alluvial ecosystems play a crucial role in the physical and biological functioning of the great rivers and their regulation. The complexity and the diversity of these alluvial ecosystems is the very expression of the river's dynamics.

1

THE RIVER AND THE FLOODPLAIN ECOSYSTEMS: A COMPLEX SYSTEM

The most important floodplains are presented in *Figure 1.1*. The surface areas are only estimations because they vary with the flood level:

- The Austrian Auswald, on the edge of the Danube between Vienna and Hainburg, covers approximately 6,000 ha. This floodplain forest, partly protected, is gradually drying up due to sinking of the groundwater level in conjunction with the excessive gouging of the Danube river bed, caused by the Altenworth and Grefeinstein dams. This is known as "incision", and is common on rivers developed by man.
- The Hungarian Szigetköz and Slovak Csallököz comprise an exceptional meandering zone around the low-water bed of the Danube, which today still includes the border between Slovakia and Hungary. It corresponds to the old fossil delta of the Danube 3 million years ago. Today, the active floodplain has been reduced by flood protection dams and only covers 6,000 ha on the Hungarian side and 23,000 ha on the Slovak side. However, if building of the Gabcikovo dam and its canal to Bratislava is maintained, the entire zone will be annihilated.

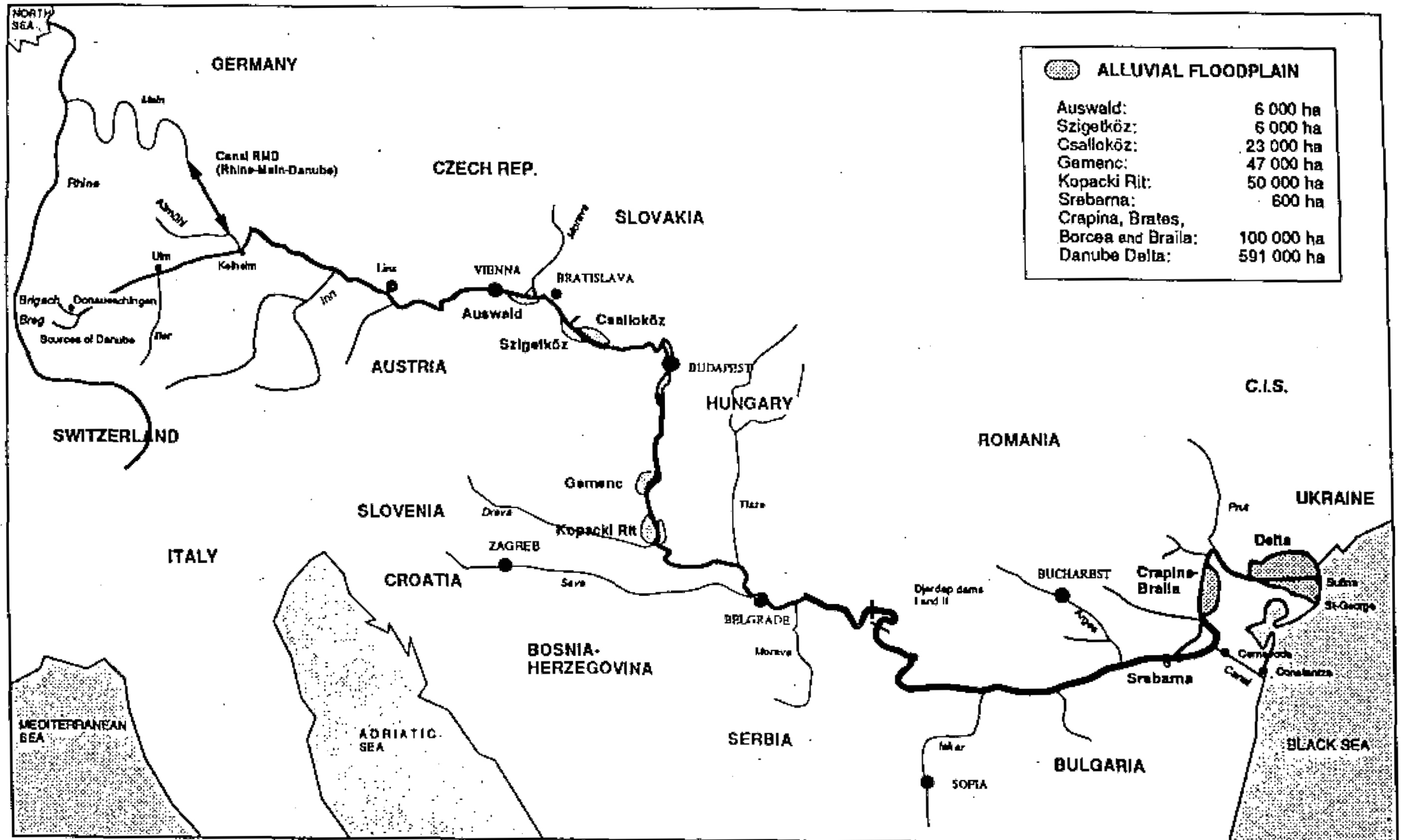


Fig 1.1 - Location of the most important alluvial floodplains in the Danube basin.

The alluvial floodplains are the richest natural regions in Europe and they cover today less than 1% of the Danube basin area. They constitute the singularity and the richness of the Danube. During the two years of the Equipe Cousteau study two of the main alluvial floodplains (Szigetköz-Csalloköz and Kopacki Rit) have been threatened by war or development.

- The Hungarian Gemenc region covers approximately 47,000 ha, 18,000 of which are classified as protected land. This floodplain, which is exemplary in terms of resources and problems, is the subject of a detailed research program.
- The Kopacki Rit, which represents some 50,000 ha lying between the Drave and the Danube - now split between Croatia and Serbia - is the richest floodplain of the Danube. It is currently impossible to obtain reliable data on its situation due to the war, but we suspect there has been serious damage.
- In Bulgaria, the Sebrarna reserve covers 600 ha, set within a larger floodable zone.
- In Romania, the floodplains of Crapina, Brates, Borcea and Braila, which once covered more than 100,000 ha, are currently partly diked. They directly determine fish farming productivity in the delta.
- The Danube delta covers 591,200 ha classified as a Biosphere Reserve, including 312,400 ha classified as World Heritage. Its resources are also highly dependent on the extent of flooding.

The river and the aquatic and terrestrial habitats of the floodplain are one of the most complex ecological systems in the world. It is made up of a group of highly diverse constantly interacting ecosystems: running waters of the river and its active arms, stagnant waters connected permanently or periodically to the river, temporary waters, terrestrial plant formations subject to variable flooding periods, and an underground aquatic ecosystem. The three spatial dimensions are therefore interacting *(Figures 1.2)* longitudinally along the upstream-downstream axis of the river channel, transversely between the river and the floodplain habitats, and vertically between the surface and underground waters.

In addition to this spatial complexity, there is the time dimension. Floodplain ecosystems are characterized by intensive dynamics and strong process interactions according to different time scales. The diversity of floodplain landscapes and the communities which live on them are due to both annual hydrological and seasonal fluctuations, erosion, sedimentation and plant succession processes spread over several decades, as well as incision and level rising phenomena which create river transformations over the centuries.

1.1

GEOMORPHOLOGY, HYDROLOGY AND MANAGEMENT CONDITIONS ON THE DANUBE

The geographical character of the Danube is highly variable, especially its longitudinal profile which is very irregular. The river can be divided into 3 stretches: the Upper Danube from the source to Vienna, the Middle Danube from Vienna to the Iron Gates, the Lower Danube from the Iron Gates to the Delta.

Outside of the gorge sections where the channel is constrained, the Danube has developed contrasting geomorphological patterns depending partly on the variations of the bottom slope. This gives a meandering pattern in the stretches with a slight slope, such as in the German course between the confluences with the Altmühl and the Isar, or downstream from the Hungarian town of Gönyü; a braided pattern occurs in the stretches with a higher slope, such as in the Austrian and Hungarian/Slovakian stretch.

The hydrological system of the Danube is very complex, due to its highly contrasting tributaries. The average discharge upstream from the Delta is 6500 m^3/s.

The major regulation works on the Danube were begun in the second half of the 18th century. Since then, the river bed, the bed load, the sediment transport, the hydrological system, the water quality and the connections between the river and its floodplain have been altered by continuous works developed for navigation, flood control, irrigation and power production purposes. In most cases, the result of these regulation works is a separation of an "active" floodplain still subject to flooding and a "fossile" floodplain which is no

Figure 1.2.a. - Vertical relations and exchanges between compartments of a hydrosystem (Trémolières).

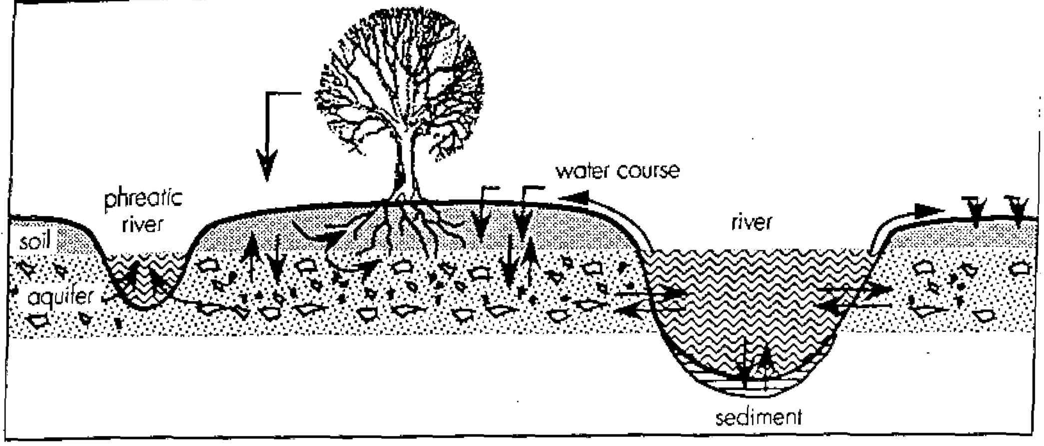
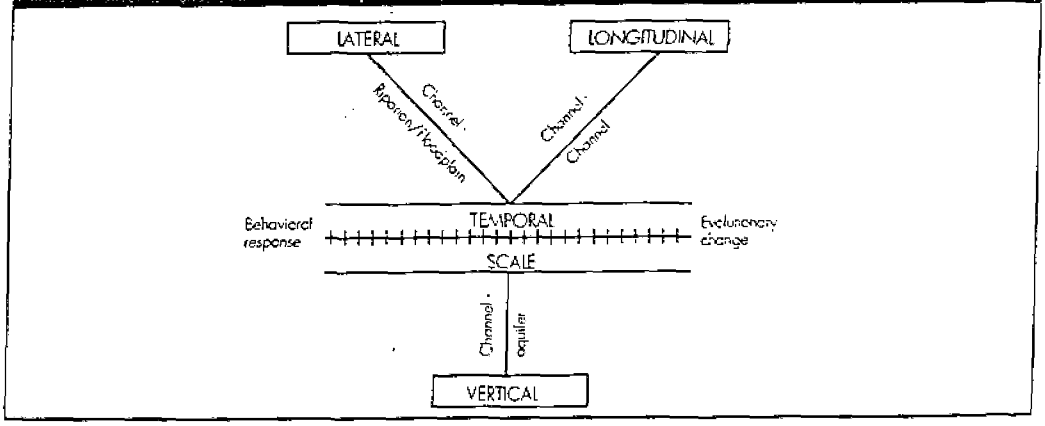


Figure 1.2.b - Schematic diagram of three-dimensional interactions in lotic ecosystems and their relation with the temporal dimension (Ward, 1989)



The periodic flooding of the alluvial flood plains conditions their richness and their diversity. Maintaining complexity and the dynamics of interactions within the lotic ecosystems is essential to their survival.

longer flooded. An other major outcome of rectification and straightening of the river is deepening of the river bed and sinking of the surface and groundwater levels. This is well documented in various Danube countries. Since the end of the Second World War, the Danube has been modified intensively in some stretches by the construction of hydroelectric plants. This is especially the case in the Bavarian and Austrian section.

1.2

WATER QUALITY AND NUTRIENT CYCLE

• WATER QUALITY •

The impact of regulating a river and its floodplain on the water quality mainly affect the water temperature and the ions correlated with primary production. In the main channel, the reservoirs act as thermal regulators (thermal regulation by the huge quantity of water, decrease in short-term and seasonal fluctuations) and as nutrient and sediment traps (suspended and particulate organic matter). The transport of nutrients, especially nitrogen and phosphorus, is often blocked in reservoirs. The physico-chemical dynamics of a regulated river are essentially controlled by the type of reservoir, the storage capacity, the position of the water outflow and the way it functions and the deep release outflow or underflow.

In the Mississippi River, during low flow, some authors note autochtonous nitrogen and phosphorus inputs from side arms and former channels to the main channel. During floods, the physico-chemical composition of the dead arms and main channel are similar. Regulation mainly affects the chemical composition of the main channel, but, depending on the exchanges between this channel and the other floodplain waterbodies, either the water quality of the river will affect the water quality of the floodplain environments, or the latter will act as refuges for the river fauna during disturbances (chemical and toxical pollutions). An example is given for a reach of the Mississippi River contaminated by PCBs.

Beside localised short-term studies, there is a well-established network of stations to monitor the quality of the Danube water. The study by Iwanow (1982) shows a slow increase in time of dissolved organic and inorganic compounds in the Danube. This does not seem to affect the river self-purifying capacity, which can be classified as ß-mesosaprobe. Due to the insufficient treatment of sewage effluents in some sections, there are local bacteriological problems. Nowadays the most acute problems are related to chemical pollution due to solvents, heavy metals, and radioactive waste, and especially to their accumulation in sediments.

Some localised work carried out in Czechoslovakia and Hungary show the prominent role played by floodplain channels connected with the Danube in oxygenating the river water.

• NUTRIENT CYCLE •

The complexity of the processes interacting in the floodplain makes it difficult to clearly define its role as a source or sink for mineral nutrients. In this respect the available data appear controversial, depending on the type of nutrient, the floodplain component and the relative position during the hydrological or seasonal cycle. However, it is agreed that flood waters entering the floodplain bring a substantial amount of nutrients with them, which are made available for plant growth and are partly responsible for the high nutrient level of alluvial ecosystems. The uptake of these nutrients by the floodplain vegetation represents a potential purification mechanism for the surface water of the river.

Through its flood waters or secondary arms, rivers provide a large quantity of mineral nutrients for the aquatic and terrestrial habitats of floodplains. Thanks to this supply, floodplains feature nutrient values which are always greater than or equal to those of temperate forests or non-fluvial humid zones.

In return, the assimilation of nutrients by the terrestrial and aquatic plants in the floodplains represents a means of purifying the river waters and the groundwater, i.e. of reducing the flow of nutrients which could increase eutrophication (nitrates, phosphates).

The effectiveness of this purification is a direct function of the type of plant life, i.e. it is linked to the diversity and organization of the plant formations. It has been shown that, on the Rhine, the terminal hardwood forest stage, which is the most complex and highly structured, is also the most efficient in purifying groundwater. In general, the quality of groundwater is improved when it circulates under a forest, and when it is separated from a polluted and/or eutrophic river by a strip of forest - the wider the better.

Purification efficiency also depends on the capacity of the water to circulate inside sediment. Here again, hydrologic fluctuations ensure sediment permeability by periodic scouring.

Surface waters, for their part, undergo optimum purification in areas where the side arms provide calm zones conducive to the development of aquatic and semi-aquatic plants and/or phytoplankton which actively use the nutrients. This effect is greatly amplified if the complexity and meandering of the secondary arms increase the time during which the waters circulate through this biological filter.

In addition, floodplains play a regulating role in the organic matter cycle: by ensuring a staggered supply for rivers, floodplains contribute to the efficiency and regulation of the organic matter cycle.

1.3

ORGANIC MATTER CYCLE AND BIOMASS PRODUCTION

• FLOODPLAIN HABITATS: HIGH BIOMASS PRODUCTION •

Two features rank floodplain ecosystems among the most productive:

- In these systems, the land-water interface zones are graded. Yet the land-water interface is always the most productive zone per surface unit along the gradient ranging from land to open water.
- The fluctuating nature of these interfaces, linked to alternating phases of immersion and drying up - the "moving littoral" concept - promotes this high metabolism. The absence of stagnation allows rapid recycling of the organic matter and nutrients, thus enabling higher productivity than would be found under stable terrestrial or aquatic conditions.

High productivity has been clearly demonstrated in the aquatic habitat as regards plankton and fish farming production in the secondary arms.

Numerous research studies conducted on the Danube floodplains of Slovakia have demonstrated:

- The contribution of secondary habitats to the productivity of the main watercourse by exporting a large plankton biomass produced in the calm habitats of the floodplain.
- The positive and direct correlation between frequency and duration of floodplain submersion periods and fish farming productivity.

Here again, it is the connection between the components of the fluvial system and their fluctuating hydrological nature which enables the circulation of the organic matter produced, regulation of its flow, and optimum use.

• ORGANIC MATTER CYCLE AND PLANKTON PRODUCTION •

Fluvial wetlands appear to be among the most productive ecosystems. This can be related to:

- The increased in land-water interfaces which characterise these systems, these boundaries have been proved to be the most productive zone along the land-to-water gradient.
- The fluctuating nature of these boundaries (moving littoral), which encourages a very active mineralisation and recycling of organic matter and hence a higher productivity than in more stable aquatic or terrestrial conditions.

Initial results obtained from forested floodplain systems on the south-east coast of the USA show:

- The quantitative importance of organic matter inputs from the floodplain into the river. These inputs outweigh the primary production of the river and are of the same order as inputs from the upstream watershed. They represent a substantial food source for river communities.
- The qualitative role of the floodplain as a buffering structure which regulates the organic matter cycle, either directly by providing snags which hold back the coarse organic particles and slow down losses caused by downstream exportation, or indirectly by postponing the major release of organic matter into the river (i.e. autumn litter) usually until the spring floods.

• BENTHIC INVERTEBRATES AND FISH PRODUCTION •

The production and the biomass of the main channel are greatly influenced by inputs of fauna (plankton, macro-invertebrates, fish juveniles) and nutrients inputs from side arms and former channels. Studies in the Upper Mississippi River and the Rhone River show the role of producer, then distributor caused by the drift of these environments.

The fish production of the fluvial wetlands and floodplain waterbodies is highly correlated to periodic flooding. Numerous studies carried out in the braided side arms of the Slovakian Danube give figures and estimations on this subject. These studies show the dispersive role of the side arms into the river during high waters, and the reservoir role played by former channels and lentic water-bodies for fish which have not drifted.

It is important to maintain these connections because, if the water-bodies are too isolated and flooded too sporadically, their biomass and production will be low. Studies of temporary and permanently connected water-bodies in the Rhine and Rhone floodplains show the higher biomass and diversity of the latter.

• BIOMASS PRODUCTION IN THE DANUBE •

Research carried out in Hungary and Czechoslovakia especially provide quantitative data on the productivity of the Danubian aquatic ecosystems.

A number of measurements of the phyto- and zooplankton productions in the Danube side-arms provide quantitative evidence of the very high productivity of these biotopes and their contribution to the productivity of the main channel when the plankton is washed out of the floodplain channels during flood recession.

The high fish productivity of the Danube floodplains is related to periodical floodings. Several authors document the linear relationship between the duration of annual submersion and fish production in the floodplain. In the Slovakian stretch of the floodplain, an increase of 1 cm in the average water level induces an increase of 500 kg in the fish production that year and of 300 kg in subsequent years.

1.4

LIFE CYCLE OF AQUATIC SPECIES

• FLOODPLAINS: A VITAL HABITAT FOR NUMEROUS AQUATIC SPECIES •

For many species of fish and certain species of aquatic invertebrates, the aquatic habitat of the floodplain can play a triple role:

- A key role for the vital cycle of species which reproduce there: their alevins are later dispersed in the main channel during high waters, and as the result of connections between the main channel and secondary habitats.
- A feeding role, making it possible to exploit the abundant resources of the aquatic and terrestrial habitats flooded by river species.
- A role of refuge in the case of disturbances (heavy flooding, pollution) in the main channel: individuals seeking refuge in secondary habitats can later recolonize and re-establish populations in the main channel.

These functions are closely linked to the hydrologic variations in the system.

• LIFE CYCLE OF AQUATIC INVERTEBRATES •

As in the case of fish, the known migration patterns of two mayfly species (*Leptophlebia cupida* in Canada and *Parameletus chelifer* in Sweden) provide evidence that floodplain water bodies connected with the main channel can be vital stages in completion of the life cycle of some invertebrate species. In these two cases, the aquatic floodplain biotopes are known to provide either a temporary shelter from severe flow conditions in the main channel, or better temperature and food conditions, allowing faster growth.

When the whole biotic community is considered, side channels or temporary inundated areas provide potential sources for recolonisation of the main channel after severe disturbances have occured here, e.g. floods shifting the river bed sediment. This case is exemplified by a study of post-flood invertebrate drift in a side channel of the Durance River, France.

• LIFE CYCLE OF FISH •

If the diversity of aquatic and semi-aquatic habitats is necessary for completion of the life cycle of numerous fish species, it is also needed to provide a refuge during disturbing events such as floods, reductions in discharge and pollution inputs.

Periodic phenomena such as floods, low flows and physico-chemical cycles are the keys to good biological functioning of the floodplain. These needs are exemplified by the study of fish migration in a sector of the Morava River floodplain.

• LIFE CYCLE OF AQUATIC SPECIES IN THE DANUBE •

The importance of floodplain biotopes for the life cycle of fish species has been thoroughly studied in the Austrian and Slovakian sectors.

The side arms connected with the main channels act as dispersal outlets for fish during high water periods, whereas the more isolated water bodies can function as stock sites. The temporary inundated zones can be used as reproduction and feeding grounds for some species which migrate to these zones during high water periods. There is a clear association between certain types of alluvial habitats and some groups of fish species, for both adults and juvenile stages.

1.5

BIODIVERSITY

• ALLUVIAL FLOODPLAIN AND BIODIVERSITY CONSERVATION •

The fundamental biodiversity of floodplain ecosystems - terrestrial and aquatic - and their biocenoses mainly result from three types of dynamic forces:

- The intra-annual hydrological dynamics which results in alternating flooding and drying up.
- The geomorphological dynamics of the river, which on a scale of decades and centuries renew diversified terrestrial and aquatic biotopes.
- The dynamics of plant successions: in this case, they are largely triggered, directed or interrupted by the two previous forces.

The diversity of European floodplain forests is a telling illustration of the result of these dynamic forces. The plant density is reminiscent of some of the structural features of dense tropical forests. Their dendrological richness (50 species of trees and shrubs) and specific diversity are remarkable in comparison with non-floodplain temperate forests (diversity index of 0.6 to 0.8 for the latter, and greater than 3 for floodplain forests). This explains a number of remarkable features such as continuous flowering from January to October. The number of species flowering at the same time is twice as high as in non-floodplain forests.

The existence of sufficiently violent hydrological disturbances is what enables younger stages to be constantly renewed (softwood forests). In terminal hardwood forests, the juxtaposed mosaic of different phases (young plants, regeneration, maturity, senescence and death) guarantees the biodiversity and long-term survival of the entire ecosystem.

In the aquatic habitat as well, the cohabitation or juxtaposition in small areas of animal populations with highly diversified ecological needs and biological strategies is made possible by the presence in the floodplain of diversified geomorphological forms and active hydrological dynamics.

Lastly, a few points should be emphasized concerning the value of floodplain systems with regard to preservation of biodiversity:

- In their original state, floodplain valleys were used as corridors or preferred paths for the migration and movement of animal and plant species (transportation provided by water, longitudinal continuity of wooded formations, warm and humid microclimate).
- The large floodplain valleys with their relatively warm and humid climate represented a refuge for a large number of tertiary plant species

during the glaciations. That is why floodplain forests currently offer a wealth of tertiary relics.

- Under certain geomorphological and hydrological conditions, former river channels can comprise actual "biotopes of mountains transposed in a plain". They ensure the survival of cold water fauna and plant life which is very pure, relics from the ice age. These are Salmonide biotopes of great biological value.
- According to recent research on the biology of Coleopteres Carabidae populations which are typical of land-water habitats, the river dynamics responsible for the constant creation of new habitats (gravel banks) could be one of the driving forces of the speciation processes within these populations.

• BIODIVERSITY OF BENTHIC INVERTEBRATES IN DIFFERENT AQUATIC ENVIRONMENTS •

Floodplain aquatic and semi-aquatic ecosystems support rich and diverse communities, not only because they encompass the whole range of aquatic conditions from flowing to standing and semi-aquatic waters, but also because specific geomorphological or hydrological features create floodplain-specific gradient or boundary conditions which allow the overlap of otherwise distinct types of faunal assemblages. One example is the Rhone floodplain and its tributary, the Ain river, in France. The high amplitude of hydrological fluctuation in a set of former meanders of the Ain river provides optimum conditions for the coexistence over a short time period of ecologically highly contrasted aquatic beetle assemblages. We propose relating this type of diversity to the "intermediate disturbance hypothesis" which accounts for the high biodiversity of ecosystems undergoing intermediate levels of disturbance (here floods or drought conditions) enhancing the productivity of the system and the coexistence of otherwise competitive species. From the point of view of a whole floodplain sector, a more traditional example is given of how the diversity of former channel types supports a high range of invertebrate community types, not only in the surface water, but also in the groundwater component of the alluvial plain. The lack of objective, comparative methods to evaluate the biodiversity and functional diversity of floodplain systems is stressed, especially when relating this parameter to different taxonomical units or assessing it for different types of wetlands subject to various types of human alterations.

The physical factors are determinant, according to the quality, quantity and stability of the benthic invertebrate communities in a regulated hydrosystem. Different studies of the Missouri, Rhone, Mississippi and Volga rivers show that there is higher diversity of species in the unembanked parts of these rivers compared to the embanked ones. This is due to the reduced diversity of the substrates (habitats) of the latter. The banks, ecotones between terrestrial and aquatic (interstitial and potamic) environments, play a very important role in the colonization processes. The vegetal habitats (macrophytes) and mineral habitats of eroding environments connected permanently to the river (lotic side channels, wing dikes and embankments of the main channel) have higher numbers of individuals than mineral habitats in silting environments and vegetal semi-terrestrial habitats, which indicate the evolution of the water-bodies towards terrestrial stages by siltation (backwaters).

• BIODIVERSITY OF FISH IN DIFFERENT AQUATIC ENVIRONMENTS •

The taxonomic diversity of fish increases from upstream to downstream as habitats becomes more diversified, that is, the floodplain increases. The positive correlation between the structure of fish communities and the increase in the stream order is a good indicator of geomorphological and hydrological changes along the longitudinal continuum. The structure of fish communities can also reflect the disruptions to which the hydrosystem is subjected (disappearance of backwaters and former channels, disappearance of islands and shingle shores). This is demonstrated by examples from highly regulated rivers in the U.S.A., such as the Missouri and the Mississippi rivers. In these rivers, numerous original lotic species have been replaced by exotic species and the emergence of littoral and pelagic planktonophage species which usually constitute a minor share of fish assemblages in unmodified reaches.

In regulated European rivers, such as the Rhone, Rhine and German-Austrian Danube, fish communities are dominated by some species which represent 80% or more of the absolute abundance. The structure of these communities has shifted to communities of limnophilic cyprinids, and from phytophilous spawners (floodplain spawners) to mainly lithophil species (main channel spawners).

Thus, the diversity of fish species is highly correlated to habitat complexity. The higher the lateral dimension of a hydrosystem, that is, the more diversified and accessible the aquatic and semi-aquatic areas are, the more variable the community structure will be, that is, the richer the species will be. The same will be true for benthic invertebrates.

• BIODIVERSITY OF THE AQUATIC ECOSYSTEMS OF THE DANUBE •

In 1967, 103 fish species were recorded in the Danube. This can be compared with 40 and 61 for the Rhone and the Rhine respectively. This taxonomic richness can be related to the number of endemic species and to the remaining high diversity of floodplain biotopes. However, the local structure and distribution of the fish communities reflect the impact of human modifications of the system, such as in the German-Austrian section. Furthermore, the Iron Gates plant has stopped the upstream movement of migratory species.

1.6

FLOODPLAINS: A FLOOD PROTECTION SYSTEM

Floodplains are natural systems for reducing the spread of floods and decreasing their strength. Two factors come into play: the roughness of the plant formations on the riverbanks, which slow water speed, and the room to expand provided by the floodplain areas connected to the river.

Conversely, concentration of the flow in a narrow channel increases the strength of the flooding river.

The consequences of the development of the Rhine are particularly eloquent. The "original" Rhine included 1,600 islands between Basel and Strasbourg. River training (1864-1876) carried out to protect the land from flooding, river regulation (1907-1939), designed to improve navigating conditions, and hydroelectric harnessing (1928-1977) shortened its channel (32 km between Basel and Lauterbourg) and triggered incision of the river bed (5 m at Rheinweiler and 7 m at Nuremberg in 1950). The faster flow and loss of 130 km^2 of retaining floodplains (60% of the initial flooding zone) increased the risk of flooding downstream. As a result, the frequency of a flood flow rate of 5,000 m^3s^{-1}, which was 1/200 years in Karlsruhe, is 1/60 years today. Furthermore, the flood front, which once took 65 hours to travel from Basel to Karlsruhe, now takes 30 hours. In addition, it cumulates its effects with those of the Neckar, Main and Moselle flood fronts, which used to run ahead of the Rhine flood front.

1.7

ECONOMIC VALUE OF THE ALLUVIAL FLOODPLAINS

The economic value of the alluvial floodplains is linked to their exceptional diversity and productivity. However, it is difficult to evaluate because the alluvial zones have vanished along the Western European countries and in Eastern Europe, it is still impossible today to obtain reliable economic data from the past.

Nevertheless, communities of professionnal fishermen, which can no longer be encountered in the rest of Europe, still exist in the alluvial zones.

Forestry exploitation is particularly interesting in these highly productive alluvial zones. In the Gemenc, production in 1992 will amount to 115,000 m^3.

Up until recently, commercial tourist hunting was a very important source of currency, especially in the Gemenc and the Kopacki Rit. The development of an ecotourism along the same lines as that which is to be developed in the Danube delta Biosphere Reserve could replace advantageously hunting.

1.8

FLOODPLAIN ECOSYSTEMS: DISAPPEARING HABITATS

Due to successive land acquisitions, river training and dam construction over the past century, floodplains are currently a disappearing habitat on a European scale. The decrease in the surface area of the Rhine floodplain forest is spectacular: from an "original" surface estimated at 100,000 ha, only 20,000 ha remained in 1840, and 7,000 ha today, and more than half of which consists of plantations.

The first to be affected are floodplain forests. The damage done by modern silviculture, which tends to simplify the forest structure by eliminating undergrowth, and whereby foreign varieties of trees are introduced and clear felling is practiced over vast surface areas, has greatly reduced the surface area of natural forests. The removal of senescent and dead trees has impoverished the fauna and flora, already weakened by the use of pesticides. The naturally structured forest decreasing surface area (99% since 1800) considerably alters the overall functioning of the floodplain system. Forests older than 250 years are extremely rare in Europe, and floodplain forests of that age are even rarer. In Europe, only a few hectares remain on the banks of the Morava, a Czech and Austrian affluent of the Danube. In our latitudes, the loss of old forests has inestimable consequences on the forest's gene pool. The decrease in floodplain zones also affects areas which are flooded either temporarily or permanently.

When these types of habitats are not destroyed, they are greatly modified. One of the most classic examples is greater isolation of the larger part of the floodplain by dikes. This creates a "fossil" floodplain which is no longer in contact with the surface waters of the river. A reduced "active" portion remains, often very narrow along the river and greatly fragmented longitudinally. This situation is often encountered on the Rhine and the Danube.

Experience shows that regulation installations cause residual zones to disappear by disconnection and regulation of the water level in addition to direct destruction of the alluvial zones flooded by damming.

Development of rivers, and particularly damming up of the minor river bed, cuts off the river from its alluvial plain.

Regulation of the river causes the alluvial floodplain ecosystem to dry out and die off downstream of the dam; upstream, it causes death by flooding.

Finally, and this is probably the most serious but also the most difficult impact to control, regulating the river causes it to subside in its bed, bringing about simultaneous deepening of the ground water. This phenomenon, called incision, is particularly serious downstream of the Austrian dams on the Danube, where subsidence reaches 1,5 meter deep. The consequences are even more serious for the alluvial zones which are literally dried out and for capting drinking water systems.

During the two years which the Equipe Cousteau and its partners have spent studying on the Danube, the situation of the great alluvial plains suddenly worsened.

The violent drying out of the large alluvial zone of the Hungarian Szigetköz and the Slovakian Csallököz (around 29,000 ha) caused by re-routing of the Danube in order to fill the Gabcikovo dam is a warning which the international community, for its own sake, must heed.

The Gemenc alluvial forest is now the last great alluvial zone of the Danube to have remained intact. It has recently been classified as a wet zone of international significance under the Ramsar convention.

Nevertheless, the Gemenc is not totally unscathed. Quite the reverse, like all alluvial plains along developed rivers it is gradually drying out.

What is more, the present developments of the Danube (not to mention the impact of the Gabcikovo dam) have causes an average subsidence of 1.5 metres. The ground water level has also decreased by 1.5 metres and floodings are less frequent and less extensive than before.

Drying out must be stopped if we do not want the Gemenc alluvial forest to die.

RECOMMENDATIONS

The alluvial zones of the Danube basin constitute a unique heritage in Europe which is necessary to the life of the river and to the quantitative and qualitative upkeep of the groundwater tables, and consequently to the quality of drinking water. Today these alluvial zones are very seriously threatened and may be lost altogether if we do not take immediate action to conserve them. Such measures must be taken at both a local and international level.

• Study and restoration of an exemplary area: the Gemenc in Hungary

The Gemenc area is relatively simple from the viewpoint of its geomorphological history and its hydrological functioning, particularly when compared with the *Szigetköz area*, in Hungary, for example. Also, it does not feature any major facilities (hydroelectric dams, locks) nor cross any international borders.

Despite this simplicity, the area contains a wide diversity of aquatic, *semi-aquatic* and terrestrial habitats representing most of the floodplain habitats encountered in middle european meander plains.

The ecological problems raised in this area are representative of situations encountered to varying degrees, not only in other Danubian areas, but also on the other large Middle European rivers, i.e. excessive exploitation of *natural* resources by man, falling water line and resulting drying up of the floodplain.

There is a regional readiness to reach a compromise between *socio-economic and ecological* constraints for integrated management of the Gemenc area. A detailed analysis of the area's hydrology and its changes since the beginning of the century has already been conducted. Furthermore, an initial program to study the physicochemical properties of the water at certain sites, *and to install piezometers to study* fluctuations in groundwater levels, has recently been undertaken at instigation of Equipe Cousteau and Pr. Zsuffa from the Baja University.

This study should be followed by a 4-phase long-term programme:

- Phase 1: analysis of *current* condition prior to intervention, provisional diagnosis (duration 1 year).
- Phase 2: development of an *action plan and an ecological* management plan.
- Phase 3: execution of *reinstatement* works.
- Phase 4: monitoring of reinstatement *procedures (minimum duration* 3 years).

The aim of this revitalization programme consists not only in *understanding the mechanisms of* water discharging in the alluvial plains but rather in restoring integrity of the ecosystem.

An inventory needs to be compiled of the *fauna* and *flora in the* region in order to understand how the current ecosystems function. This inventory may then be included in the larger programme launched by the IUCN *in order to* compile a biodiversity inventory of the Danube basin.

Given the piecemeal information *currently available on the Danube* alluvial ecosystems and fluvial incision problems in general, from both a geographic and thematic viewpoint, the Gemenc study and *revitalization project* offer the possibility of comprehensive research which would lead to a better understanding of the consequences of the phenomena involved *to test solutions combining* economic and socio-economic *factors*.

• Creation of a green corridor

Protection of the Gemenc alluvial forest alone would not make it possible to preserve the genetic heritage of the vegetal species along the Danube in the long term. Genetic diversity is necessary for the survival of species.

RECOMMENDATIONS

For plants, the only way to maintain this diversity is to multiply intraspecific exchanges between natural zones.

To do this, we propose creating a diffusion corridor between currently isolated natural reserves. This is the necessary accompaniment to redevelopment of the Danube banks. A certain number of protective dikes must be moved further out, at least several hundred meters on either side of the minor bed, so that they are at least in line with the major bed which corresponds to the average annual flooding.

• All relations between the alluvial plain and the river bed must be maintained

No new channelization is needed, nor any rectification of the river bed; the connections between the secondary arms and the main channel of the river must be kept. It would be advisable to reinstate connections between the main river channel and the secondary channels by destroying certain groynes as part of our proposition for restoration of the Gemenc alluvial forest.

River flow irregularities must be maintained. High-low water alternations are vital. The construction of any new dam must therefore be shelved.

• Which management for these alluvial zones

Ecotourism can be a source of reserve financing. However, it must be strictly managed by natural reserve protection institutions. The type of management we have proposed for the Danube delta can serve as an example.

• International protection and world heritage

The wet zones of the Danube constitute a unique heritage for future generations, the responsibility of which is not merely of national interest but of international importance.

The patrimonial value of the alluvial ecosytems alone justifies their conservation by the international community.

The Convention on Biological Diversity signed in June 1992 at the Rio Conference clearly showed the need to preserve not only the plant and animal species as units of the biodiversity bases but also the ecosystems and their dynamics. It has also been admitted that the possible absence of scientific arguments is not a sufficient reason for postponing protective measure to conserve this patrimony. Thus conservation of the mid-European alluvial ecosystems and their restoration are a vital issue for Europe. These ecosystems are the most complex and most highly organized ever to be found in our climatic zone. The river must be given sufficient freedom to generate a mosaic of diverse ecosystems. The conditions for this freedom must be then consolidated, limits on lateral movement of the river reduced and hydrological fluctuations and sediment availability maintained.

The Danube alluvial zones must therefore benefit from classification by international institutions: Ramsar Convention for the wet zones of international importance, and Unesco for Worldwide Heritage and Biosphere Reserve label.

• International financing

Given the financial interests involved, particularly now that the Eastern European countries are opening up to the free market, these classifications need to be reinforced by international financial aid. This could be done by "swapping" the foreign debt for alluvial zone protection. This type of financial aid has already saved a large number of threatened areas by having foreign trading partners swap part of the foreign debt for their protection.

2
THE DANUBE DELTA

The Equipe Cousteau has been conducting its field studies in all the countries along the banks of the Danube, cooperating with scientists and officials as well as inhabitants, to address the issue of how the Danube should be utilized. The question is especially crucial in the delta as it is affected by all the disturbances to which the river and its tributaries have been subjected, and under pressure from totally diverging interests.

At the present the Danube delta is an exceptionally rich natural zone, in spite of the sometimes severe changes that have occured in places. The immense size and impenetrability of the reed beds, still intact, and the "plaur" (floating reed islands and decomposing vegetable matter) guarantee the best protection for the fauna, and in particular, the remarkably abundant birdlife.

The delta is the last European delta ecosystem of such scope and richness. It is essential for migratory birds. The migratory birds of Northern Europe fly over this area in tens of thousands on their way to Africa where they spend the winter. Birds from Africa come to the delta in the summer to breed. The pelicans' breeding ground must be designated as a strictly protected area.

The Danube delta records and concentrates all the disturbances that the river and its tributaries have endured. It is a privileged area for monitoring the evolution of the life of the river and the quality of the water.

The Equipe Cousteau teams spent several weeks in the heart of the delta, both in winter and in summer, to complete their study. They used all available means (helicopter, Zodiac, rowboat...), to explore those areas of the delta which are the hardest to reach. They had numerous meetings with local people and paid special attention to their vision of past and future changes in their region. The methodical grid-pattern helicopter survey of the delta played an essential part in the generalization of accurate but selective field-collected information. Through aerial observation we were finally able to ascertain the state of some areas which were either inaccessible or so remote that they could not be visited.

The Equipe Cousteau has paid particular attention to proposing a management plan which will enable the inhabitants to have a decent standard of living by benefiting from the wealth of this exceptional patrimony recognized as such by the international community, while at the same time preserving it. The work has been carried out in close cooperation with the delta inhabitants, Professor Vadineanu, Secretary of State for the Environment, Romania, Mr. Gomoiu, Manager of the Biosphere Reserve, and IUCN representatives. The management plan was presented at the Bucharest conference organized by the Commission of the European Community and the Romanian government on "Tourism and Conservation of Deltas". Our proposals are largely drawn from the final recommendations.

2.1
GEOGRAPHICAL CHARACTERISTICS

The Danube delta, which covers 591,200 ha, is the widest and the richest wet zone in Europe after the Volga delta. The delta and the banks of the Black Sea representing 679,000 ha were designated a "Biosphere Reserve" by the Unesco. In 1991, 312,440 ha, i.e. 53% were designated "World Heritage"; the delta has been declared a "wet zone of international significance" under the Ramsar Convention.

2.2
HUMAN IMPACT

In 1990, the delta's population amounted to 15,600 inhabitants spread out over 28 villages. The density is 2,6 inhabitants per km^2. However, man has not altered the area uniformly: some zones have been greatly affected whereas others have remained untouched. On the other hand, the human impact has been very different whether it concerns for food or a quasi-industrial activity, therefore of national concern.

Food production activities, mainly agriculture and fishing but also traditional hunting, have not affected the delta ecology not only because the density of the inhabitants is low and because these activities are not widespread, but also and above all, because their aim is not large-scale commercial development.

Development of the Sulina channel, in 1990, and the Saint George channel as well as the sinking of the transverse channels to connect the lakes to the main channels have considerably modified the natural water discharge. The sedimentation and the natural percolation of the water through the reed-beds have been greatly altered affecting not only the Danube delta but also the coastal area along the Black Sea.

The polder surface area altogether is about 36,000 ha, i.e. about 8% of the delta area.

- Sireasa to the west: 6,000 ha
- Pardina to the north: 27,000 ha
- Rusca: 3,000 ha
- Smaller agricultural zones are to be added to those above: Sulina and all those recovered to the south of the area upstream of the Saint George branch, from Tulcea to Dunavatu.

All the polder farms have gone bankrupt, not only because yields have never reached expected levels but because most polders become unproductive because of salinization problems.

The overall surface area which has been turned into piscicultures is similar to that of the polder area in that it is very difficult to estimate accurately as data are considerably varying: there may be 32,000 ha in all, about 7% of the Romanian delta surface area. The following fish farms: Fortuna (2,500 ha), Grindul Stipoc, Chilia Veche, Caraorman, and the one to the north of Crisan (about 3,000 ha), seem to be still operating today but it is difficult to ascertain their results in any detail.

The large fish farms of Popina (8,000 ha) and Dranov (5,000 ha), however, seem to have been abandoned. Official reports confirm that these giant farms have failed and show a loss of several million lei per year (no further details are available).

Two zones are regularly cut: Uzlina Gorgova (2,500 ha) and the zone between the Sulina branch and the meander the furthest upstream from the old Danube, around Obretinu Mare lake. The present situation of the Periteasca zone which has been proposed as a strictly protected area its present situation is very poorly defined.

Reed exploitation reached its climax in 1963, when the yearly crop was about 226,000 tons. However the mechanical destruction of rhizomes by reapers and the insufficient nutrient supplies in polders which are no longer flooded, have caused production to drop to 33,000 tons.

Industrial navigation stands apart because although it does not directly involve local communities, it produces very pronounced changes, i.e. the rectification and channelization of branches. It also allows veiled threats to hang over the future of the biosphere reserve if it is further developed. The accident involving the Russian ship "Rostock" on 3rd September 1991 in the Sulina Channel serves as a reminder. This accident occured near the village of Partizani and could have caused an environmental catastrophe if it had been full of oil or had been carrying toxic substances. This warning must be taken into account in the legislation to preserve the biosphere reserve.

In 1989, 2,327 boats carried 5.2 million tons of cargo along the Sulina Channel. The port of Galati, the largest port on the Danube, deals with the majority of traffic (15.2 million tons). The Ukrainian port of Reni on the Chilia branch comes second with 12.6 million tons. Tulcea is far behind with 1.4 million tons (2/3 from the Black Sea). Traffic is mainly local, i.e. raw minerals, ferrous and non-ferrous metals. The outgoing freight (2.5 million tons on 1,205 boats) equals the incoming freight (2.7 million tons transported by 1,122 boats).

It is to be noted that more than half of cargo (about 6 million tons) that are off-loaded at Galati goes through the Constanza - Cernavoda Canal.

RECOMMENDATIONS

The alluvial zones of the Danube basin constitute a unique heritage in Europe which is necessary to the life of the river and to the quantitative and qualitative upkeep of the groundwater tables, and consequently to the quality of drinking water. Today these alluvial zones are very seriously threatened and may be lost altogether if we do not take immediate action to conserve them. Such measures must be taken at both a local and international level.

• Political driving force and legal framework

The Biosphere Reserve Authority will have to ensure that relations between local people and all those involved in developing and managing the delta remain on a human scale, so that this unique European natural area will continue to develop harmoniously.

The delta is sufficiently large for the creation of strictly protected areas and inhabited zones for people interested in the development of the reserve. The inhabited and working zones should preferably be isolated by buffer zones in which traditional activities and crafts and moderate tourism would be possible, rather than protecting the natural zones by buffer zones. The philosophy is not the same for each approach: in one, man is tolerated in the reserve because he lives in a traditional way in the delta; in the other, the nature islands are protected against economic development and tourism that would otherwise threaten them with all kinds of pollution.

However, all the efforts made by the Romanian Environment Ministry and the international community to find the necessary balance between environment and development and enable the inhabitants of the delta to have a decent standard of living while preserving the wealth of the Biosphere Reserve, will be vain if the Romanian government does not set up the necessary legal framework for application of the management recommendations.

• Strictly protected areas: passive protection

The Romanian Government has suggested a certain number of zones that have been chosen for the diversity of habitats they cover and their abundant birdlife. These choices seem perfectly justified.

Nature is tough. She quickly takes back abandoned cultivated areas and fish farms. If a certain number of channels which provide access to bird breeding zones are no longer maintained, they will very quickly become impenetrable. Difficulty of penetration and inaccessibility to certain zones must be maintained. In this way the delta will recover a large part of its wealth and will protect itself without any unnecessary outlay.

Generally, apart from the pelican breeding area to the north of Lake Merhei, the suggested zones appear to be too easily accessible and, more importantly, are criss-crossed by numerous channels navigable by motor boat. This situation requires very strict control, which is much more difficult to enforce than if they were naturally inaccessible. Inaccessibility is the best guarantee of strict protection of these areas. Strictly protected areas should be placed under scientific control and the care of officially appointed wardens. Only scientists who are in charge of monitoring the ecosystem, and birds in particular, would be able to enter these zones occasionally for regular observation, according to a schedule that would be defined and monitored by the Danube Delta Biosphere Reserve Authority.

In addition to the zones suggested by the Romanian Government, we think it important for the Lake Dranov region to be considered a strictly protected area. Not only do pelicans go there to feed in peace, but it is also a well-protected area, since access to these zones is naturally difficult. And finally, as the fish farming has failed, there is nothing to stand in the way of rehabilitating the entire area.

• Buffer zones

Buffer zones must surround the already existing inhabited and economic zones. They correspond to areas that are neither economic zones nor strict reserves. Only traditional activities and crafts as well as moderate tourism will be tolerated. Access will be by rowing boats or low power motor boats.

However, certain canals that link villages and remote economic zones cross the buffer zones. Only inhabitants who have a permit issued by the Danube Delta Biosphere Reserve Authority will have the right to travel on these canals by motor boat. The speed will be limited to 5 knots to avoid any disturbance.

The only way of penetrating the delta is by river, and this must remain so. There must be no bridges and no new roads.

• Economic zone

All zones that are regularly served by motor boat carrying passengers and cargo must be considered economic zones.

RECOMMENDATIONS

Large scale work has disturbed the delta. This is why we suggest setting a maximum limit on large scale activities and buildings.

All new industrial economic activities must be forbidden. The present economic zones must be maintained but not expanded. Zones where there is economic activity and traffic at the present must be carefully delimited. They will not be able to extend beyond their present limits.

Moreover, fish farming and agricultural zones which are not viable should be rehabilitated. If large polder farming is not abandoned it must prove its profitability over a 5-year period (enough time for climatic variations not to interfere with the experiment).

It would seem very reasonable to rehabilitate these last two types of zones. Pelicans have already chosen the Dranov pisciculture region as a feeding zone because of its peacefulness.

The natural water flow must be re-established by destroying the dikes surrounding the large-scale fish farms (those in Popina to the North-East with a surface area of 8,000 ha and in Dranov - 5,000 ha) and the polders which have failed.

In any event, cutting new channels must be prevented and cutting channels parallel to the littoral must be stopped or the delta hydrology, which has already been sufficiently disturbed, will be altered even further.

Reinstating the natural flow of the water will have three beneficial results:

- Better distribution of the sediment and nutrients coming from too many fertilizers transported by the Danube and used in the polders, with the resulting reduction in eutrophication.
- Renewal of anoxic water in the closed, or slightly open branches and lakes which increasingly prevent life from developing.
- Opening up of zones conducive to delta fish breeding.

Reasonable reed cutting does not seem to harm the delta ecology. Reed is a renewable resource which can be profitably harvested provided it does not extend beyond the two zones (Uzlina-Gorgova and Sulina) and that it is done without machines which are destructive for the ecosystem. A time limit for cutting should be defined so as not to disturb the first nesting species. Finally, the true advantages and consequences for the fauna of large scale stubble burning at the end of winter should also be studied.

- Delta inhabitants

More importantly, the Biosphere Reserve cannot be created without the help of the delta inhabitants who must be directly involved in its development. In order to achieve this, their traditional activities must be preserved and they must also benefit from the tourism linked to the richness of the reserve. The inhabitants must therefore be offered training and the preferential status of tourist guide or officially appointed warden; above all, tourist accommodation in the inhabitants' homes must be encouraged.

A legal framework must be created which favours the life of the delta inhabitants whilst preventing any large-scale changes likely to disrupt the ecology of the delta. The geographic extension of human activities must be prevented and construction in zones that have already been developed (main roads, existing villages) must be limited. The development of large tourist complexes that would go against the interests of the reserve and particularly those of the inhabitants, must be prevented.

A status for the delta inhabitants is essential if the classification into different zones is to be effective. Their ancestral property rights, their fishing rights, and, in general their traditional activities in the buffer zones must be preserved. To do this, the inhabitants must have a status that allows them to practise, within limits, activities which would be forbidden to non-residents.

With this aim in mind, everything must be done to interest the delta inhabitants and to involve them directly in the life of the delta. Traditional human activities have a negligible impact on the delta ecology. The inhabitants would more easily accept to live in a biosphere reserve if they are directly concerned by compensatory measures: tourist accommodation, tourist guide or reserve warden jobs.

The economic activities in zones set aside for this purpose do not pose any real problem provided their extension does not threaten the buffer zones around them. The same cannot be applied to economic activities in the buffer zones. These buffer zones must be even more strictly controlled to promote improvement of the existing habitat, rather than new constructions.

This policy has all the advantages from an economic and environmental point of view: inhabitants who benefit from tourism (rented rooms, guides, etc.) will be the

RECOMMENDATIONS

most enthusiastic supporters of the protection of their reserve. On the contrary, large hotels will bring nothing to the delta inhabitants.

This improvement in the habitat must have two priorities:

- Drinking water. It may be necessary to install earthenware or porous stone filters so that water from the delta can be used. Setting up a local network for the distribution of drinking water must perhaps be considered.
- Waste water. The seasonal increase in the number of inhabitants is going to create a big sewage and plumbing problem as it does in all areas where tourism is developed. Sewage disposal and treatment for a greater number of inhabitants than today must be contemplated.

• Controlled tourism

Well-organized tourism tempered with lodging with the locals must be promoted if uncontrolled tourism is not to take over as well as large structures which drain local resources without any profit for the delta inhabitants.

Tourists staying in the delta, be they Romanian or foreigners, could explore the buffer zones with a guide travelling in rowing boats outside canals navigable by motor boat. Apart from special dispensation granted by the scientists in charge of reserve management, bivouacs and camping will not be authorized in the buffer zones i.e. outside zones designated for economic activities. This means:

- Encouraging lodging with the locals. This entails financial incentives for home improvements so that the inhabitants can offer a minimum of comfort to tourists: comfortable rooms, sanitary facilities.
- Organizing lodging with the locals. This means setting up an organization to register rooms, check their condition, and allocate them according to availability. The information centre or the tourist board in Tulcea could be made responsible for this, since all the tourists pass through there.
- Creating tourist circuits which channel the tourists and offer them choice observation points so that they can really take advantage of the abundant delta birdlife. Advantages: the people cannot go just anywhere and they come back enthusiastic because they have seen the birds without having disturbed them, which is certainly not the case when they travel on the channels.
- Training guides and wardens. The guides and wardens who oversee the reserve must be trained in ecology. This will enable them to understand and notice any changes in the delta, guide the tourists, advise anybody caught committing an offence, etc. Obviously, the delta inhabitants would be given first choice as guides. They can be trained in the Uzlina centre.

• Developments and investments: keeping things on a human scale

To improve local housing, local people must be able to borrow, often moderate amounts at preferential rates. International banks (World Bank, EBRD, etc.), which because of their size, cannot provide direct services to private individuals, must put this in the hands of a local development bank, to be controlled by the Biosphere Reserve Management Agency.

• Long-term survey

The delta collects all the pollution slowly transported by the river. The Uzlina centre could become a "field antenna", i.e. the monitoring centre for the scientific centre of Tulcea in the event of serious pollution. The purpose of the Uzlina centre is threefold: a research centre, educational and training centre, and a reserve management centre. The centre will monitor the evolution of the delta ecosystem: pollution of the river water that flows into the Black Sea, eutrophication of the most stagnant delta water, coastal erosion, abundance in birdlife, etc. The centre must also monitor the sturgeon population and no doubt take large-scale protective measures.

We have to clearly bear in mind that all the actions made by the inhabitants of the delta themselves, the Romanian government and authorities, international institutions and the non-governmental organizations allow a decent standard of living while preserving the exceptional wealth of the Danube delta will be vain if a new dam is built on the river and if we do not pay particular attention to reducing of the pollution of the river.

The delta is an indicator of the health of the river. But it would be as ridiculous to consider it outside its economic, social and political context. Conservation of the delta can only be the result of deep international reflection concerning overall management of the river.

SECTIONS OMITTED

PARTS 2, 3, & 4

PART 5

GABCIKOVO: A CASE STUDY

GABCIKOVO: A CASE STUDY

The concept and execution of the Equipe Cousteau Danube programme are based on a complete overall approach to the environmental problems which takes the long-term into account. The Gabcikovo dam supplies us with ideal proof to demonstrate by example that this approach is a suitable one to use.

In recent decades, the consequences of our shortcomings in development planning have manifested themselves in the form of a proliferation of environmental problems at the local, regional, and global levels. Remedial efforts have engendered two principles which are now well-recognized:

- Most of the problems result from narrow sector-based processes of logic. The solutions developed by specialists acting on the basis of their own field of skill alone result in dead-ends. Development projects or solutions to existing problems must be researched from the points of view of all their various aspects.
- Short-term reasoning results in consequences for which heavy premiums must be paid in the long term. It is no longer possible to exploit our resources as if they were infinite. The concept of long-term management, or sustainable future, imposes itself as a necessity.

The Equipe Cousteau, using these two fundamental principles as a basis, has developed the concept of Ecotechny. This involves compromising within the same rational process between technical, economic and ecological rationales in order for decisions made by the sociopolitical mechanism to proceed (See Figure 5.1).

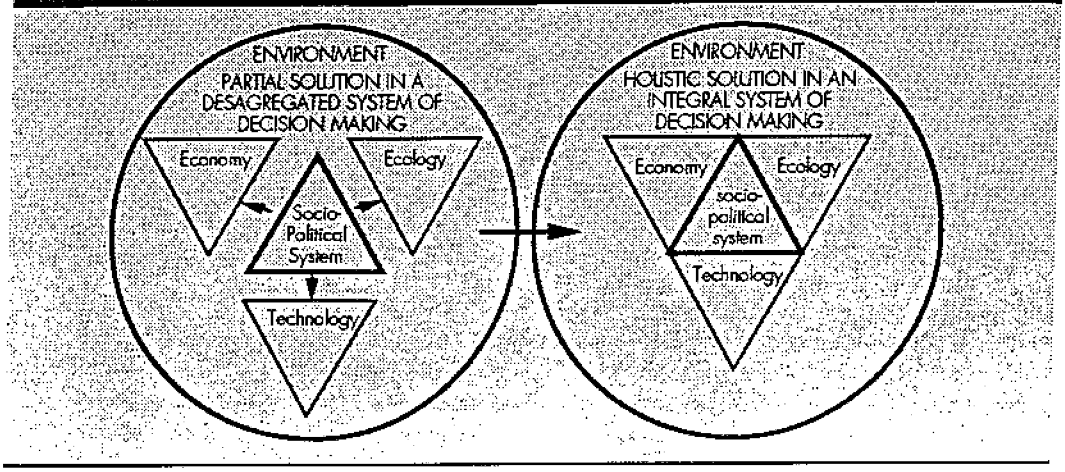
The importance of a complete overall approach and taking the long-term into account is rendered absolutely crucial in river exploitation, as rivers are highly complex ecosystems and constitute resources common to a great number of human activities. This applies all the more so since river developments are irreversible.

The Gabcikovo dam is the legacy of the past in which narrow rationales and short-term reasoning were exacerbated by a factor inherent to the communist system: a totalitarian approach to government, where opposing viewpoints were unacceptable, and a will to raise man's status by controlling the environment. These brought about the hegemony of technology.

The Gabcikovo dam is the perfect result of this technician's rationale, which gave carte blanche to the know-how of hydraulic engineers and which still persists. Such a rationale is not limited to the design of civil engineering works but is extended to the ecological and economic fields:

- The solutions envisaged for environmental problems are "added on". Rather than removing the causes of problems, new technical devices are designed which are intended to correct the consequences of preceding technical devices. The results sometimes attain the absurd. For example, the installation of a network of pumps was imagined in order to compensate for the water table level variations downstream from the dam. These pumps would have consu-

Figure 5.1 - Ecotechny, a new concept for long term environmental management and sustainable future.



med a large part of the electricity produced by the dam!

- The evaluation of the dam's economic viability as presented in the reports which were accessible was carried out using a simplistic rationale involving no strategic reflection or long- term forecast concerning future energy requirements or navigational development potential.

The work carried out in the context of the Danube programme enables us to present a complete overall evaluation of the dam's advantages on an economic level and of its environmental consequences.

1
DESCRIPTION OF GABCIKOVO

The Gabcikovo dam is located on the Hungarian-Slovak section of the Danube, a few kilometres downstream of Bratislava.

In the initial design, the system included a set of dikes containing the reservoir, a dam at Dunakiliti (in Hungary) blocking the Danube and diverting water towards the supply canal, a hydroelectric station at Gabcikovo, an outlet canal returning water to the Danube at km 1811 (See Figure 5.2).

After the works on the Hungarian side had been stopped, the Slovaks had implemented the alternative "C", which comprises a new dam at Cunovo (in Slovakia) and new dikes modifying the right bank of the reservoir, limiting its perimeter to within Slovak territory.

2
CONSEQUENCES FOR THE ENVIRONMENT

We will limit ourselves here to the two major problems: the effect on the alluvial ecosystems lining the Danube in this zone and the risk of pollution of the water resources. For further details, please refer to the report "The Gabcikovo dam: a textbook case".

2.1
EFFECT ON THE ALLUVIAL ECOSYSTEMS

Filling of the dam at the end of October 1992 raised the risks or threats which were hanging over the alluvial ecosystems to the level of a concrete reality. In a few days, the consequences of flow reduction in the river bed to around 300 m^3/s were measurable; while it was possible to cross the Danube without wetting one's feet, the water table level plummeted by several metres. The wells dried up and secondary channels and ponds drained, leading to the death of thousands of animals, and at medium-term, threatening the whole of the plant communities.

These facts demonstrate the incompatibility between operation of the dam according to the planned method, which scheduled flows in the Danube comparable to those actually observed: 200 to 300 m^3/s, and survival of the ecosystems which line the river. They also demonstrate the failure of the environmental studies carried out by the dam builders.

Studies which we carried out on these alluvial ecosystems "Alluvial ecosystems: a unique heritage" enable their value to be specified.

• VALUE AS HERITAGE •

These alluvial plains and forests are the richest regions in Europe, not only in terms of the diversity of species, but in terms of biomass and productivity as well. This richness is directly linked to river dynamics - proportional to the surface area flooded - and the extent and steadiness of the flooding. Because they combine the resources and diversity of terrestrial and aquatic ecosystems, while remaining a highly dynamic and original environmental interface, alluvial ecosystems are the richest and most productive ecosystems of the temperate regions.

Alluvial zones are used by animal and plant species as migrating and travel corridors. These corridors played a crucial role for terrestrial plants during the glaciations. That is why current alluvial forests are so abundant in remnants from the tertiary era.

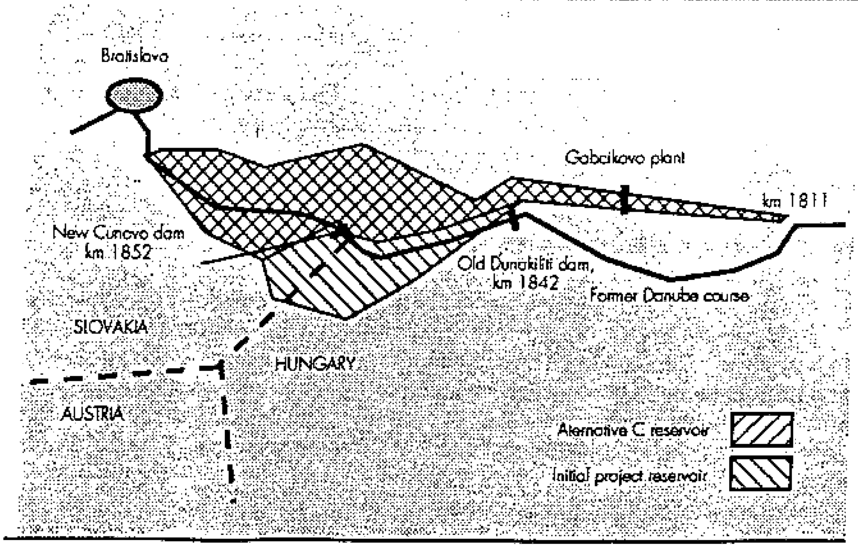
Taking this heritage value into account was recommended by the Rio Conference through the Biodiversity Treaty.

• FUNCTIONAL VALUE •

Alluvial plains have direct economic value linked to this exceptional diversity and productivity. However, it is difficult to evaluate because alluvial zones no longer exist along the courses of Western European rivers, and in Eastern Europe it is still impossible today to obtain reliable economic data on river resource exploitation in recent years.

Figure 5.2 - Schema of the Gabcikovo dam and of the alternative C.

After work was stopped on the initial design of the dam on the Hungarian side, the Slovak unilaterally simplemented the so-called "alternative C" on their own territory. It was put in operation at the end of October 1992.



The fishing communities, which have completely disappeared from the rest of Europe, subsist only in the alluvial zones. Logging is particularly promising in these alluvial zones with high productivity.

Alluvial plains, but more importantly alluvial forests, provide the best system for purifying water and recycling organic matter. The assimilation of nutrients (phosphates, nitrates) by terrestrial and aquatic plant life in the alluvial plain offers a means to purify river water and ground water.

Alluvial plains offer the best protection against flooding, because they slow the flow and give the water room to spread out. In addition to the roughness of the plant life on the riverbanks and the plain, which slows water speed, seepage decreases the level of flooding. On the other hand, canalization increases the power and propagation speed of flooding.

The importance of the functions of the alluvial plain is not marginal. Certain territorial collectives in the French region of Alsace have understood this importance perfectly: with a view to long-term management of the quality of their drinking water (taken from an alluvial water table), they fund maintenance of natural meadows in the wet zones in order to favour self-purification of the water passing down towards the water table during high water.

2.2

CONSEQUENCES FOR THE QUALITY OF WATER RESOURCES

Following filling of the dam, a reversal in the position of Slovak experts concerning the risk of subterranean water pollution was observed: whereas it had always been denied, it suddenly became a very serious threat to the Samorin taps which supply the town of Bratislava, upon which it was proposed to reduce the water flowing through the by-pass channel!

Our studies fully agree with the recent convictions of these experts.

The risk of contamination is linked to two phenomena:

- The accumulation of polluted sediment on the bottom of the reservoir may enable the passage by pressure of pollutants through to the subjacent water table. This storage may create the conditions for a chemical time bomb: beyond a certain concentration threshold or if reducing conditions develop on the bottom, massive rerelease of pollutants may take place with serious consequences for the environment.
- Eutrophication, created by the conjunction of strong nutrient concentration (leaching of agricultural soils, urban or industrial waste), of water clarification by settlement and water temperature increase through reduction of current velocity in the reservoir and creation of still, shallow zones. The explosive development of algae leads to anoxic conditions and to the development of reducing conditions on the bottom.

Two of the studies which we have carried out enable these risks to be determined. The first "Overall evaluation of pollution and high risk zones" highlights significant sources of pollution upstream of the dam: the cities of Vienna and Bratislava, which are very poorly equipped with purification plants, the Brno region connected to the Danube by the Morava. These are sources mainly of organic substances and nitrogen and of phosphorus to a lesser degree. The presence of these sources worsens the risk of eutrophication.

The second "Concentration of chemical pollutants in sediments and mussels along the Danube" carried out by the Marine Environmental Laboratory of the International Atomic Energy Agency confirms the existence of these sources and defines them. High concentrations were measured in the sediments of the Bratislava region for the following pollutants:

- PCBs associated with the city of Vienna.
- Hydrocarbons.
- Coprostanol (an indicator of sewage pollution) associated with the city of Bratislava.
- Benzopyrene and lead, a combination of products characteristic of fossil fuel combustion (including the combustion of leaded fuel).

Another result of this study is the highlighting of the very high level of pollution in sediments taken from the Djerdap dam reservoir (Iron Gates); this sample was a hot spot for almost every measured parameter.

One of the conclusions of this report is "The important point is that any dam in the river downstream of identified sources of pollution, will create a potential build-up of contaminants and, in some cases, a future chemical time bomb."

Moreover, installation of purification plants in the surrounding urban areas of the reservoir, promised by the dam builders, has always been postponed. It has now been postponed until the first profits from the power station. In the meantime sewage from the cities and villages will be ejected untreated into the storage lake ...

All of the above factors would tend to result in contamination of the region's drinking water reservoir. Loss or deterioration of these resources would have serious consequences at an economic and social level. A large number of the inhabitants are not connected to a drinking water distribution network and depend on the quality of subterranean water in their daily lives.

3 THE DAM'S ECONOMIC VIABILITY

Will the economic advantages of the dam be sufficient fund measures that would compensate for its drawbacks?

3.1 ELECTRICITY PRODUCTION

In the documents supplied by the Hydroconsult firm analyzing the economic value of the dam, the production of electricity is considered as a net profit (equivalent to the energy produced multiplied by the import cost of the same amount of energy). However, this is only true if it meets a quantitative need both now and in the future and if the production is coherent with the most applicable energy strategy.

The study "Energy in the Danubian Countries. Current situation and outlook." shows that this is not the case.

The Czech Republic and the Slovak Republic consume large amounts of energy and electricity with a very high electric intensity (two to three times higher than in Western countries).

Efforts made in energy efficiency could allow these countries to have energy supplies comparable to those of Western Europe today by the year 2020. Electricity consumption would be then about 6.5 TWh lower than its current levels for the Slovak Republic alone.

In this future context, which is indispensable to ensure the transition of the Slovak economy to a modern economy open to the rest of the world, the Gabcikovo dam does not respond to any future requirement.

Moreover, electricity production from the dam is very slight by comparison with Slovak consumption and with the savings potentially able to be made by improvement of energy efficiency. Production, which was to rise from 1.2 TWh to 2 TWh depending on the configurations applied, will have to be reduced further because filling of the dam has proved that it corresponds to a flow distribution which cannot be withstood by the alluvial forests. This being the case, electricity production will be absolutely marginal.

Nor can Gabcikovo be considered as one component of a strategic reorientation of electricity production, since the Slovak Republic is continuing its investments in the nuclear industry and in hydroelectric equipment on its other rivers.

These investments combined, which contribute to over-equipment in Slovakia, are subtracted from other sectors which are far more crucial to the economy. Allocated to industrial modernization, they would have been able to dynamize this sector of activity and at the same time generate energy savings.

Investment could also have been made in renewable energy sources which represent a far greater potential than that of Gabcikovo's production (it totals 7% of current consumption in ex-Czechoslovakia as a whole). Exploitation of these resources would also have the advantage of solving certain environmental problems such as exploitation of rural or urban waste and of inducing the integration of new technology which constitutes a development opportunity for the private sector.

3.2
IMPROVEMENT OF NAVIGATIONAL CONDITIONS

The major difficulties for navigation on the Danube are located along the Hungarian-Slovakian section, since the depth of 25 dm recommended by the Danube Commission is not reached there for 30% of the year. These difficulties are particularly expensive as they occur during periods in which the Danube's other sections are generally navigable.

Following the same simplistic line of reasoning as for energy, it was thought that the advantages of the dam would correspond to a traffic increase equal to the increase in the number of navigable days (around 30%) and to the fuel savings associated with the reduction of current along the developed section. It was also thought that opening of the Rhine-Main-Danube canal would lead to a significant increase in deep draught traffic.

But evaluating the advantages of a project like Gabcikovo requires an overall assessment which includes the following phases:

- Clearly setting out the existing traffic hindrances caused by bad navigational conditions and define the developments and investments required to remedy the problems.
- Establishing a forecast on the potential future traffic using the Danube, taking the developing economies of the local populations and the opening of the Rhine-Main-Danube canal into account. This will make it possible to define the quantity of traffic that will use the river as a result of the developments.
- Evaluating the profits to be gained from the increased traffic and the improvements that would be made to the fleet following the developments, and identify the beneficiaries.
- Comparing these profits with the costs of the developments in order to calculate the profitability and their economic and social efficiency.

This assessment was carried out by Patrice Salini and presented in this report (Part 2).

In fact, this evaluation exceeds that of Gabcikovo proper because the thresholds which limit navigation do not only concern the developed dam sector. The latter alone does not solve the problems, and this fact suffices to show Gabcikovo's non- advantageous nature where navigation is concerned.

In a broader hypothesis in which the entire Vienna-Budapest Danube bottleneck would be developed by four dams in addition to Gabcikovo, analysis shows that such investments would not have any direct profitability. The increase in traffic following development would be very limited, around 1.8 million tons per annum. The major beneficiary of these developments would be the Austrian Steel Industry, which competes with Slovak steel and would imperil its continued existence.

It seems far more profitable to invest near the Danube in order to improve the organization of transport and the operability of harbour infrastructures.

The Gabcikovo dam provides excellent proof of the advantages of a complete overall approach, since its multi-sector characteristics (it integrates the fields of energy, transport, water resources, nature conservation) match perfectly the complexity of environmental problems.

This approach paints a very negative picture and it is clear that if it had been used from the project's outset, Gabcikovo would never have seen the light of day.

This absurd decision to build a dam reveals itself as the stumbling block of a system in which decision-makers incorporate only a very narrow range of criteria. No alternative solution which would have enabled the same energy or navigation services to be provided, implementing alternative resources less detrimental to the environment and more profitable for the economy, was seriously studied.

Granted, Gabcikovo is an heirloom from the past, but it is to be regretted that the current Slovak Government has at the same time inherited the mode of thought from which Gabcikovo was born. By willing to put this dam into service at all costs, the Slovak authorities are starting on the path to a sequence of technical and environmental problems and financial difficulties.

Only two months after the dam had been filled, catastrophic reports were coming in: the alluvial forest had dried out to a great degree, with as yet unforeseen consequences; the dam's electricity production potential had been reduced significantly; two boats had wrecked in the storage lake; structural erosion problems had been observed; several gates of Cunovo dam had been washed away by high water; one of the locks of the Gabcikovo plant has never worked; the ferry linking inhabitants of one bank of the canal to the rest of the country is chronically malfunctioning; navigation had repeatedly been blocked.

This situation requires energetic measures if it is hoped to avoid serious and in some cases irreversible consequences for the environment and the quality of life of the region's inhabitants.

In the longer term, removal of the two main sources of disturbance, i.e. the storage lake and reduction in flow in the Danube's bed, fundamentally calls into question the design of the dam and its advantages. Basic reflection on the matter is imperative in order to find a viable solution.

RECOMMENDATIONS

Solving the Gabcikovo problem and saving the endangered zone would be a landmark decision and an example for the future.

• To refill the Danube in priority

Most of the water in the Danube (95%) must be returned to the river bed as soon as possible and at the latest before Spring growth season.

• To apply the principle of precaution for the intermediate period

The principle of precaution must be applied in decisions concerning the dam's future, especially concerning how the water is managed, decisions due to be made for the near future. The Danube must not become a laboratory where experiments are carried out.

• To engage in a global integrated reflection guided by democratic principles

Basic reflection on the matter must be engaged in incorporating the technical, ecological, economic and social data and drawing on international experts, the public and non-governmental organizations for environment protection. It must lead to an exhaustive and detailed cost/~~advantages~~ analysis of all alternative solutions. It must be carried out in a spirit of transparency and its conclusions must guide decisions concerning Gabcikovo's future.

• Courageous and reasonable solutions must be supported by Western countries

Our own analysis leads us to the conclusion that abandoning the dam and reinstating the site is the most courageous and also the most reasonable solution with a view to achieving a sustainable future. This solution must have the advantage of solid financial backing from Western countries and the large international financial institutions. Such aid is indispensable for implementing alternative solutions in the field of energy and navigation and for a site reinstatement project if these are to have credibility with the public and with political leaders.

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LIST OF THE DOCUMENTS ISSUED IN THE FRAMEWORK OF THE PROGRAMME "THE DANUBE... FOR WHOM AND FOR WHAT?"

FINAL REPORTS

A survey of resources in the Danubian basin.
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Long-term programme on the environmental survey of the Danube river basin. Equipe Cousteau, December 1992.

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PART 1 DANUBIAN WET ZONES

A Functions of wet zones and aquatic environment of alluvial plains related to the main stream of great rivers.
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B The aquatic ecosystems of the Danube. Current knowledge of their functionings. Project for the study of the Gemenc sector (Hungary).
C. Amoros, E. Castella, J.F. Fruget, A.L. Roux, March 1992.

C Aquatic and terrestrial vegetation of Danubian alluvial plains.
M. Trémolières, A. Schnitzler, April 1992.

D Arguments for preserving and restoring alluvial ecosystems. Application to the rehabilitation project of the Gemenc sector (Danube, Hungary).
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F The Danube delta. Biosphere reserve.
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PART 2 NAVIGATION AND TRANSPORTATION

A The future of navigation on the Danube. The economic interest improving the Danube for navigation. Final report.
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PART 4 EVALUATION OF THE POLLUTION OF THE DANUBE

A Report on a joint assessment of pollution in the Danube river.
Marine Environmental Laboratory of the International Atomic Energy Agency, Monaco and Water Resources Research Center (VITUKI), Institute for Water Pollution Control, Budapest, January 1993

B Report on the pollution state of the sediments and mussels within the Romanian sector of the Danube river.
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C A study of radioactivity in and around the lower river Danube by radiometrics sections.
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D Evaluation of the radioactivity in the river Danube basin using airborne gamma-cartography.
CEA Valduc, November 1992

E Helinuc airborne gamma-cartography device.
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F Methodological study for pollution evaluation in the danube river basin.
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G Environmental Decision Support System for the Danube river basin EDSS-Danube,
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H Proceedings of the GIS in Environmental and Water Management Workshop,
Budapest, September 28-30, 1992

I Proceedings of the meeting of "Citizens Concerned by an Energy-efficient and Environment-respectful Society", Sofia, October 13-15, 1992

PART 5 GABCIKOVO

Gabcikovo: a textbook case. Equipe Cousteau, September 1992.

Annex 17

DAMMING THE DANUBE

What Dam Builders Don't Want You To Know

A Critique of the Gabcikovo Dam Project

Bratislava, March 1993

STOP

GABČÍKOVO

PHOTOS AND ANNEXES OMITTED

SZOPK - Slovak Union of Nature and Landscape Protectors

SRN - Slovak Rivers Network

DAMMING THE DANUBE

What Dam Builders Don't Want You To Know

A Critique of the Gabcikovo Dam Project

Bratislava, April 1993

SZOPK - Slovak Union of Nature and Landscape Protectors

and

SRN - Slovak Rivers Network

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Editor

CONTENT

LIST OF ABBREVIATIONS

GNDS - Gabcikovo (Bös) - Nagymaros Dam System
GP - Gabcikovo (Dam) Project
HAS - Hungarian Academy of Sciences
NP - Nagymaros (Dam) Project
NWCO - Hungarian National Water Conservancy Office

INTRODUCTION

The Gabcikovo - Nagymaros Dam System Project has become undoubtedly one of the best-known environmental-political problems in Central Europe. Recently, many politicians have tried to present Gabcikovo as a conflict between Slovaks and Hungarians. Actually, this has never been the case. In reality, this is a conflict between two groups; the members of these two groups come from both sides of the Danube. This is actually a conflict between the Slovak and Hungarian representatives of the old-fashioned Communist approach to nature, and the Slovak and Hungarian representatives who support the preservation of natural values and sustainable development. Environmentalists, scientists and ordinary people on both sides of the Danube have fought for more than ten years against this monsterous project. Hungarians, Slovaks, Czechs, Austrians and people from other nations have joined together in the biggest environmental battle in the history of the region.

Quite often during the Gabcikovo debate, contradictory and confusing information has been presented, mostly by Slovak politicians and the official media. This has led to misperception and a wrong interpretation of the real situation by the majority of the Slovak public and, what is even worse, by the Slovak Government itself, in whose hands the fragile future of the natural values in the Central Danube region now lies.

This book was edited by the Slovak Union of Nature and Landscape Protectors (SZOPK) and the Slovak Rivers Network (SRN) to provide interested Slovak and international members of the public, journalists, and politicians with basic information on the Gabcikovo Project and some of its most important environmental, economical, social and legal consequences, many of which are still not widely known. One of the most important reasons why many consequences are still relatively unknown is because of the strong information campaign in favour of the completion and operation of the Gabcikovo Project. This campaign has been run by the Slovak dam-builders (the "water lobby") and their powerful supporters since the beginning of the project; this campaign has been especially strengthened during the last three years.

The information compiled in this book comes from various sources. Most arguments presented against the Gabcikovo Project have been known among scientists and environmentalists for many years, the most important ones known even since the very beginning of the project. However, it was not possible to widely publicize these arguments under the Communist regime and even now, more than three years after the November '89 democratic revolution in Czechoslovakia, all such efforts in Slovakia are severely limited by the current political situation.

Wherever possible, the information given was extracted from the latest independent expert studies available.

Primarily, information from the following sources was used in these chapters:

1. Historical Survey 1951 - 1993 (Hajósy, Hollós,1991; SZOPK, WWF and Equipe Cousteau materials, Slovak daily press clippings)
2. The Original Gabcikovo-Nagymaros Dam System Project as Laid Down in the 1977 Treaty (1977 Treaty and miscella neous SZOPK materials on GNDS)
3. Variant C (Berrish,1992; Equipe Cousteau,1992)
4. What Dam Builders Don't Want You to Know: A Summary (all sources mentioned in endnotes)
5. Impacts of GNDS on Ecosystems and Wildlife (Hajósy,Holós,1991;Perczel, Libik,1989; WWF 1991; Holcik, Bastl, Ertl, Vranovsky,1981; SZOPK materials on GNDS)
6. GNDS and Water Quality (Perczel, Libik,1989; Lichvár,1990; Zekeová 1990; Lehock,1990)
7. Impacts of GNDS on Fishery - General Prognosis (Holcik, Bastl, Ertl, Vranovsky,1981)
8. Effects of GNDS Imposed on the Soil and Agriculture (Hajósy, Hollós,1991)
9. Geological and Seismological Problems (Hajósy,Hollós,1991)
10. Flood Control (Hajósy, Hollós, 1991)
11. The Gabcikovo Project and Navigation (Equipe Cousteau,1992)
12. The Gabcikovo Project and Production of Energy (Equipe Cousteau, 1992)
13. Social Impacts of the Gabcikovo Project (WWF,1991)
14. Political Aspects of GNDS (Galambos,1992)
15. Construction and Operation of Variant C under International Law (Hunter,1992)
16. Alternatives to the Gabcikovo Project - What Should be Done to Resolve the Conflict (unpublished materi als by SZOPK, WWF and ISTER)

For practical reasons, we refrained from the strict use of footnotes in the text. All other sources quoted in the respective chapters (except those mentioned above) are listed among the end notes. Most of the materials used were shortened, edited and updated. During the time of collecting and editing materials for the book (1992 and the beginning of 1993), there were substantial political changes in Czechoslovakia which had to be reflected in the text.

Among them, most important was the split of Czechoslovakia, involved in the Gabcikovo Project since 1977, into two independent states as of January 1, 1993. This has also had direct consequences on the further development of the Gabcikovo conflict. Since January 1, 1993, the government of the newly-created independent Slovak Republic took over the formal responsibility for the Gabcikovo case, although, in fact, it had already had a decisive position in the former Czechoslovakia for a long time before then.

The information given here is not (and for obvious reasons can not be) in any case exhaustive. The more detailed (original) sources, listed at the end, are highly recommended for more dedicated readers. SZOPK and SRN intend to publish an updated version of this publication by the end of 1993. Therefore, it would be highly appreciated if any comments, suggestions or copies of materials and papers concerned with this topic could be sent directly to the SZOPK central office in Bratislava.

It is also important to state that all comments, adjustments, and changes in the materials used are the full responsibility of the Editor. Authors quoted do not share any responsibility for the context in which his or her original papers or their parts were used.

The end of the Gabcikovo story is still open. This book is intended to serve as a guide to all who are willing or forced to participate in the painful process of searching for the lesser of many evils.

Editor

1. HISTORICAL SURVEY 1951 - 1993

The planning of the Dams on the Danube

The idea of jointly-operated Hungarian and Czechoslovak dams on the Danube first arose in 1951. The original intent was to alter the shallow reach of the Danube between Bratislava, Czechoslovakia and Györ, Hungary, and connect these two inland countries to the Danube-Main-Rhine trans-European waterway that was being planned at the time. This would provide a direct, uninterrupted waterway from the Black Sea via Budapest and Bratislava to Rotterdam and the North Sea.

Joint planning commenced in the early 1950s. After the so-called planning committees of the two countries had approved the plans of the dam system, the appropriate standing committee of COMECON also approved them in 1961. They were signed at the governmental level by the two countries concerned in 1963.

At that time, the only mention of water power was the observation that a power station on a flat stretch would not be efficient in terms of power gained. The main issue was the uninterrupted waterway.

The uninterrupted waterway became the subject for joint regional planning. It was stated that a certain number of secondary effects would be caused by dams; these effects would be considered socially and/or economically harmful. When regional planning commissions found undesirable effects which were impossible to avoid, the usual policy was (and is) to consider these effects as part of the cost of the project, thus reducing them to a problem of economic calculation. The undesirable effects of the GNDS project, however, have never been factored into the economic calculations, even though the Czechoslovak-Hungarian Joint Committee of Technology and Science decided to undertake a long-term regional planning project that included an assessment of the dam's effects on the environment and on regional development.

This long-term regional plan was to have been completed by the end of 1978. Because of the oil crisis, however, the GNDS treaty was hastily ratified in 1977, prior to the completion of the regional plan. The oil crisis also changed the primary purpose of the project; the Hungarian and Czechoslovak government now decided that the dam system's primary purpose would be energy production. Additional project priorities would be flood prevention, followed by the elimination of shallows for the uninterrupted waterway; regional development would become the fourth priority.

The original plan, centering around the issue of a new waterway, would have been much less harmful to the environment than the plan which followed the oil crisis (the Contract Plan). Because of rising oil prices, the planned dam at Gabcikovo was extended, and a side channel and large reservoir at Dunakiliti were planned.

If the Contract Plan is not implemented, 50% of the environmental damage and 40% of the expense can be avoided; 14, 000 hectares of good forest and 15,000 hectares of agricultural land would be saved. /1/

The joint CSFR-Hungary investment program proposal for the Gabcikovo (Bös)-Nagymaros Dam System (GNDS) Project was completed during 1972-73; the decision to construct the hydro-power station in the Visegrad area had been already made in 1958. After preparation work lasting almost 20 years, the two countries signed a contract for the construction and operation of the GNDS (the "1977 Treaty) /3/ on 16 September 1977. It came into force on 30 June 1978. Earlier, on 6 May 1976 in Bratislava, the two parties had signed an agreement on a so-called joint contractual plan (the "Agreement"). The Agreement laid down detailed rules for mutual assistance during the construction, and set the years 1986 to 1990 as a target for starting operation of the Gabcikovo-Nagymaros system of locks. An implementation time schedule was also agreed to on 16 September 1977. According to that schedule, the first turbine in the Gabcikovo power station would be operational in 1986; the first turbine in the Nagymaros power station would be operational in 1989.

In over 13 sections and 28 articles, the treaty between the Hungarian People's Republic and the Czechoslovak Socialist Republic deals with the "joint investment" and additional "national investments". Regarding national investments, the treaty states that "...the Contracting Parties may, in addition to the joint investment, also undertake national investments exclusively in their own interest and for their own purposes." The treaty further states that these national investments "...may not have a detrimental effect on the results of the joint investment." (Article 2)

Utilization of the profits and benefits system are outlined in Article 9; "The Contracting parties shall participate in the use and in the benefits of the System of Locks in equal measure...."

Construction of the Gabcikovo power plant began in the Czechoslovak territory in 1978. Following this, economic difficulties in both countries necessitated the postponement of construction. Despite the fact that public opposition was illegal, very opinionated articles were published which drew attention to both the ecological hazards and the irresponsible design of the construction.

In June 1981, bilateral governmental discussions concluded that neither of the two countries was capable of ensuring implementation according to the original time schedule. Therefore, Hungary made private contracts with foreign companies for construction and financing. In particular, it assigned work at the Dunakiliti head-water station to an Austrian company financed by Austrian loans, and work at the downstream channel to a Yugoslav company. Hungary also decided to postpone the construction of the Nagymaros dam until 1988 because of a lack of finances. On 10 October 1983, the parties signed a protocol modifying the 1977 Treaty, and postponing the project for five years. The joint contractual plan (Agreement) was also modified and the final deadline was set to 1995. On 6 February 1989, the Agreement was once again modified and the deadline changed to 1994.

Together with revisions related to the rescheduling, it became necessary for the Hungarian National Water Conservancy Office (NWCO) to request official expert opinions from objective organizations regarding the effects of the project on the environment and agricultural production. These expert opinions were requested in order to acquire more "reassurance" in these matters. Organizations providing expert opinions were not involved with the design or implementation of GNDS.

At the request of the Central Committee of the Hungarian Socialist Workers Party, the Hungarian Academy of Sciences (HAS) formed a special committee to investigate the scientifically disputed matters related to GNDS. In a resolution dated December 1983, the Presidency of HAS unanimously approved the draft plan of this special committee. In part, the draft plan stated:

Regarding the investigation of technical, agricultural, water engineering, communication, economic, environmental and regional development problems: "No comprehensive approach to ecological effects and consequences of GNDS was made in the agreed plan. To date, no survey has been made with the aim of revealing the technical, ecological and relevant hazard relations of this important group of subjects in the system, and their mutual effects".

"On basis of the complex consideration of the listed and other listed factors, the Presidium sees a postponement of the investment and validation of the verified modifications, but preferably its cessation, ... as justified."

The Environmental Effect Study, which examined only the effects in Hungarian territory, was completed in 1984-85. Although many questions were answered by the study, it only addressed the ecological effects expected from the implementation of the commonly agreed-upon plan. The study did not investigate the effects which would result if alternative technical solutions were implemented.

Beginning in 1985, the continuation of construction work caused protests. Experts and professionals protested at conferences and wrote sharply-worded articles against the project and its harmful and irreversible progress. The Hungarian people rejected the Nagymaros Dam in street demonstrations. Finally, in the summer of 1988, the Hungarian Parliament also spoke up on the issue. Parliament requested the information the government ministries had used in making the decisions regarding the planning and future of the Nagymaros project.

The Hungarian Parliament did decide to continue with the Nagymaros construction during its 7 October 1988 session, but it bound further construction to strict environmental protection conditions:

"The ecological risks have to be reduced to a minimum, and for this reason, both in the course of the investment and the operation, the ecological interests shall take priority over the economic interests.... As a guiding principle of operation, it must be declared that the quality of the water of the River Danube must not deteriorate. Peak-capacity operation should be commenced only after establishing the water purification plants required on both sides of the river for safe operation of the system, free of environmental risk."

Following this, and in consequence of the aforementioned events, a general demand for a thorough, scientific assessment of the merits of the project arose; this assessment would include a prioritization of the values of the project and information on the extent of the expected ecological damage.

In March 1989, the Hungarian government requested a recommendation from the "Ecologia" group of Northampton, Massachusetts, USA /4/. In part, this recommendation stated:

"In the case of the project examined, certain decisions of the Hungarian, Czechoslovakia and Austrian governments were made ignoring environmental and other serious misgivings.... Thus, the procedure failed to follow the recommendations given previously by us, proposing that the effects and alternatives should be thoroughly examined before anything is done.... In regard to the power station and shipping project in question, international misgivings in keeping with the order of magnitude [priorities] were expressed. A conceptual answer comparable to these misgivings should be proposed, for the realization of which comprehensive circumspection, courage and an approach of international nature are indispensable."

Worries related to GNDS were amended with new expert opinions, which proposed a suspension of the construction on the basis of the geological and geophysical research performed regarding the construction of Nagymaros and the seismologic problems found in the Gabcikovo effect area.

On 13 May 1989, the Hungarian government suspended the construction at Nagymaros, and on 24 May 1989, informed the government of Czechoslovakia accordingly. This step of the Hungarian government was approved by the Hungarian Parliament on 2 June 1989, which also authorized the government to enter into negotiations on the termination of the 1977 Treaty.

During 17-19 July 1989, Hungarian-Czechoslovak expert consultations were held in Budapest to discuss disputed issues in the areas of ecology-hydrology, geology-seismology, and soil science-agricultural production. The experts of both countries agreed that GNDS is a greatly significant intervention into nature, affecting inestimable ecological values.

In all work groups, the differences of opinion between the Hungarian and Czechoslovak experts were related to the mode of preserving the ecological values: according to the Czechoslovak experts, the subsequent technical interventions were sufficient to preserve the values while according to the Hungarian experts, they were insufficient.

The Hungarian Government, on the basis of the available information, professional analyses and comments, recognized the need to avoid the indirect hazards stemming from the peak-capacity operation of the GNDS and its unknown risks; they also recognized the need to solve the problems surrounding the increase in water quantity which would pass into the Old-Danube. The immediate halt of the work at Nagymaros was in line with the idea that the ultimate decision regarding continuation or cessation should not be taken under the pressure of irreversible technical steps. A similar concept guided the decision on the suspension of the work in the Dunakiliti region. On 20 July 1989, a meeting took place between the Prime Ministers of Hungary and Czechoslovakia during which Hungary announced the suspension of the construction at Nagymaros and Dunakiliti until 31 October 1989. It furthermore proposed to suspend the project for three to five years in order to have sufficient time to evaluate alternatives. Prior to this, the Hungarian Government made a decision to establish expert teams whose task was to perform the studies and evaluations necessary for decision-making. The HAS was called in to summarize its opinion in the scientifically disputed environmental, ecological, water quality, and seismological areas.

Parallel with the professional committees, independent experts and environmentalists published their opinions and standpoints for both the decision makers and the general public. Quoting from the summary prepared for the Prime Minister:

"The realization of GNDS was justified exclusively by the aspects of an earlier age proven nowadays outdated and false. All other further aims (shipping, flood prevention etc.) can be achieved with lower expenditure and the use of other technical solutions. The ecological and other (technical, social) hazards and risks are carried by the solutions required for the electrical power generation, especially for peak-capacity operation. The requirements (e.g. for sewage purification) defined for the operation of GNDS in the original contract, and were not satisfied even in timing, and the conditions of their satisfaction are not ensured on a long-term basis either."

On 25 July 1989, and further through a diplomatic note dated 18 August 1989, the Czechoslovak government, for the first time, informed Hungary on the possibility of a unilateral provisional solution. This solution became known as the "Variant C". Hungary protested against Variant C on 4 October 1989.

In the spring of 1989, the World Wide Fund for Nature (WWF) sent an expert team to Hungary to study the GNDS. The team was sent at the request of the Hungarian government, which wanted additional information in order to be able to make a sound decision. The WWF experts studied the GNDS from the standpoints of hydro-engineering, hydro-geology, virology, fish biology and fishing, landscape and tourism. Charles de Haes, Director General, sent the team's findings to the Hungarian government Commissioner on 28 August 1989 /5/. This report also contained some research into the area of international law. The final conclusions and recommendations of the WWF work group follow:

1. The project has a serious negative effect on the environment. It has already caused a considerable amount of devastation in the living land and water environments. 2. The available ecological technical data is insufficient and does not support the continuation of the construction nor justify making the project operational. The construction of the barrage at Nagymaros would further worsen the negative environmental effects. For all these reasons, no construction of the barrage at Nagymaros is permissible. 3. Prior to the continuation of any construction work or any other operation related to the project, further studies are needed, especially in the fields of water quality, seismo-tectonics, ecology and flood-area management. 4. To this end, the moratorium must be prolonged for at least three years, so the above-mentioned studies can be completed. Work to rehabilitate the environments in the Nagymaros region, at the section of the Danube between Gabcikovo and Nagymaros, and at Szigetköz must be started immediately.

On 25-27 September 1989, expert scientific discussions concerning the water quality and ecological problems of the Dunakiliti-Hrusovo reservoir were held in Bratislava. As at the July meetings dealing with the problems of

Nagymaros, mutual agreement existed regarding the importance of preserving the drinking water sources. Howeve: the differences in opinion concerning the possible ways to preserve the drinking water remained unchanged. Th Czechoslovak delegation agreed with most ecological misgivings raised by the Hungarian delegation, but it wa said that these problems could be solved during the course of the construction of the project, or subsequent to that.

On 31 October 1989, the Hungarian Parliament adopted a resolution to abandon the peak operation mode at th Gabcikovo dam and to abandon the construction of the Nagymaros dam. The Parliament also called for further in vestigation into the matter. Subsequently, Hungary terminated all contracts with private parties on the financing an construction of the various premises. All private contractors were compensated. Eventually, in November 1990, i was agreed that Hungary would pay Austria 2,65 billion Schillings (USD 255 million) for the completed and deliv ered plans, machinery, and construction. The sum also included damages for Austrian businesses that were n longer required to deliver products ordered from them. Payments will be made in the form of electricity deliverie that will start in 1996 and are estimated to end by 2016.

After the change of governments in Czechoslovakia and Hungary, further negotiations between the two partie took place in 1990 and in particular after April 1991. During these negotiations, Hungary aimed at an agreement t abandon the project or at least to suspend it until the ecological risks were sufficiently investigated. It was also gen erally willing to compensate Czechoslovakia and to assist in the construction of alternative power stations. Czecho slovakia took the position that work on the constructions for the Gabcikovo power-station and its eventual operatio could not be suspended given the fact that large parts of the constructions were ready. It also disagreed with Hun gary's assessment of the ecological risks of the project.

In February 1990, in answer to a letter from the Hungarian authorities confirming the abandonment of th Nagymaros project and proposing a renegotiation of the 1977 treaty, the Czechoslovak authorities accepted the re negotiation on the condition that the Gabcikovo dam be filled in 1991 (which presupposed the completion of th Dunakiliti facility). The Hungarians reiterated their proposal in May by demanding that work be stopped at Gabcik ovo.

In November 1990, Hungary and Austria agreed on the compensation conditions for the Austrian companie: hurt by the abandonment of the Nagymaros project.

In April 1991, the Hungarian Parliament adopted a resolution whereby the government was only mandated t negotiate the cancellation of the 1977 treaty and return the sites to their initial condition.

During the summer of 1991, the conflict in Slovakia came to a head. On 3 July 1991, the Slovakian environ mental protection organizations Eurochain and SZOPK, backed by WWF and Global 2000 in Austria, as well as b Reflex and Dunakör (Danube Circle) in Hungary, started a campaign of demonstrations, sit-ins and site occupa tions. The response from the Slovakian government has consisted of nothing more than political arguments an massive police actions. Every demand that construction be stopped has been curtly turned down, as have all re quests for comprehensive environmental impact studies. The government has also refused to engage in any discus sion with the local population.

On 23 July 1991, the government of the Slovak Republic, followed on 25 July by the federal government of th Czech and Slovak Republics, basing themselves on the report prepared by several Slovak experts, approved th work for Variant C. This solution was chosen from 7 others (ranging from retention of the initial project to return ing the sites to their initial condition) and allowed for the filling of Gabcikovo without Hungarian cooperation b limiting the site perimeter of the project to Slovak territory.

On 30 October 1991, the Slovak Environmental Commission gave construction permission for Variant C whilst formulating 19 conditions that had to be fulfilled prior to starting up the work.

On 18 November 1991, Czechoslovakia began construction of the Variant C on its territory.

In December 1991, the Hungarian authorities sent a number of ultimatums to Czechoslovakia demanding sus pension of the work.

On 26 February 1992, the Hungarian authorities gave Czechoslovakia a one month period to suspend the work otherwise they would unilaterally denounce the 1977 treaty.

During the whole period of negotiations, the parties discussed several possibilities for the settlement of thei dispute. Among them was an offer made in April 1992 by the European Community for "good office" (bon offices) in particular to assist in the establishment of a trilateral committee of experts. The Commission of the Europea Communities, however, made the offer subject to the conditions that both parties would agree to accept the finding: of the expert committee as the basis for further negotiations, and that the parties would not undertake any step: while experts were at work which would prejudice possible actions to be undertaken on the basis of the study' findings. The parties could agree on the first condition. Hungary, however, interpreted the second condition a: meaning that construction of Variant C would have to be suspended during the work of the committee, wherea: Czechoslovakia held that this was not the case. It insisted on continuing the construction because it could not, fo economic reasons, afford a suspension. This disagreement could not be overcome and no committee was estab lished until 28 October 1992. In fact, during the whole period of negotiations, Czechoslovakia had continued wit the construction of Variant C and on 23 April 1992, it announced that it would start operations on October 1992.

On 8 May 1992, Hungary once again proposed a discussion on the 1977 Treaty and on the dispute between the two parties, provided that work on Variant C was suspended. Czechoslovakia did not react to this proposal. Finally, on 19 May 1992, Hungary handed over to the government of Czechoslovakia a declaration on the termination of the 1977 Treaty. This declaration contained detailed reasoning for the termination and was accompanied by a "note verbal". The termination came into force on 25 May 1992.

On 2 October 1992, the Hungarian Governement announced that works to revitalise the landscape of Nagymaros would start in spring 1993 and should be completed by 1995, and would cost about 97 milion US dollars.

On 13 October 1992, the initial negotiation started between Hungarian and Slovak delegations in Bratislava to set up a trilateral commission with EC participation.

The delegations did not reach agreement on the mandate of the commission and on the conditions of setting up the commission. CSFR rejected the demand of the Hungarian Governement to stop construction activities on the Slovak side, for example the damming the Danube River and diverting its course during the work of the commission.

On 14 October 1992, the Hungarian representative in the Danube Commission asked the Commission to call emergency discussion in response to Slovak intention to put the Gabcikovo Project into operation.

On 18 October 1992, the Hungarian Government informed the CSFR Government about its desire to set up immediately a trilateral expert commission to evaluate the Gabcikovo Project, on condition that no actions would be realised which might negatively affect the future results of the commission's work. The Hungarian Government considered the damming the Danube River to be in contradiction to such a condition.

On 18 October 1992, there was also the initial discussion between the CSFR Government delegation and the Commission of European Communities in Brussels.

On 19 October 1992, the Hungarian State Commissioner for Gabcikovo-Nagymaros Dam System, Mr. Tatar, claimed that the Hungarian Government did not prepare sanctions against the Slovak Republic but "counter-measures". These were already adopted by the Hungarian Government but would be used only if international law was violated.

On 19 October 1992, the Slovak Minister of Environment, Mr. Zlocha, claimed that the CSFR is willing to consider the latest proposal of Hungary according to which the constructions of the Gabcikovo Project (by-pass canal and navigation locks) would be used only for navigation.

On 21 October 1992, the CSFR Government adopted a resolution saying that it is willing to accept conditions set by the EC to start the work of the trilateral commission, but it stated that the work of the commission must be finished by 2 November 1992.

On 22 October 1992, the first discussion of the delegations of the CSFR, Hungary and the representatives of the Commision of EC took place in Brussels. The CSFR submited a proposal to dam the Danube during the work of the trilateral commission, but not to divert water from the river bed. Hungary refused the proposal. CEC stated that the main condition for the work of expert commission - a moratorium on construction works during the commission's work - has not been accepted.

On 23 October 1992, the Czech Minister of Foreign Affairs, Mr. Zielenec, after a meeting with the German Minister of Foreign Affairs, Mr. Kinkel, reported the discontent of the EC and Germany caused by the CSFR Government's decision to complete the damming of the Danube by 2 November. The CSFR was still subject to international law and therefore both the Czech Republic and the Slovak Republic together were responsible for the situation. After the return of Mr. Zielenec to the CSFR, the tension between the Czech and the Slovak politicians has gradually increased.

On 23 October 1992, the Hungarian Goovernment turned to the International Court in the Hague requesting it to decide on the Gabcikovo case. The State Secretary of the Hungarian Ministry of Foreign Affairs, Mr. Martonyi, at the same time announced that his government has asked the Conference on Cooperation and Security in Europe to open a so called "crisis procedure for the solution of international conflicts".

On 24 October 1992, the damming of the Danube and the start of operation of Variant C began on Slovak territory.

On 25 October 1992, the Deputy Prime Minister of CSFR, Mr. Baudys, claimed that the CSFR Government is internationally responsible for Gabcikovo problem, but at present it is not able to prevent the actions of the Slovak Government.

On 28 October 1992, negotiations between representatives of the CSFR Government, the Hungarian Government and the EC took place in London. The participants signed the London Protocol. According to the Protocol, all works on Variant C (except works related to the navigation, flood control and environmental protection) should be postponed for a period decided by the EC. The CSFR undertook to guarantee to mantain the whole traditional quantity of water ("whole" means not less than 95%) into the whole old Danube riverbed, including the section between Rajka and Palkovicovo, and to refrain from operating the power plant. The trilateral working group should be set up immediately, consisting of three experts nominated by the EC, assisted by one expert appointed by the CSFR and Hungary each. They should review constructions involved in alternative C, and destimate the need for flood prevention, and the risks to the environment, water economy and navigation. They should state if the constructions are reversible, and estimate the costs of landscape rehabilitation. On the basis of the working group's conclusions, further steps of a common approach were to be identified. Both Hungary and CSFR agreed that the International Court of Justice in the Hague should decide on the Gabcikovo case (including legal, economic and environmental aspects).

On 31 October 1992, the damming of the Danube river was completed.

After October 1992, the water level in the old river bed dropped dramatically to a level about 2 m below the lowest mark ever recorded. While Slovak sources repeatedly stated that there would be more than 600 m3/sec of water left in the Danube, Hungarian official measurements recorded only 200 to max. 350 m3. In addition, Hungarian and Slovak sources reported of the dying of millions of fishes and of big masses of snails, crabs and other aquatic creatures because not only the Danube itself but also most sidearms and oxbow-lakes fell dry. Yet, large-scale catastrophic ecological damages could not be observed because of the end of the biological season. They can be expected for spring and summer 1993.

With the lowering of the river and groundwater level, several hundred local wells in Hungarian and Slovak villages (the number is growing) dried out as well. Many people still don't have public water supply becuase, yet, the Danube always guaranteed enough water for their wells. This concerns mainly old people who now carry their water from their neighbors (getting public water). Some people are now waiting for public supply but many can hardly afford to pay for this.

February,1993

Slovak environment minister Jozef Zlocha explained that because the investor could only partially fulfill his duties the ministry so far could not give permission for the construction of parts of the dike, for the new navigation route, for the preliminary manipulation order and the use of the Danube water as well as for the premature use of some objects.

The Slovak Union of Nature and Landscape Protectors (SZOPK) demanded in a letter referring to the published documents ("justified suspicion of the concious violation of law and of unpredictable impacts") the Slovak State Attorney to investigate the legality of the construction and operation of Variant C. He confirmed on 2 March 1993 (i.e. one month after SZOPK sent the letter) the reception and announced to inform about the results.

March,1993

On 15 March 1993, the European Parliament adopted a joint Gabcikovo Resolution. The text supported by 5 fractions includes i.a.

* supports the CEC compromise proposal (50-75% of the water in Danube)
* urgently calls upon the Slovak government to act more flexible and to cooperate in a solution on the open questions;
* asks the EC Commission to put its weight for a quick provisional water supply to prevent further environ ment damages;
* asks the CEC to evaluate the possibility of a financial help to recompensate the possible loss of energy production;
* asks CEC to get done a comprehensive EIA of this project by independent experts as well as a study on the effects on navigation, energy production and other relevant aspects;
* asks CEC to present proposals for an internationally protected area in the Danube floodplains along the bor der involving national and international GOs and NGOs.

On 24 March 1993, responding to the Hungarian Parliament's resolution from February 1993 inviting all parliaments of the world to critisize Gabcikovo, the Slovak Parliament accepted a resolution (against the votes of the Hungarian minority parties) asking the Slovak government for stronger measures in favour of Gabcikovo Project.

Present situation - April 1993

On 7 April 1993, the State Secretaries of Foreign Affairs of Hungary and Slovakia, Mr. Janos Martonyi and Mr. Jan Lisuch, in the presence of Mr. Hans van den Broek, Commissioner for External Political Relations, signed the Special Agreement to submit the Gabcikovo-Nagymaros case to the International Court of Justice in The Hague.

The Danube is still very low (ca. 400 m3/sec). The Slovak constructing companies are continuing to realise their plans and working schedule without interruption. In the floodplain near Bodiky and Dobrohost the most intensive constructions are going on. At several places still intact (but at present dry!) oxbow lakes were filled up with gravel and boulders. The boulder deposits are to be used for new dikes (and new access roads for their construction) which will prevent the irrigation water from "leaking" into the old river bed. Also, several new forest clearcuts have started along the oxbow-lakes.

All political pressure and the resulting bi- or trilateral agreements aiming to save the existing and still near-natural wetland may become useless because until then the investor will have done large-scale destructions in the same wetland.

2. THE ORIGINAL GABCIKOVO-NAGYMAROS DAM SYSTEM PROJECT AS LAIDDOWN IN THE 1977 TREATY

2.1. TECHNICAL DATA ON THE GNDS PROJECT

The original Gabcikovo-Nagymaros Dam System (GNDS) project consisted of two dams between Bratislava (r.km 1860) and Budapest (r.km 1657), and comprised 203 km of the Danube.

According the 1977 Treaty /3/, the principal parts of the Gabcikovo Dam Project (GP) are as follows:

a) The Dunakiliti-Hrusov head-water installations in the Danube sector at r.km (river kilometre(s)) 1860-1842, designed for a maximum flood stage of 131.10 m.B. (metros above sea-level, Baltic system), in Hungarian and Czechoslovak territory;

b) The Dunakiliti dam and auxiliary navigation lock at r.km 1842, in Hungarian territory;

c) The by-pass canal (head-water canal and tail-water canal) at r.km 1842-1811, in Czechoslovak territory;

d) A series of locks on the by-pass canal, in Czechoslovak territory, consisting of a hydroelectric power plant with installed capacity of 720 MW, double navigation locks and appurtenances thereto;

e) Improved old bed of the Danube at r.km 1842-1811, in the joint Hungarian-Czechoslovak section;

f) Deepened and regulated bed of the Danube at r.km 1811-1791, in the joint Hungarian-Czechoslovak section.

According to the 1977 Treaty, the principal parts of the Nagymaros Dam Project are as follows:

a) Head-water installations and flood-control works in the Danube sector at r.km 1791-1696.25 and in the sec tors of tributaries affected by flood waters, designed for a maximum flood stage of 107.83 m.B., in Hungarian and Czechoslovak territory;

b) Series of locks at r.km 1696.25, in Hungarian territory, consisting of a dam, a hydroelectric power plant with an installed capacity of 158 MW, double navigation locks and appurtenances thereto;

c) Deepened and regulated bed of the Danube, in both its branches, at r.km 1696.25-1657, in the Hungarian section.

2.2. DESCRIPTION OF NAGYMAROS AND GABCIKOVO PROJECTS AND THEIR CURRENT STATUS

The Nagymaros Project (NP)

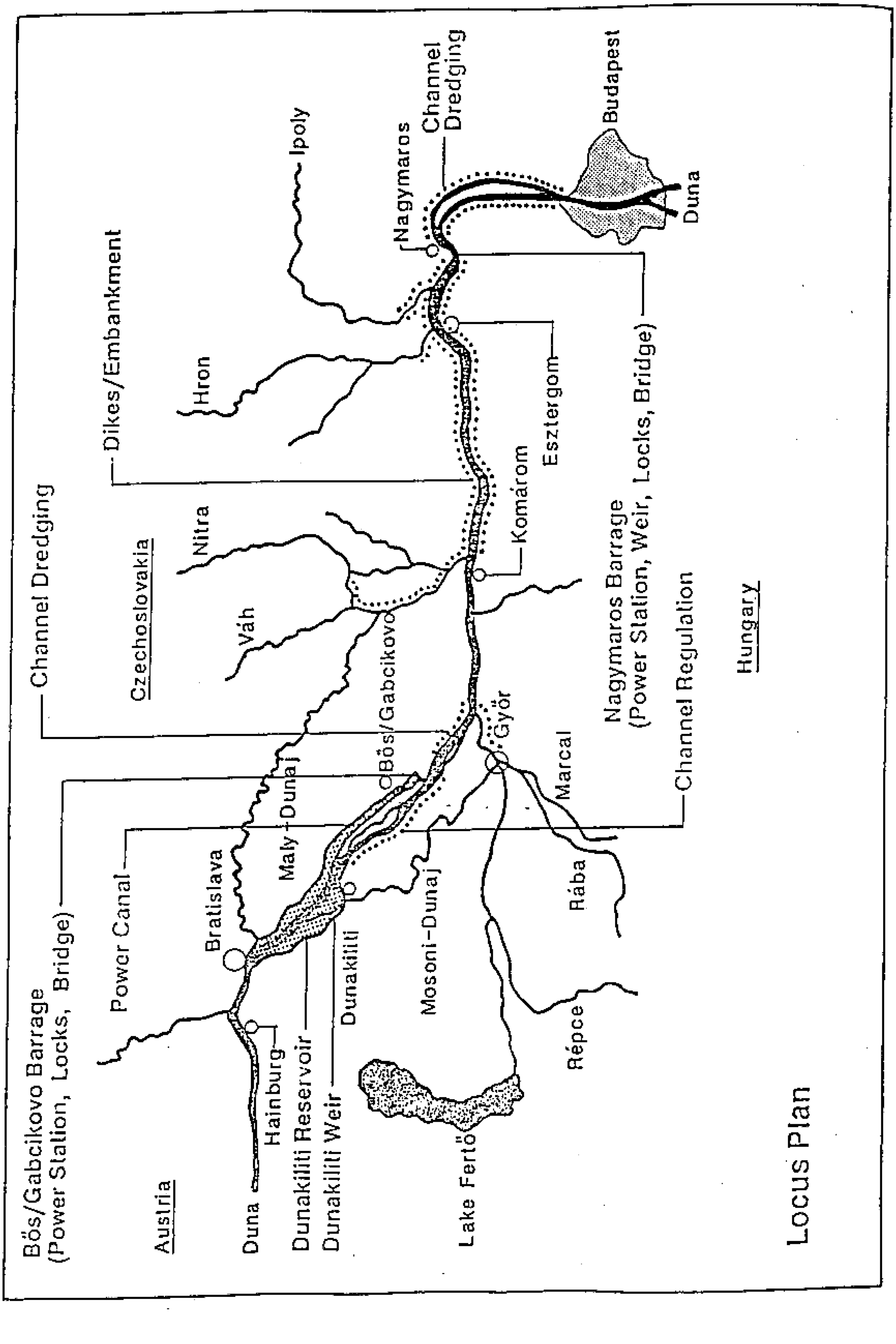
This project, subsequently abandoned by the Hungarian government, started at r.km 1791, and was to serve as an equalization reservoir for the Gabcikovo project. Nagymaros would have taken up an enormous length of 134 km of the Danube flow, and would have consisted of several constructions, i.e.:

- The river barrage at Nagymaros (at historical Visegrad). This dam would have contained 6 turbines, each producing 27.4 MW, for a total output of 1040 GWh/year;

- Extremely expensive protective constructions along the Czechoslovak river bank (paralleling 152 km of the Danube, Ipel, Hron, Vah and Little Danube Rivers) and along the Hungarian river bank (paralleling 127 km of the Danube and Ipel rivers). These constructions included dikes, canals, pumping points, water pipes and sewage-water renovations, electric and heat networks and other constructions;

- The deepening of both of the dissected Danube River branches (2x40 km) from Visegrad to the northern boundary of Budapest.

According to the 1992 decision of the Hungarian Government, the dismantling of the Nagymaros Project's structures, which were already built in Hungarian territory, and the restoration of the whole area should start in the spring of 1993.


Bös/Gabcikovo Barrage
(Power Station, Locks, Bridge)
Power Canal
Austria
Duna
Hainburg
Bratislava
Dunakiliti Reservoir
Dunakiliti Weir
Dunakiliti
Maly-Dunaj
Mosoni-Dunaj
Lake Fertő
Répce
Rába
Marcal
Győr
Bös/Gabcikovo
Channel Dredging
Czechoslovakia
Váh
Nitra
Dikes/Embankment
Hron
Komárom
Esztergom
Ipoly
Nagymaros
Channel
Dredging
Budapest
Duna
Nagymaros Barrage
(Power Station, Weir, Locks, Bridge)
Channel Regulation
Hungary

Locus Plan

The Original Gabcikovo Project (GP)

This project is 69 km long, consisting of a dam and storage lake Hrusov-Dunakiliti, a by-pass canal, hydropower plant with locks, protective dikes, and filter canals, required since the dam is situated in flat terrain.

A dam on the Danube River close to the Hungarian village of Dunakiliti would create a lake 25 km (15 miles) long, covering an area of 60 km^2 (24 square miles) with a total volume of 200 mil. m^3 of which 60 mil. m^3 can be used for peak-shedding power generation through periodic drainfill cycling. The dam at Dunakiliti would be opened only during extreme floods, causing the flood surge to flow through the old water course.

From the Hrusov-Dunakiliti dam, the river would flow through an artificial head-water canal, which is 17 km long, up to 730 metros wide, and towers up to 18 m above the surrounding plains, bringing the Danube water to the hydropower plant at Gabcikovo. The dimensions of this canal are greater than those of the Suez Canal. This canal will reroute as much as 90-97.5% of the Danube's natural flow. Only 2.5-10% of the river's current flow would continue to run through the old bed of the Danube.

The power plant has 8 turbines of 90 MW output. In the continuous mode, the rate of power generation on a yearly average (assuming that no water is left in the old Danube riverbed) is 340 MW and in the "peak shedding mode" (water closet mode) it is 311 MW on a yearly average /6/. Operating continuously, the plant would produce 2980 GWh of energy per year. Approximately 2730 GWh of potential energy would be gathered in the Hrusov dam and then it would suddenly flow through the turbines twice a day after accumulation.

The Danube water then flows from the Gabcikovo power plant through an 8 km long tail-water canal, which is 17-18 m deep, back to the original Danube riverbed. Twenty km down from the mouth of the canal, the stretch of the original riverbed to Gönyu would be deepened.

Since Hungary backed out of the Nagymaros project, the necessary damming on the Hungarian side (the Dunakiliti weir) has not been completed. Now that the Czechoslovak government can unilaterally operate the Gabcikovo power plant, it has built a new weir 10 km upstream from Dunakiliti, close to the Slovak village Cunovo, and extended the canal into Slovak territory (Variant C). These new constructions made the damming on the Hungarian side unnecessary.

3. VARIANT C

In 1989, when Hungary decided to suspend the Gabcikovo-Nagymaros project, large parts of the constructions necessary for the operation of the Gabcikovo power-station and system of locks were ready. These were the Dunakiliti head-water station, the water reservoir, the by-pass canal, and the Gabcikovo power-station and system of locks itself.

The Dunakiliti head-water station was on Hungarian territory and thus could not be operated by Czechoslovakia without the co-operation (or consent) of Hungary. Therefore, Czechoslovakia decided to build a new head-water station 10 kms upstream at Cunovo where the Danube is still totally on Slovak territory. The new head-water station has been built only a few hundred meters away from the point where the Danube becomes a boundary river (at r. km. 1851,75). Czechoslovakia also restricted the water reservoir to its territory, and prolonged the by-pass canal accordingly.

Variant C was chosen by the Slovak authorities from amongst 7 technically possible solutions:

- Variant A: The original project - completion of both the Gabcikovo and Nagymaros Projects, with peak flow operation.
- Variant B: Work completed at Gabcikovo and Dunakiliti, but Nagymaros not built. Dam working continuously.
- Variant C: Land perimeter limited to Slovak territory,avoiding the Dunakiliti dam.
- Variant D: The reservoir is omitted; the main canal is extended to the entrance to Bratislava. Production of electricity is maintained. Weirs are installed on the old river bed to limit falls in the water level and in the groundwater table.
- Variant E: Same system as the previous alternative, but the canal only being used for navigation. The flow retained for the old Danube river bed would then be sufficient to avoid the installation of weirs.
- Variant F: This represents the status quo, the work is not completed and the constructions are left as they are.
- Variant G: The site is returned to its original condition after the destruction of the existing constructions ("Zero Alternative").

The method used to determine this choice was as follows. In 1990, six specialized expert commissions classified the 7 alternatives in function of the following points of view:

- international relations and law	(coefficient of 7),
- influence on water resources	(coefficient of 7),
- economic feasibility	(coefficient of 6),
- influence on the environment	(coefficient of 6),
- social and psychical influences	(coefficient of 3),
- feasibility and risks represented by the work	(coefficient of 3),
- hygiene and epidemiology	(coefficient of 3),
- preference expressed by the contractor	(coefficient of 1).

Those responsible for the various commissions defined the criteria to be evaluated and proposed balancing coefficients attributed to each point of view (in parentheses above). Mr.Liska carried out the final evaluation and classification. It should be said that those responsible for the commissions including Mr.Liska were directly or indirectly linked to the designers and builders of the dam. No independent experts participated in this evaluation.

Although the method used may appear surprising, the same cannot be said for the results /7/.

Since the Danube was diverted at the new Cunovo head-water station on Slovak territory on 24 October 1992, only about 400 m^3/sec (or 20 % of the average flow of 2000 m^3/sec) remain in its old river bed.

The diverted water is returned to the Danube at the point originally foreseen in the 1977 Treaty. Slovak authorities have claimed that the amount of water that will eventually be diverted depends upon the outcome of investigations to be undertaken during the trial period that shall also take into account environmental aspects.

Slovakia also stated repeatedly that, should Hungary not change its position and further refuse to participate in the project, it will build an additional and rather smaller power station on its territory close to the Dunakiliti head-water station /8/.

4. WHAT DAM BUILDERS DON'T WANT YOU TO KNOW: A SUMMARY

Environmental Impacts

The dam builders conclude that the Gabcikovo Project will enhance the environment.

Independent experts have found:

1. Nowhere in Europe is there a more reckless or devastating river construction project than at Gabcikovo. According to the International Rivers Network (IRN), it is among the top-ten most environmentally destructive hydraulic engineering projects in the world.

2. To date (March 1993), no complex environmental impact assessment study has been done neither on Variant C nor on the original Gabcikovo Project, as required by Czechoslovak federal Environmental Act No 17/1992.

3. The Slovak dam-builders' conclusions are inadequate, misleading, and irresponsible because they intentionally neglected the extensive environmental destruction which the construction and operation of the Gabcikovo Project would cause (or has already caused).

Effects on Wildlife and Biotopes

The dam builders conclude that the "optimalization of flow conditions" and "prevention of disasterous, uncontrolled floods" in the floodplain will have a positive effect on wildlife.

Independent experts have found:

The immediate consequence of the power station involves an actual loss of land due to the installation itself. According to data from the Hydrostav construction company, some 5,500 hectares (13,500 acres) of Danube countryside which was very close to its natural, unspoiled state, have already been destroyed. But the indirect consequences of the start-up and operation of the plant will be considerably more serious:

- The typical animal and plant communities and species, many of which are on the endangered species list, will die out in this completely altered habitat. The reduction of many plant and animal species would ensue, primarily the species living in the wetlands and floodplain forests.

- Directly endangered are 130 species of birds (54 % of the total number living in the region), 30 species of mammals (75 %), 8 species of reptiles (90 %), 6 species of amphibians (55 %), and 28 species of fish (50 %).

In addition, at least 17 protected areas in Slovakia would be negatively influenced. The Cormorant Island Nature Reserve has already been destroyed, and at least 4 other reserves have been recently endangered. More than twenty other areas proposed for protection would be negatively influenced. If no change in the attitudes toward the Gabcikovo Project occurs, the proposed National or International Danube Park would lose its sense.

Groundwater Quality and Drinking Water Supplies

The dam builders state that the Gabcikovo Project will not have any negative impact on surface and groundwater quality in the region.

Independent experts have found:

- Europe's largest and, for the most part, still untapped reserves of drinking water exist downstream from Bratislava. Millions of people in Slovakia and Hungary are currently supplied by these reserves. The drinking water situation, which is already precarious in both countries, will worsen considerably as a result of the start-up of the Gabcikovo plant. The plan to increase utilization of these drinking water supplies in the future is therefore questionable. Concerns regarding drinking water supplies was one of the main reasons Hungary abandoned the formerly joint project.

Because of the low rate of flow in the reservoir, an accumulation of mud develops. This accumulation is an ideal breeding-ground for germs that are human-pathogenic (hazardousto humans). These bacteria and viruses find their way into the groundwater by means of infiltration.

In addition, pollutants coming from existing (deposit) sources of pollution downstream from Bratislava could leach out through the water damming and poison the groundwater.

A further danger is posed by hydrocarbon substances from the asphalt layer lining the canal - in particular, carcinogenic benzopyrenes.

Effects on Agriculture, Forestry and Fisheries

The dam builders state that the overall effects of the Gabcikovo Project on agriculture, forestry and fisheries will be positive.

Independent experts have found:

Agriculture:

- Due to the permanent construction, an agricultural area of several thousand hectares has been lost for all time. This loss can be estimated at 5,000-6,000 hectares.

- Because of the barraging and the riverbed change, ground water levels will rise in the vicinity of the flooded area. Ground water levels will decrease in the environment of the rerouting(Old Danube and by-pass canal) because of the reduction of the natural leakage from the live river basin.

This would cause a substantial decrease in agricultural production on more than 107,000 hectares of agricultural soils. The expected decrease of production on the soils most influenced (about 26,000 hectares) is about 40,000 tons of wheat (or an equivalent amount of other crops) annually.

Forestry:

- More than 4,000 hectares of floodplain forests have already been destroyed and an additional 4,200 hectares will suffer due to a lack of water. For this reason, at least 2,700 hectares of the forest will dry out within 3-5 years from the start of the operation of the Gabcikovo Project.

- The expected annual loss of soft-wood production is about 70,000 m^3, which is one half of the total soft-wood (poplar) production of Slovakia. Three thousand and six hundred hectares of the typical floodplain poplar and willow forests will have to be replaced by other tree species which do not require as much water. However, these new, slowly growing forests will not have as much ecological value as the original ones and will not be able to be harvested for 100-130 years.

Fishery:

- The traditional fishery on the Hungarian-Slovak section of the Danube will expire. Because of the water level variations, the spawn laid in the river bank areas and the young fishes living there will not be able to tolerate the flow fluctuations and the muddying. Therefore, the stock of fish will decrease and its composition will change considerably. In the by-pass canal, no durable fish communities will exist.

- The total weight of the fish stock per 1 hectare compared with the present state will decrease by about 66 %. The annual yield will decrease by about 170 tons, even though the total surface of the permanent water bodies in the area will increase. The main reason for this is because the present well-functioning naturally complex water ecosystem will be replaced by several separated, mostly artificial habitats.

River-bed erosion

The dam builders often emphasize that the process of the artificial deepening (erosion) of the Danube's river-bed endangers the floodplain by drying and can be stopped only by impounding water in the Hrusov-Dunakiliti (Cunovo) reservoir.

Independent experts have found:

The last decade's erosion of the main bed between Bratislava and Gönyü can be attributed to three reasons. One is the higher slope of the main river bed, caused by the shortcuts; the second is the large-scale gravel production; the third is the sediment-retaining effect of the barrage systems constructed on the Austrian part of the river.

The formation of the Danube bed into a meandering, middle-reach character would decrease the deepening of the bed, improve the conditions of low-water regulation, augment the water reserves of the region, and could enable the ecological rehabilitation of the side-arms of the river.

The gravel production from the main bed must be stopped. The deepening below the last Austrian barrage can be compensated by retransporting the alluvials carried down-stream, a process which has been carried out on the Rhine for more than a decade.

Geological and Seismic Risks

The dam builders cite the sufficiency and complexity of the geological and seismological research conducted before the construction of GP.

Independent experts have found:

Geological and seismiological documentation evaluating the Gabcikovo Project as a whole is not available. The geological and seismological studies were insufficient and some necessary studies have not been undertaken at all.

The seismic risks were underestimated. The seismicity values defined in the joint contractual plan are not acceptable.

No summary (integration) of the research works, conducted separately on the Hungarian and Slovak sides has aken place so far.

The Gabcikovo dam is built next to a geologically young fault. There are also additional uncertainties concerning the position of the frontier between the Alpine and Trans-Danube tectonic plates.

Flood Control

The dam builders claim that operating the Gabcikovo Project is necessary in order to ensure effective protection against floods in the area downstream from Bratislava.

Independent experts have found:

- New hazards will arise with the declared flood prevention advantages (e.g. dam heightening and strengthening or distribution of the large flood waters between the by-pass canal and the Old-Danube bed). One of these hazards is inherent to the permanent flooding of the reservoir area to a level higher than the all-time floodwater level.

- Another hazard is related to the water mass of the reservoir and the elevation of the by-pass canal to 6-16 m above the surrounding terrain.

- The possibility of a canal bursting its banks or a dam bursting threatens the region with more disastrous flooding of indescribable dimensions.

- As experience from other regions shows, (e.g. the Rhine, the Danube in Austria), peak floods and the danger posed by flooding will increase downstream from the power station.

- Because of the power plant installation and river development, important natural areas that once held back the waters have now vanished. All small floods are rapidly channeled down stream. As a consequence, more frequent and higher floods occur downstream. In addition to the height of the flood-waters, the form that the flooding takes also changes. Instead of a specific, given rate of flow, the sluices and floodgates at the power station are opened which causes a sudden rise of water and mud content downstream. The danger of damage increases accordingly.

Design and Safety

The dam builders cite the high quality of construction works done at the Gabcikovo Project and their high safety standard.

Independent experts have found:

- The manner of construction has been slipshod and, to some extent, unplanned or undertaken without due regard to the plans.

- There are more indications and signs (e.g. flaws and cracks in the dam wall and canal, the halt in the prefilling of the canal with water in August 1991) which indicate the project does not comply with the required specifications concerning structural stability.

- The studies dealing with the dimension design of the earth dam of the Gabcikovo Project concluded that there are earth dams sections which would not be able to withstand an earthquake of the presently - forecast intensity.

- Independent engineers and safety specialists, as well as people formerly working on the project, have repeatedly expressed misgivings in this respect, and consider an immediate examination and verification of the entire installation to be an absolute necessity.

Navigation

The dam builders conclude that the Gabcikovo Project would improve navigation.

Independent experts have found:

- The increase in shipping traffic predicted to follow the dam's construction is unsupported by any studies.

- Navigation problems essentially concern the Vienna-Budapest sector and, in itself. Gabcikovo cannot resolve them. This elementary statement is sufficient to show that Gabcikovo serves no purpose in terms of navigation.

- To resolve the problems, there is a need to build 4 dams. This represents a USD 1 billion investment, being USD 707 million based on values updated at 8 %.

- The development of the Vienna-Budapest sector does not offer any direct profit for navigation: the internal profit rate is negative. The impact of these investments on the overall productivity of the fleet is far from negligible but does not offer any significant profit level: a maximum of 2.5 %.

- The only direct beneficiary from these developments would be the Austrian iron and steel industry for whom they would offer a powerful position for the future. It might then, by offering direct competition, endanger and accelerate the decline of the Slovak iron and steel industry.

- However, the analysis shows that it is essential, inexpensive, and profitable to invest in the structures around the Danube, which could well be more important than making investments in the river itself.

Electricity Production

The dam-builders imply that the Gabcikovo Project must be completed and operated to alleviate Slovakia's energy crisis.

Independent experts have found:

- The Czech and Slovak Republics are characterized by a particularly high over consumption of energy and electricity which exacerbates the difficulties encountered in developing their economies.

- A technical saving potential in Slovak electricity consumption is 40-50 %. However, even assuming full production, Gabcikovo will generate only 6,7 to 7,5 % of Slovaks electricity production.

- Efforts made in terms of energy efficiency could allow the Czech and Slovak Republics to attain by 2010 energy intensities comparable to those currently existing in Europe. Electricity consumption would then be lower than its current level: 23 TWh for all of Czechoslovakia and 6.5 TWh for Slovakia.

- In this context, the electricity produced by Gabcikovo meets no requirements for the future and is worthless in terms of quantity.

- The capital invested in Gabcikovo has been taken away from projects that are far more important to the country's economy. Although it is not possible to redirect the initially invested capital, part of the 5.7 billion crowns (260 million USD) recently earmarked for the construction of alternative "C" could have been used to improve the efficiency of economically profitable electricity production installations. This would have led to energy savings which would at least equal Gabcikovo production. The difference could have been ear industry which, in turn, would have led to greater energy savings and thus provide capital for new investments. This solution would have set up a dynamic favouring the revival of the country's economy.

- The value of Gabcikovo as a source of energy, substituting existing sources (thermal and nuclear), can only be evaluated within the framework of an overall redefinition of the country's energy strategy. Nonetheless, it would appear to be relatively unimportant in quantitative terms.

Economic Aspects

The dam-builders state that the Gabcikovo Project is technically, economically, and financially feasible on a basis acceptable to international financing institutions.

Independent experts have found:

- Many factors which may be very important to decision making were ignored or intentionally underestimated by designers. Among them, the more serious, in the long term, are the inevitable follow-up costs of starting-up and operating the plant:

* Plant repairs and maintenance
* Artificial management of the water table (pumping installation and maintenance)
* Reinforced flood control and protection downstream
* Loss of output in agriculture, fisheries, and forestry
* New irrigation installations for agriculture
* Improved water purification
* Improved drinking water treatment
* Loss of biodiversity - gene variants, species, living communities and ecosystems
* Loss of recreational potential of the area and the output in the service sector (recreation and tourism),etc.

- These consequences and side-effects and their costs affect not only Slovakia, of course, but Hungary as well, even though Hungary backed out of the project in the Autumn of 1989 for these reasons.

- A thorough accounting of these costs has never been done, however it is almost sure that it would make the whole project non-viable.

From an economic point of view, the complete cancellation of the project would be more favorable in the long run, and for the Hungarians, even in the short run the costs of cancellation and continuation would be about the same.

Social Impacts

The dam builders state that the Gabcikovo Project will have a positive impact on the regional development and the living conditions of local inhabitants.

The elected representatives of local citizens and a vast majority of citizens themselves disagree:

- Local people both in Hungary and Slovakia have opposed the GNDS project since its very beginning. They have been never asked for their approval of the project, nor have any compensations been paid them for the reclaimed land, destroyed environment and loss of natural values in their traditional communities and landscape.

- Local residents are losing touch with the Danube, a river that has given rise to centuries-old customs and traditions, and which is a decisive factor in their very identity. As a result, they are losing a large portion of their homeland habitat.

- Above all, the inhabitants of the three villages of Dobrohost, Vojka and Bodiky are feeling excluded and rejected. Stranded between the canal and the Danube, they are watching a rural exodus which may leave their villages completely abandoned in the near future. (The population dropped about 50 % during the last decade due to induced emigration.) For them, this project is an "indirect eviction".

Construction and Operation of Variant C under International Law

The dam builders and the Slovak government officially state that the construction and operation of Variant C of the Gabcikovo Project is in accordance with international law because it finds a "justification" in the 1977 treaty. They consider Variant C to be a "lawful response" to an alleged violation of the 1977 treaty by Hungary. In addi-

tion, the Slovak government argues that Hungary had no right to terminate the 1977 treaty, because it does not contain any provisions concerning potential termination.

Independent experts have found:

- Slovakia's unilateral diversion of most of the Danube, and any resulting environmental damage to the portion of the Danube flowing into Hungary or any other part of Hungarian territory (including, for example, the groundwater aquifer), violates the basic international principle of state responsibility that one country should not use their territory in such a way as to harm another.

- Variant "C" is in violation of well established and fundamental principles of customary international law on the environment and the use of international rivers: the principle of good neighborliness and the principle of equitable utilization. In addition, construction and operation of Variant "C" is contradicting the spirit of many legally nonbinding international declarations on the environment which were supported by Czechoslovakia.

- Variant C is in violation of the principle of good neighborliness because in will cause significant or appreciable harm to Hungary.

- Concerning the examination of Variant C under the principle of equitable utilization, it cannot be regarded as an equitable utilization, mainly because the negative effects of Variant C far outweigh its benefits and the legitimate interests of Czechoslovakia and Slovakia in carrying out the project. The diversion of the Danube will have extremely negative impacts on the environment and on the traditional uses of the Danube so that it must be regarded as inequitable.

- Slovakia's diversion of the Danube by construction of Variant C violates the treaties establishing the borders between the CSFR and Hungary. Variant C is also in violation of provisions on the management of boundary waters contained in the 1956 Boundary Treaty and of provisions contained in a treaty of 1976 regulating questions of water management of boundary rivers.

- Variant C contemplates diversion of frontier waters at a place and with structures not contemplated by the 1977 treaty. Whatever the current legal status of the 1977 treaty, the dam and diversion of the Danube now being constructed under Variant C were never agreed to by Hungary and cannot establish a legitimate border change.

- Czechoslovakia and Slovakia were not allowed to implement Variant C as a unilateral action after Hungary decided not to fulfill its obligations of the 1977 treaty. Instead, both parties must seek a peaceful settlement of their dispute through negotiations and refrain from unilateral actions.

Alternatives to the Gabcikovo Project

The dam builders state that if the Gabcikovo Project is not completed, then there would be no possibility of restoring the area affected by construction into its original natural state. Moreover, they consider the removal of existing constructions and the restoration of the area to be the most expensive and therefore an unacceptable alternative for Slovakias economy.

Independent experts have found:

- The total costs for removal of all GP constructions in the case of Variant C, including incomes from recycled materials, would be about 12-13 billion Czech crowns. However, there is no urgent need to remove all the constructions within few years. Some of them can be used directly or redesigned for certain purposes, e.g. the dikes of the reservoir for flood protection of the adjacent area, others can be removed gradually. The efficient reuse of all usable constructions would reduce the total costs of removal up to 60%.

- The primary building materials used for the constructions, especially gravel, sand, soil, steel, asphalt, and plastic films and also some of the concrete, can be reclaimed.

- A relatively simple task is the demolition of the coffer dam at Nagymaros and the restoration of the river bed. The reconstruction of the previously curved shoreline at Visegrád seems to be an important question, since this is one of the essential elements of the landscape of the Danube-bend.

- Since the structures of the Dunakiliti weir and the power station Gabcikovo cover relatively small areas, their demolition would be rather costly, so they could remain where they are. A tender may be announced for their utilization. The new structures of Variant C should also be pulled down.

- During the reconstruction of the area, the Nagymaros coffer dam and constructions of Variant C have to be demolished first. The next task would be to correct the wrong regulation, rehabilitate the branches, and begin the restoration of the forests on the flood plain. The dismantling of the side channel can be a slower process, and can be coordinated with the soil-regeneration.

- The restoration of the shoreline forests upstream from Nagymaros and other elements of the landscape could be done later, depending on the available financial means. The damages caused to the population by the construction of the barrage system should be refunded quickly and should be covered by the state budget.

- The restoration of the floodplain forest and other floodplain ecosystems should be left to natural self-restoration processes, only with some supportive measures in some areas, e.g. connecting the isolated branches with the main Danube bed, planting trees, introduction of sound forestry and fishery practices, etc. The most valuable floodplain areas which were damaged by the Gabcikovo Project can be restored to a state which world be very close to the "original" one (the state before beginning construction in 1978) within 15 to 20 years, for a cost of about one billion Czech crowns.

- The costs should be divided fairly between the parties. The expenses of those works which were accomplished within the framework of the 1977 treaty - before that treaty was terminated - and the costs of the restoration tasks should be reasonably divided between Hungary and Czecho-Slovakia (or her legal successor), in equal proportions.

5. IMPACTS OF GNDS ON ECOSYSTEMS AND WILDLIFE

Both the Gabcikovo and Nagymaros projects are planned in the floodplain area, where the ground and surface water systems determine the landscape. Changes in that system due to GNDS will impact the floodplain landscape enormously:

5.1. IMPACTS ON THE IMPOUNDED STRETCH ABOVE THE HRUSOV-DUNAKILITI DAM

Ground water levels will be elevated in the area upstream from the dam Hrusov-Dunakiliti, causing ground waterlogging shortly after filling the dam with water. However, the decline of ground water levels due to human activity near Bratislava can hardly be corrected in this manner. Survival of the floodplain forests in Rusovce (downstream from Bratislava) is threatened. In that area, Slovak environmentalists have obtained partial changes in the technical project.

Muddy sediments will be deposited at the upper end of the Hrusov-Dunakiliti basin, especially under the peak mode of Gabcikovo power plant operation. A lower water velocity, together with large quantities of muddy deposits (several millions tons a year), will deteriorate the oxygenation of bank-filtered water. This will be followed by the deterioration of ground waters used for drinking in Bratislava and the surrounding areas, the water pollution coming partially from Austria but mainly from the Czech and Slovak Republics (down the Morava River and from Petrzalka - the 140,000 inhabitant suburb of Bratislava without a sewage plant, from the Bratislava port, etc.).

5.2. IMPACTS ON THE IMPOUNDED STRETCH ABOVE THE NAGYMAROS DAM

Due to the elevation of the water level in the Nagymaros dam, both extensive seasonal waterlogging of the ground (6,000-11, 000 hectares on the Czechoslovak side) and constant waterlogging (about 2,300 hectares) would occur. High levels of ground water would cause the damaging salinization of about 1,600 hectares of productive soil. Massive water pollution would be a danger for ground waters, since construction of sewage plants is still far from finished for the waters coming to both dam reservoirs via the Danube and its tributaries. This threatens to damage the drinking water sources originating through bank filtration. Moreover, the karsten waters in northern Hungary could be endangered. Other threats are the destruction of cultural heritage and archaeological monuments and the loss of the natural landscape.

5.3. IMPACTS ON THE STRETCH BELOW THE HRUSOV-DUNAKILITI DAM

A primary environmental and economic problem is the by-pass canal area downstream from the Hrusov-Dunakiliti dam. In this area, the ground water levels around the original, abandoned Danube riverbed would sink, declining by 3-4 m, with smaller declines farther away from the Danube.

Because an insufficient amount of water is planned to be left in the Old-Danube:

- the basin will become marshy,

- the water supply of the branches from the main stream will cease or decrease; the isolated old river branches may get filled in,

- the wet living places will become isolated, the coherent flood areas fragmented, and the parkland ecosystems accustomed to oxygen-rich waters will become seriously degraded.

The by-pass canal has a waterproof construction. Without sufficient bank-filtered water, 30,000-40,000 hectares of soil on the Slovak side would be negatively influenced, 26,000 of which would be severely affected leading to a loss of agricultural production equivalent to 39,000 tons of wheat. Irrigation cannot replace the natural ground water system. Forests and river branches in the unique area of the inland Danube delta would dry up.

An additional modification of the Danube branch system downstream from the Hrusov-Dunakiliti dam has been accepted according to the demands of environmentalists, ecologists, water-managers and others in the area. The modifications consist of the possibility of filling the branches with 50-250 m^3/s of water, infiltrating the ground with occasional or even regular intentional flooding of the area, and making the nature around the Danube function on the principle of a water-closet. However, this would create only a local benefit of saving the trees adjacent to river branches and would not benefit the flood-plain forests as a whole, since the ground water would be drained further from the branches by the abandoned Danube riverbed.

The decline of ground water levels would probably also cause the mineralization of soils, together with an elevation of nitrates in ground waters. Remember that there are 10-14 km^3 of drinking water stored in the gravels on the Slovak side of the Danube; the same is true for the Hungarian side of the Danube.

5.4. THE IMPOVERISHMENT AND DETERIORATION OF THE LIVING COMMUNITIES

The living communities (biocenosis) are natural resources and national treasures of inestimable (and as yet unassessed) value.

Due to the change in hydrodynamic conditions and the drifts of the bio/geochemical processes induced by the new conditions, moreover, due to the deterioration of the water quality:

- The composition of the living communities will also be changed, and their patterns rearranged within a short time.

- In the course of this process, the variety of species and the genetic diversity of types will decrease. An essential degradation will take place.

The rapid variations will ultimately eliminate varieties (presumably millions) of gene variants from the area. This will endanger the adaptability of the surviving members of the remaining living communities. This adaptability would be vital for them in the changed environment.

Because of the water level variations, the spawn laid in the river bank areas and the young fishes living there will not be able to tolerate the flow fluctuations and the muddying. Therefore, the stock of fish will decrease and its composition will change considerably. In the by-pass canal, no durable fish communities will exist.

5.5. NATURE PROTECTION

As for nature protection, at least 17 protected areas in Slovakia would be negatively influenced. The Cormorant Island nature reserve has already been destroyed, and at least 4 other reserves have been recently endangered. Twenty other areas proposed for protection would be negatively influenced. If no change in the attitudes toward the Gabcikovo Project occurs, the proposed National or International Danube Park would lose its sense. The reduction of many plant and animal species would ensue, primarily the species living in the wetlands and floodplain forests.

6. GROUNDS AND WATER QUALITY

6.1. EFFECTS ON THE WATER ABOVE THE GABCIKOVO AND NAGYMAROS DAMS

If the dams are built, the river transport of drift gravel will be blocked. Polluted mud, unfiltered by gravel, will settle on the banks and on the river bottom for about 200 km where the river is artificially slowed.

The current in the lower reservoir will drop to half its present average speed. Along the riverbanks, the drift speed will drop below 0.4 meters per second, allowing even the finest granules of mud to settle on the gravel that now acts as a filter layer for riverside wells. Oil pollutants, becoming more and more frequent, tend to block this gravel filter. The increased water pressure, instead of washing the blockage away, tends to make the mud more compact, with an increase in oozing resistance and a decrease in dissolved oxygen.

The effects discussed above lower the output of riverside wells and the water quality. Chemical purification plants must be built, and/or other sources of water must be found and exploited, at considerable cost.

6.2. EFFECTS ON THE WATER BELOW THE NAGYMAROS DAM

The effects of the Nagymaros Dam will also be felt on filter wells downstream, on the 30 km stretch where most of the wells supplying Budapest are located. These wells produce about a million cubic meters of water per day. Gravel was dredged here before dam construction began, making the riverbed, on average, 70 cm deeper. The water level also dropped by 70 cm, resulting in a 60,000 m^3 drop in well output.

This first dredging produced shallows and deep cavities, and compensatory dredging is required to make the riverbed suitable for shipping. This would stir up the mud again, and it will most likely settle on the filter layer of the best wells along the banks and seep into the extracted water. The water studies, anticipating this, predict that the available water output for the capital will drop by another 78,000 m^3 as soon as the dam is built. The further deepening of the river below the dams, where 70% of the wells supplying Budapest are located, is expected to cause a further 14% drop in the capital's water supplies.

6.3. ENVIRONMENTAL EFFECTS OF OPERATION AT PEAK CAPACITY

Periodically, the level of stored water is to be raised and the water released for peak energy production. This means that the flow of the Danube will be blocked for eight hours once or twice a day, and then released over the following five hours. The water level of the lower reservoir will fluctuate by about five meters. The level of underground water below Gabcikovo will rise dramatically and then sink again. There is no doubt that this will be harmful to farmland.

The area worst hit by the abruptly-released water mass will be Györ, a town of 140,000 located at the confluence of four tributary rivers that flow into the Danube. Every day the reserved water would flow as much as 20 km upstream into these rivers, and then flow back downstream as the water is released. Urban and industrial sewage water, which is still untreated in the Györ area, would flow back and forth along the riverbanks.

In 1983, the Governmental Environment and Nature Protection Board ruled that the biological purification of Gyor's sewage water, as well as that of all settlements and industrial plants between Györ and Nagymaros, is to start before the year 2000. If the plans are followed and the power stations are put into service by 1992 before purification plants are in operation, the riverside filter wells will be irrevocably polluted.

This is the situation on the Hungarian side. The Hungarian study of environmental effects, made on the basis of data published in Czechoslovakia, indicates that the amount of pollutants entering this stretch of the Danube from the Czechoslovakian side is ten times greater than the amount of pollutants entering from Hungary. The issue of sewage purification is not mentioned in the bilateral contracts.

6.4. EFFECTS ON GNDS WATER SUPPLIESIN HUNGARY

More than half of the clear water reserves in Hungary are located in or near the Danube. If these are lost or polluted, Hungary will be one of the countries hit by a water deficit sometime after the year 2000.

The clear water reserves in the alluviums accumulated by the Danube over the course of geological history are therefore important. These reserves are largest where the river passes from mountain to flatland - exactly between Bratislava and Gyor, where it has created two large islands and deposited a gravel layer containing 14 km^3 of clear water, 6 km^3 of it on Hungarian territory.

The reservoir impounded by the Gabcikovo dam would lie above this gravel field. Silt containing pollutants from Bratislava will inevitably be deposited, and make its way into the gravel bed. The depth streams caused by the repeated closings will wash the pollutants into the stratum water.

Anticipating this, the planners have suggested that the polluted mud be regularly dredged and deposited on the riverbanks. However, the pollutants would still be seeping into the gravel stratum and thus spoil a quarter of the Hungary's sub-surface water reserves.

The other major clear water reserve is the karst water in the trans-Danubian mountain range 50 km away from Budapest. A research report from the Hungarian Hydraulic Research Institute states that, due to the opening of new coal mines, "the level of karst water has become considerably lower than that of the Danube when impounded by the barrage, which is six meters higher than flood level. ... Since the Danube can flow directly into the karst water through cracks in the rocks... if the Danube stays highly polluted and if the direction of flow changes, the Danube will spoil the karst water supplies once and for all."

That means another 40 km^3 of clear water lost, in a country where clear water is fast becoming scarce.

6.5. The Influence of the Gabcikovo Project on the Quality and Quantity of Surface and Ground Water in Slovakia

The Danube River as a Primary Source of Drinking Water and the Problem of the Influence of the GP

Source: Lichvár, 1990.

Every country evaluates the wealth of its land and the possibilities of its development by the resources of raw materials it owns. The two main resources are: water and soil. And to be more precise, it is mainly drinking water and soil with the highest fertility.

In Slovakia, such a source can be found in the Danube River and the so-called Zitny Island - the granary of the country. Both sources are in the critical area where the GP is situated. In connection to the evaluation of the GP influence, we consider this fact to be the most relevant collision factor. All other ecological risks are connected to it.

According to the Czecho-Slovak Water Act, areas with natural water accumulation can be proclaimed as protected water management regions (PWMR). Zitny Island, the left bank plain of the Danube River downstream from Bratislava, belonging to the Podunajska Plateau with an area of 1273 km^2, was the first region to be proclaimed a protected area (PWMR) by Slovak Government Order No. 46 - 1978. So the importance of Zitny Island as a drinking water resource is not unknown, both specialists in water management and the Slovak government are familiar with this fact. The Danube River enters Slovakia by the "Devin Gate" after flowing 1000 km from the French border, through Germany and Austria. For centuries, it has brought great amounts of sand and gravel, which after passing the narrow "Devin Gate" at higher velocities, flooded the lower lying areas (the so called "Panonia Sea") and gradually filled the region downstream from Bratislava and Zitny Island with sedimented silt.

The decrease in the river flow velocity after "Devin Gate" meant good conditions for the sedimentation of gravelsands which created an enormous sedimentation cone there. The depth of the sand and gravel sediment belt is approximately 25 m at Bratislava, 15 m at Komárno and 400 m at Gabčikovo. From the geological viewpoint, these are mostly Quarternary sediments under which neogene sands and clays can be found - practically impermeable.

From the water supply point of view, most important are the Quartenary sand and gravel sediments layered underneath the covering clay and clayish sand layers (1 to 3 m thick); in some places these gravel-sand sediments reach the surface. The existing Danube river-bed is placed on these gravel-sand sediments and so river water infiltrates easily into the underground.

The construction and especially the operation of GP will considerably influence the creation and formation of the groundwater supplies of Zitny Island, especially in the the section of the Danube of very intensive infiltration (downstream from Bratislava).

The infiltration of the Danube water into Zitny Island consists of some vertical infiltration through the bottom of the river-bed, but mostly of horizontal infiltration through the left bank which is most intensive in the upper part of the PWMR. Groundwater flow is almost parallel to the flow of the Danube River. Surface water infiltration decreases gradually along the river but exists along the whole bank-line up to Gabčíkovo, although not with the same intensity. Hydrogeologists calculated the utilizable groundwater capacity of Zitny Island to be 17 800 l/s, based on the above mentioned facts. T his was also approved by the Slovak State Commission for the classification of natural resources.

According to administration information, up to tue year 2030, this drinking water resource should provide 9 983 l/s of pure drinking water with a quality meeting Czecho-Slovak standards for the approximately 1.5 million inhabitants of Bratislava, the West-Slovak region and South Moravia. Local water resources in small towns on the Island having about 100,000 inhabitants expect the demand to increase by another 824 l/s to the year 2000. The water management development conception also considers the delivery of another 1 000 l/s for the water-deficient areas in Central Slovakia and up to 1 200 l/s for the Eastern Slovak region in the year 2030.

That would mean that in the next 40 years, Zitny Island will have to supply the inhabitants of the Slovak and Czech Republics with approximately 13 000 l/s of drinking water. Further permanent claims on groundwater from

Zitny Island are for irrigation purposes, existing and planned water treatment plants, and also technological demands for various economic purposes.

Danube Water Quality in Relationship to the GP
Source: Zekeova,1990

The influence of the Gabcikovo Project on Danube water quality and consequently on the quality of water infiltrated into the groundwater basin of the protected water management region (PWMR)

- Zitny Island will be determined by processes undergoing in the Hrusov reservoir. The reservoir is 16 km long, 3-4 km wide, with a storage capacity of 49 million m^3 and covers an area of 52 km^2. It is situated downstream from Bratislava at the Danube River section where water infiltration into the groundwater basin of Zitny Island occurs. According to Gazovic (VÚVH, 1975), the amount of infiltrated water is 2 to 8 m^3/s and Hálek (VÚT Brno, 1965) considers an average of 4.4 m^3/s.

Water quality in the Hrusov reservoir will depend on the following :

- The quality of water entering Slovak territory from the "Danube states" upstream;
- The quality of water from the Morava River, the waters of which are not fully mixed with the Danube waters upon entering the reservoir. According to Rodziller, at average discharges of the Danube and Morava Rivers, an 80% mixture can be achieved only 135.8 km downstream from the confluence of these two rivers;
- The amount and composition of waste-water discharged directly into the reservoir from Istrochem chemical plant (CHZJD) Bratislava after mechanical and biological treatment and from the city sector Petrzalka (at present without waste-water treatment);
- The physical-chemical, biochemical and other processes taking place in the reservoir itself under various hydraulic-hydrological conditions.

Characteristic values of water quality indexes on the inflow into the reservoir from 4.1989 to 4.1990 are evaluated from data gathered during a complex Danube water quality monitoring program (Czecho-Slovak-Hungarian KHV). From 61 monitored indexes, those which are vitally important for determining water quality were chosen.

According to the long-term results of the Danube water quality analysis (Antonic, 1966, Rothschein 1966-1975, Ardó 1963-1989), its basic water chemistry is relatively stable. This is a result of the hydrological and hydrochemical regime of the Danube, which is formed basically in the territory of Austria, where the biggest Danube tributaries from the Alps enter the river. The main alpine tributary is the Inn River, which has a higher discharge than the Danube at their confluence, and gives the Danube River an expressive alpine river character. Consequently, the Danube water preserves its relatively stable mineralization even on Slovak territory. The difference between the summer minimums at high discharges and winter maximums at low discharges fluctuates within the range of approximately 25%. Individual components of mineralization, also being rather stable (chlorides, sulphates, hydrogencarbons, calcium, sodium, potassium, magnesium), have a high grade of statistical dependence on discharge values (correlation coefficient $r=0.85$), which allows us to calculate the concentration of individual mineralization components using regression analysis.

Viewing the oxygen regime of the Danube River and consequently the Hrusov reservoir, the key role of dissolved oxygen is quite obvious.

In regard to this fact, the volume of organic matter subject to biochemical decomposition has to be studied. If we consider the character of the river and the water temperature, which does not exceed 20$C even in summer periods, the concentration of dissolved oxygen stays within the range of 7.4 to 13.1 mg/l O2, with an average of 10 mg/l O2. That means that the water saturation by oxygen related to these values does not drop below 81% and maintains 90% of average saturation. An oversaturation of water by oxygen (101-110%) can be expected in the vegetation period, due to increased occurrence of algae, with maximums from late May to late July when concentrations of chlorophyll "A" are higher than 60 mg/m^3.

The organic contamination of the Danube River, as expressed by the biochemical oxygen demand (BOD), has a dropping tendency in the past five years due to paying more attention to the biological purification of waste-waters, especially from big agglomeration centers (Linz, Vienna). The values of BOD5 decreased during that period to an average 4.7 mg/l O2 in the winter period.

The evolution of the contamination of the Danube River by organic substances is characterized by an increase of substances less liable to biological decomposition in comparison to biologically easily decomposed matter. This can be documented by measurements of BOD5 and ChOD (chemical oxygen demand) in a monitored profile. The ratio BOD5/ChODcr is now in the range of 0.16 to 0.20, while in the years 1985-87, the range was 0.27 to 0.29.

The values of ChODcr are a good indication of the so called "excess materials" which were not removed by the waste-water treatment plants. These are above all organic substances, biologically less decompositable, discharged from oil refineries, chemical productions, cellulose plants and so on.

The SC/MS method was used for the identification of organic matter. Altogether, 255 different organic substances were qualitatively identified in the Danube, belonging to the following groups :

- aromatic hydrocarbons and their derivatives;
- aliphatic linear and ramified hydrocarbons;
- cyclic aliphatic hydrocarbons;
- polycyclic aromatic hydrocarbons;
- oxidative hydrocarbon derivatives including heterocyclic;
- pesticides and similar compounds;
- organic phosphorous, nitrogen and sulphur compounds;
- single-phased phenols and their derivatives.

Aliphatic and aromatic hydrocarbons are represented in the greatest amounts as "oil substances". When some of these substances were quantified (benzene, toluene, ethylbenzene, 1,3-dimethylbenzene...) it was found that their concentrations did not exceed the WHO drinking water limits. Oil substances measured in the UV zone (nonpolar extractable substances) were in the range of 0.02 to 0.06 mg/l in the monitoring profile, but values ranging from 0.3 to 0.71 mg/l were also measured (profile center and left bank). These are considered extreme, but cannot be excluded from the evaluation. From the viewpoint of water quality in individual sections of the reservoir, this extreme contamination has a far-reaching importance.

Twenty-seven different compounds, mainly under the detection limit of 0.1 ng/l, were identified from the group of aromatic polycyclic hydrocarbons. Using a highly effective LC with flowmetric detection at river km 1842 (Hrusov) on the Danube the following compounds were found : fluoranthen 0.5-10.5 ng/l and benzoapyrene 0.2-1.3 ng/l. According to the CS Standard 75 7111, the limits for permissible risk for drinking water are exceeded for benzoapyrene and the indication value for fluoranthen.

An increased amount of phthalic acid derivatives were found in the Danube River. According to the US EPA, these are main pollutants, so more attention should be given to them in further observations.

In addition, increased amounts of pesticides (29) and similar compounds were found (degradation products). Some were quantitatively analyzed (hexachlorbenzol, heptachlorine, DDD, DDT, methoxichlorine, heptachlorepoxide, aldrin, dieldrin) and their concentrations were under the indication limits using present analytical methods.

From polymeres - derivatives of heterocyclic compounds of sulphur and nitrogen (especially derivatives of benzthiazol, mercaptobenzthiazol, nitroanthracene and others) were observed.

Organic pollutants belonging to the group of volatile chlorinised hydrocarbons were represented in the Danube by trichloroethylene, tetrachloroethylene, and chloroform. Their concentrations did not exceed the WHO limits for drinking water.

From the prognosis viewpoint, we have to count with the cumulation of these compounds in the Hrusov reservoir the consequence of sorption processes on dissolutable matter, which will sediment in the reservoir.

It is important to state that among the identified compounds there are substances which are on the so called list of "forbidden pollutants". These are isomers of lindan, aldrin, dieldrin, hexachlorobenzene, alachlorine, penthachlorophenol from phenol derivatives, diazobenzene from organic nitrogen compounds, and benzoapyrene from polycyclic aromatic hydrocarbons.

The oxygen regime of the river is also influenced by the spreading of phytoplankton, which is caused by the increased amount of biogenne elements. The concentrations of nitrogene and phosphorous compounds are high in the yearly average, and in the winter months, they almost double. For instance, the maximum total nitrogene amount of 4.69 mg/l N in the Bratislava profile and the 5.00 mg/l N in the Hrusov profile (5.2 mg/l N in Rajka) are 10 times the amount in pure natural waters without considerable anthropogenic pollution. From the standpoint of algae development, the Hrusov reservoir will serve as a catalyst of the eutrophysation process which can be influenced only by minimalizing the amount of macrobiogenne elements (N and P) - that means inserting another procedure into the treatment of waste-water discharged into the Danube River.

An evaluation of the chlorophyll concentration measurements as a measure of the phytoplankton biomass influence on the process of changes in water quality needs deeper analysis. Current studies and works of experts from the 1970 s (Ertl, Tomajka, Vranovský and others) should be used.

The water flowing into the reservoir contained the following inorganic micropollutants : copper, total chrome, lead, cadmium, nickel, arsenic, mercury, zinc, iron and manganese. Concentration amounts provided by Wachsom exceeded in average concentrations of zinc, lead and mercury. Taking into account the hardness index of water (9-13.2 $N), and the concentration of hydrogen-ions (pH=7.9-8.4), then the concentration of metals in the water after filtration is low. As testified by our Hungarian collegues (analyses of unfiltrated water samples), an essential part of these metals is sorbed to dissolutable matter. The measured values support the prognosis that fine suspended particles, especially clay particles, will enrich bottom sediments and heavy metals.

It is well known that the evaluation of Danube water quality is not positive from the microbiological point of view (due to anthropogenic influences). The amount of coliform bacteria, with a maximum amount of 210 000 per liter in the winter months and a minimum from April to mid July, classify this water as polluted (strongly polluted). Psychrophylic nucleus also have their maximum concentrations in the winter months (from 2 300 to 28 000 per ml). A similar trend can be noticed for mesophyle nucleus (from 700 to 10 000 per ml).

When forecasting water quality in the reservoir, especially the left-bank infiltration zone, the amount and composition of waste-water discharged directly into the reservoir from the two big industrial complexes of Istrochem (CHZJD) (river km 1863.4 and 1863.45) play a very negative role. Even from the viewpoint of a currently good hydrological regime of the Danube River, this state is not satisfactory due to the composition of these waste-waters. The quality of the infiltrated water will decline due to the changes in water flow velocity in the reservoir, changes of dispersion conditions, sedimentation, and possible interactions between the liquid and solid phases.

The municipal sewerage system from the Bratislava suburb of Petrzalka is ousted into the right bank of the Hrusov reservoir. Waste-waters from 120 000 inhabitants of this part of the city and from city industry are currently not treated.

Groundwater Quality in Relationship to the GWS
Source: Lehocky,1990

Natural conditions belong to the most important factors influencing groundwater quality - the natural environment in which groundwater accumulates and creates its own natural regime. Water "enters" this environment usually by bank infiltration in the horizontal direction or by seepage through the profile in the vertical direction. The limiting factor in both cases is the initial state (quality) of the infiltrating water. The processes which take place in this environment and have prior importance for the quality of the groundwater are mainly chemical, physical-chemical, biochemical, microbiological, and some others. The final groundwater quality and the evolution of its overall chemical composition, in addition to the above-mentioned processes, also greatly influenced by human activities.

The Danube is the limiting factor for the amount and groundwater quality of the Zitny Island region - this significant European groundwater reservoir.

The Danube supplies the groundwater basin of the river sand and gravel sediments directly after flowing through the "Devin Gate" onto Slovak territory. The permeability of these sediments is very high and reaches an average of approximately 3,8 . 10-3 m^3/s. These sediments create an enormous groundwater basin with water of very high quality which can be utilized without any further treatment.

Changes in the flow and water level regime of the Danube River directly influence the groundwater levels. The Danube permanently supplies the groundwater basin downstream from Bratislava, also during extremely low flows. The fluctuations of the Danube water level oxidise the upper groundwater layer and so create an oxidation zone which is very positive for processes influencing the groundwater quality.

Based on conclusions of long-term observations and chemical analyses, we can state that groundwater in this region is of average mineralization of the hydrogen-carbonate calcareous-magnesium type, with an optimal representation of the individual elements which create water of high quality.

Interference and anthropogenic influence of the last decades have negatively interfered with the groundwater quality. In the bank zone of the Danube River, an area of very intensive infiltration, the groundwater quality is to a crucial extent directly dependent on the quality of the water infiltrating from the Danube river-bed. This area extends a few kilometers inland into Zitny Island. Numerable water sources which supply the inhabitants with drinking water prove that this water is of high quality and can be utilized without further treatment or purification.

Until now, the construction of GP has interfered considerably into the ecology of the region, negatively influencing forest management and agriculture. If GP is brought into operation, it would also mean a negative influence on not only the quality of the water in the Danube River (especially the Hrusov reservoir), but also in the groundwater quality of Zitny Island.

Principle changes in the water quality of the Danube will occur in the Hrusov reservoir. These will considerably influence the groundwater quality in the infiltration zone.

Changes in the quality of the water in the reservoir are dependent on :

- the quality of Danube water flowing from Austria;
- the quality of water in the Morava River (there are almost no waste-water treatment plants in the Morava River watershed);
- the composition of waste waters discharged into the Danube in the Bratislava region, especially from Istrochem (CHZJD) - water is not purified at present; Slovnaft (excess contamination); winter port; untreated waste-water disposal from the Petrzalka region; and so on;
- the complicated physical-chemical, biochemical, biological, microbiological and other processes which will take place in the Hrusov reservoir under new conditions.

The above-mentioned changes in the quality regime of groundwater will show themselves in the following way:

1. The intensity of water infiltration into the groundwater basin will increase in the first stage of the Hrusov reservoir filling, due to the increase in the water level (from 122 m.s.l. to 131.1 m.s.l.).

2. Due to a decrease in the waterflow velocity in the Hrusov reservoir, great amounts of deposits (about 2.6 million m^3 of suspended material per year, that is a layer about 5 cm thick over the whole area of the reservoir) with a 10-12% content of organic matter in the dry residue will remain deposited in the reservoir. The decomposition of this organic matter will demand a certain amount of oxygen, so the present oxygen balance of the Danube River will be unsettled (anaerobic processes will occur in some places in the reservoir).

3. The ammount of oxygen in the reservoir will decrease about 40-50%, that is to a concentration of 5.5-6.0 mg/l O_2.

4. Complicated phenomena in the structure of groundwater flow are expected in the infiltration zone. This fact may result in the spreading of contaminated material via the so-called "privileged routes" (at high water levels oil substances and other contaminated matter can be found in deep horizons (50-80 m) and at a distance of over 100 meters from the river-bed).

The above-mentioned facts, in relationship to the evolution of groundwater quality in the riverine zone of the Danube after filling the Hrusov reservoir, lead to the following assumptions:

a) A considerable and fast decrease in groundwater quality will occur in the Danube riverine zone. Fast transport of various hydrocarbon substances and others of a mainly organic character can be expected (oil hydrocarbons, chlorinated hydrocarbons, Cl-insecticides, phenols, products of organic decomposition, decades of sludge deposits in the Danube river-zone and the area of the Danube flood plain).

b) These water pollutants will penetrate and spread relatively quickly even to regions distant from the reservoir edge (to a distance of hundreds of meters, or even some kilometers by groundwater flow and diffusion flow).

c) These processes and their negative influences will speed up in areas of useable water sources (Kalinkovo, Hamuliakovo, Samorín and other local sources) by increased pumping of groundwater, which could prevent utilization for drinking purposes for weeks or even months. It is necessary to stress that these pollutants are dangerous in drinking water in microgram amounts; some are carcinogenic or have mutageneous and teratogeneous effects.

d) In the next period, water polluting substances will penetrate into distant areas through groundwater flow, and they will gradually contaminate groundwater until further utilization as a water supply is not possible (permanent water level rise in the reservoir corresponds to maintaining the level of the 100 year flood).

e) The decreased amount of oxygen in the Hrusov reservoir will be used during infiltration for the oxidation of organic matter deposited in the reservoir (biochemical processes). Reduction processes will take place in the infiltrated groundwaters with all corresponding phenomena.

f) As a result of increased sedimentation of suspended matter in the Hrusov reservoir, gradual colmatation (siltation) will take place. Decomposition of organic matter contained in the bottom sediments of the reservoir will consume all available oxygen; anaerobic processes will begin; iron and manganese will be gradually released into the groundwater; sulphates will reduce to hydrogensulphide; and nitrates will reduce to ammonia. For these reasons, groundwaters will have unsuitable sensoric qualities (colour, taste, smell).

g) By gradual clogging (siltation) of the Hrusov reservoir bottom, the quantitative regime will also change. The amount of infiltrated water from the reservoir into the groundwater basin will decrease. But even at maximum colmatation of the reservoir bottom, a certain amount of water containing organic matter will infiltrate into the groundwater basin and will evidently have a negative influence on the utilization of this groundwater (according to the Czecho-Slovak Standard 83 0611 and regulations of WHO - microgram amounts of these elements contaminate drinking water).

h) In the event the colmatated layer is disturbed , for instance by dredging (dredging gravel in the reservoir), contaminated, oxygen-deficient infiltrating water will penetrate from the reservoir and threaten deeper groundwater layers.

i) Gradual stabilization of the water quality will follow after a certain stabilization of the hydrological regime, especially in the areas distant to the levees. A principle improvement in the qualitative parameters of groundwater cannot be expected due to the permanent inflow of contaminated matter from the reservoir. This will inevitably influence the utilization of groundwater for drinking purposes.

The filling of the Hrusov reservoir undoubtedly requires the construction of costly water purification plants, and the acquisition of technological devices for removing manganese and iron, as well as oil and other hydrocarbons, chlorated hydrocarbons, phenols and other contaminants some of which are carcinogenic, mutageneous, or teratogeneous. All this has to be done prior to the reservoir filling so that polluted groundwater can be purified and supplied to the consumer.

In the studied area of Zitny Island, all currently used water sources - Kalinkovo, Hamuliakovo, Samorín, Gabcikovo and other local sources supplying drinking water without costly purification - are endangered by the operation of GP. Also enadngered is the drinking water supply to parts of Bratislava and other areas of Slovakia (totally

1.082 million inhabitants) in the amount of 6.2 m^3/s up to the year 2000. This does not even consider local sources, industry, and agriculture demands. According to the approved water management plan (WMP), a further supply of drinking water without costly purification is needed for 36% of the inhabitants of Slovakia, and the regions of Trencin and Southern Moravia should also be added.

It is evident from the above mentioned facts that the influence of GP on the hydrological and qualitative water regime of the Danube River and the groundwaters of the adjacent areas is considerable. Actions of the past, when great amounts of contaminated material of various composition were discharged into the Danube River domestically and abroad, are also coming into play now. This material was deposited in the bank-zone and the flood plain system of the Danube. The present unsatisfactory state of waste-water treatment in the Danube basin also contributes to this problem.

The change in the hydraulic-hydrological conditions after the possible filling of the Hrusov reservoir will express itself in the influences mentioned above to such an extent that an inevitable decline in the Danube surface and ground water quality will follow. Since both supply and the quality of a groundwater reservoir of European importance are threatened, everything should be done to save them.

7. IMPACTS OF GNDS ON FISHERY - GENERAL PROGNOSIS

Source: Holcik, Bastl, Ertl, Vranovsky, 1981

After the completion of GNDS and, in some part during the course of construction, several isolated biotopes will arise from the present single ecosystem. Each of the new biotopes will exhibit not only different limnological characteristics, but also different fishery potentials as well. In the present ecosystem, the main channel biotope is closely integrated with those of the floodplain and arms; they are dependent on each other. The hydrological and hydrobiological regimes interact to produce an unusually high species diversity of hydrobionts and high biological productivity. In the area between r.km 1842 and the mouth of the Ipel River, (which includes almost 86 % of the total water area of the Slovak-Austrian, Slovak and Slovak-Hungarian Danube sections affected by the GNDS project), there are, in all, almost 98 % of all of the zooplankton, 97 % of all zoobenthos, 97 % of all fishes, and about 99 % of all available fish production of this Danube section. Moreover, the project - affected region provides for almost 92 % of the overall fish yields (with only the Slovak and Hungarian fish yield included) which are obtained in this Danube section. The most important region of the entire section stretches between Bratislava and Palkovicovo, and despite the fact that it makes up only 28 % of the total area of the Danube (between the mouth of the Morava and Ipel Rivers), it provides for about 59 % of all zooplankton and 39 % of all zoobenthos, contains about 55 % of the overall fish biomass, and provides 58 % of the overall annual available production. In addition, it comprises both the Czechoslovak and Hungarian fish catches whose annual yield averages 63 % of the overall yield obtained from the entire area. It should be especially emphasized that from the fishery viewpoint the section affected by the project activities is very important economically. The Danube section stretching between Hrusov and Palkovicovo provides an average value of almost 97 kg.ha-1 of fish yields, which is more than three times the yields obtained in the region between Bratislava and Hrusov and more than seven times as large as those obtained in the section between Palkovicovo and the mouth of the Ipel River. The Danube section affected by the project has an economic advantage in that its high fish yields are obtained in an almost exclusively natural way. Because the floodplain is inundated during periods most suitable for fish reproduction, the floodplain, together with its water bodies, acts as a gigantic hatchery system as well as a nursery. It is also replete with overwintering ponds. During the periods of heavy floods, it acts as a system of holding ponds for fishes carried downstream from upstream Danube sections. This section supplies downstream sections with fishes and fish food organisms, and functions as the focus for reproduction of the upstream Danube sections in post-flood periods.

In the region affected by the project, the total water area will increase from the present 11,889 ha to 16,424 ha, or as the case may be, to 17,224 ha provided that the arm systems in the region of the old Danube bed will be filled. Of the original 1884.5 ha of these branch systems, only about 800 ha will remain intact with respect to the lowering of the underground water level of this area. Consequently, the total water area will increase by 38 or 45 %. The area itself is not important. However, owing to the different hydrologic-limnological conditions, it is the quality of individual biotopes which is important from the viewpoint of future fishery potential. The diversion canal and the old Danube bed are not utilizable for fish production, and the area subject to fishery activities in the region affected will be 14,858 or 15,658 ha representing an increase from the present 25 or 32 %.

In all regions, losses are expected both in relative values, i.e., those estimated on a unit area basis, and on an absolute basis where, as a result of the creation of additional areas, the losses are relatively lower. With the less favourable alternative i.e. vanishing all the arms on either side of the present floodplain stretching between Hrusov and Palkovicovo, the losses will be the highest. The total ichtyomass will decrease in the entire section between Bratislava and the Nagymaros Reservoir by 57 %, available production by 75 %, and the possible yield by 91-82 %. The section most affected will be that adjacent to the old Danube bed where total losses in all parameters of this alternative exceed 95 %, and on a unit area basis 80 %. Highest losses will be in production and yield, since after completion of the construction programme, the present production of the floodplain and accompanying yield increases in the high water years will cease to exist. In the optimal alternative, i.e. if the arms are partly preserved, the losses expected will be from one half to one third of those in the least favourable alternative.

With respect to the distribution of losses on the Slovak and Hungarian sides, the highest absolute and relative losses are expected to be suffered on the Hungarian side. This is due to the smaller augmentation of areas available for fishery exploitation after completing GNDS. In the optimal alternative which assumes the preservation of the remnants of the arms on the Slovak side, the total ichthyomass decrease will amount to almost 20 %, available production to 32 %, and yields to 64-27 % , respectively, despite the increase of water areas. Highest losses will be recorded in the Bratislava-Palkovicovo region again.

It should be noted that this prognosis does not consider any additional increase in pollution whose magnitude and effects cannot now be predicted. It can only be stated that unless pollution is limited in the German, Austrian, and Slovak portions, the expected parameters of fish populations will drop, particularly in the Hrusov Reservoir. With regard to the yield to be obtained in the Hrusov and Nagymaros reservoirs, the estimates indicated by the prognosis will not apply at all unless pollution is limited. Both reservoirs possess slightly diverse shores which will seriously limit commercial catches. The current velocity in reservoirs will not allow for the use of gill-nets and traps, and the banks made up in both reservoirs by dams will not allow seines to be used to the extent that both gears are presently used in the main Danube channel, where conditions suitable for using this kind of fishing gear are only found in some places. Bacause of the low efficiency of the gear, catches made by electrical gears cannot be considered important. Sport fisheries which are of a highly selective character will be of little importance in the reservoirs, because they are not able to utilize the available production.

All reports published on the hydrobiology of Danubian reservoirs show quite clearly that the remarkable zoobenthos biomass increase is not accompanied by a corresponding increase in ichthyomass. On the contrary, the ichthyomass of the reservoirs seems to be lower than in the non-dammed river. Though the causes of this phenomenon are not yet known, we believe that this is caused by the interaction of the following factors:

1/ The increase in sedimentation evidently reduces light penetration to the lower layers, and consequently the visibility and orientation of fishes in search of food.

2/ The density of suspended solids which are concentrated towards the bottom irritates the gills of the fishes and interferes with their respiration. For this reason, fishes probably avoid the bottom.

3/ The largest part of the benthic fauna is made up of Oligochaeta populating the deeper muddy layers, inaccessible to fishes.

4/ When compared to rivers not subject to canalization, the reservoirs provide at most only very limited conditions for fish reproduction. Continuous siltation partially prevents reproduction of lithophilic species and causes the death of newly laid eggs. Water level fluctuations, for their part, and the negligible development of submerged vegetation limit the reproduction of phytophils and indifferents (=litho-phytophils).

5/ Evidently, there are no suitable food organisms in the reservoirs for the newly-hatched juveniles: reservoir flow, relatively great depth, and slightly diverse shores, when compared with the uncanalized stream, do not enable a greater development of zooplankton. Consequently, the new reservoir zooplankton remains almost identical, both qualitatively and quantitatively, to the former riverine zooplankton.

These outcomes of existing hydro-development projects serve to support our predictions about the negative effects of the GNDS project on fishes and fisheries, especially with regard to the decreases in available production and fishery yield which we have predicted.

Conclusions

We may now conclude by stating that after the completion of the GNDS project, the entire Danube section stretching between Bratislava and Nagymaros will have only a minimal biological importance. Moreover, the fish populations of both the lower and upper Danube sections can be expected to show considerable decreases. The principal negative influence of GNDS is that the conception of the project with a diversion canal eliminates the very floodplain which, together with the arm systems, makes up the productive base of this region. A region also acting as a sort of biocenotic centre, which determines to a considerable extent, the population of the main channel by all aquatic organisms.

8. EFFECTS OF GNDS IMPOSED ON THE SOIL AND AGRICULTURE

Source: Hajósy, Hollós, 1991

Due to the permanent construction, an agricultural area of several thousand hectares has been lost for all time. This loss can be estimated at 5,000-6,000 hectares.

Because of the barraging and the riverbed change, ground water levels will rise in the vicinity of the flooded area. Ground water levels will decrease in the environment of the rerouting (Old-Danube and by-pass canal) because of the reduction of the natural leakage from the live river basin.

In the areas where the ground water level lowers:

1) Mineralization of plant residues will speed up, the organic material content of the soils will decrease, and the soil structure deterioration and the hazard of nutrient leaching will be boosted.

2) GNDS operation will stop the capillary water supply of the root zone in areas where the ground water level now stands in a fine covering layer. This means an annual reduction of 50-100 mm of the water supply coming from the bottom, which will reduce the yield of the cultivated plants and production levels, making the area more sensitive to drought. This will also result in adverse changes in the natural ecosystems.

a) The favourable water supply of the flood-plain forests will change.

b) The existing flood-plain living communities will isolate into separate areas.

c) The organic material production of plant life communities will decrease.

In the areas where the ground water rises:

1) The soil becomes deaerated, making anaerobic processes dominant.

2) The hazard of internal waters increases.

3) In areas with bad natural drainage conditions (primarily on the left bank of the Danube, downstream from the mouth of the River Vah), secondary alkalinization may occur.

The change of the ground water system modifies the material circulation of the soil too. If frequent and important ground water changes take place at the boundary of the fine covering layer and the gravel base, (which is especially possible during peak-capacity operation), then the carbonates precipitating from the high carbonate content ground water may result in the formation of a strongly cemented "mite" layer, possibly a solid limestone bank. This would give the soil a shallow fertile layer sensitive to drought, reducing productivity and agricultural usefulness.

The dynamics of the reoxidation processes related to the bacteriological activity of the involved ground waters will also change. A result of this: the circulation paths of the various elements and the kinetics of their reaction paths will change, e.g., iron and manganese will continuously precipitate from the ground waters, while manganese and sulphates reduce to sulphur-hydrogene and the nitrates reduce to ammonia.

These material circulation changes will cause modifications in the composition of the plant covering; in consequence of this, the communities of the animal world will be modified also.

9. GEOLOGICAL AND SEISMOLOGICAL PROBLEMS

Source: Hajósy,Hollós,1991

In Hungary, and in CSFR, no valid technical specifications or standards exist for the regulation of the geological and seismological research of the water barrage construction. The investors took the responsibility of organizing these research works and asked the participants to perform sub-tasks. Thus, on the Hungarian section of GNDS, no summarizing closing report was made (that is, an evaluation approved by a professional jury analysing the sub-reports of the research work). No closing report exists, even though in Hungary, a closing report is a valid specification for all geological and seismological research work.

Geological or geophysical documentation evaluating GNDS as a whole is not available. Likewise, no regional engineering geological report was made on the effect area of the water barrage. A further problem exists because no summary of all research works performed on the Hungarian and the Czechoslovak sides has taken place so far (e.g., we only have data on the accurate position of the large Hungarian fault lines to the line of the Danube). Similarly, the peculiar fault line in the Gabcikovo area on the Slovak side is unrevealed in the Hungarian area. In 1978, due to this fault line, the position of the dam was moved about 600 metres with respect to the original plan. Therefore, complex geological, tectonic, engineering-geological, hydro-geological, environment-geological, and regional pollution sensitivity studies on the full effect area of the water barrage system are absolutely necessary before any further decisions are made.

The geological model of the Nagymaros barrage and its surroundings is based on a 1980 report made by the Hungarian Geological Institute. In designing the position of the barrage, the geological aspects were not considered seriously, so the projects have been situated on a tectonically strongly-disturbed area. After opening the working trench, direct observation was possible, showing that the geological structural pattern is even more complicated than expected. Thus, the performance of the tectonic, geodetic, and geomorphological research works clarifying the recent movements of the area - as already proposed in the report of the Hungarian Geological Institute - gained a special significance.

According to the summary of this report: "We have no direct data or observations on the recent movement along the designated main fault lines break. The possibility of this - on the basis of a study of the environment - cannot be excluded. All main fault lines must be qualified as potential water conducting zones. ... In our opinion, the solution of the above outlined tasks belongs completely to the research phase preceding implementation. Solving these tasks unsatisfactorily, or ignoring them, may cause difficulties in the implementation of the water barrage."

Seismological problems of the GNDS area

According to our present knowledge, the seismicity values defined in the joint contractual plan are not acceptable. Since the necessary studies have not been undertaken, no responsible answer can be given to the question of seismicity. The consequences of this fact must be investigated in respect to the safety and economy of the already existing projects and those planned. In the original plans, for example, the method of the dynamic analysis, alongside other imperfections, is disregarded.

The two studies dealing with the dimension design of the earth dams of the project system became public in the summer of 1989. On the basis of engineering-seismological evaluations, it was concluded that there are earth dam sections (Dunakiliti, Esztergom, etc.) which would not be able to withstand an earthquake of the presently-forecasted intensity. Thus, these plans must be revised for the entire water barrage system, using data from up-to-date forecasts, including economic aspects.

10. FLOOD CONTROL

Source: Hajósy,Hollós,1991

New hazards will arise with the declared flood prevention advantages (e.g. dam heightening and strengthening or distribution of the large flood waters between the service water channel and the Old-Danube bed). One of these hazards is inherent to the permanent flooding between Esztergom and Nagymaros to a level higher than the all-time floodwater level. Another hazard is related to the water mass of the reservoir and the elevation of the service water channel to 6-16 metres above the surrounding terrain. Another risk not yet investigated is the distribution of the highest (10 thousand m^3/s) floodwater yield. The reservoir of Dunakiliti would need to be kept filled to capacity. Should a dam burst occur under these conditions, or a discharge of the reservoir due to an accident be required, (e.g. radioactive pollution wave in consequence of a nuclear power station accident), an unprecedented flood-wave would occur. No defensive works have been constructed to protect against such a flood-wave.

11. THE GABCIKOVO PROJECT AND NAVIGATION

Source: Equipe Cousteau,1992

Evaluating the advantages of a project like Gabcikovo requires an overall assessment which includes the following phases:

- Clearly set out the existing traffic hindrances caused by bad navigational conditions and define the developments and investments required to remedy the problems.

- Establish a forecast on the potential future traffic using the Danube, taking the developing economies of the local populations and the opening of the Rhine-Main-Danube canal into account. This will make it possible to define the quantity of traffic that will use the river as a result of the developments.

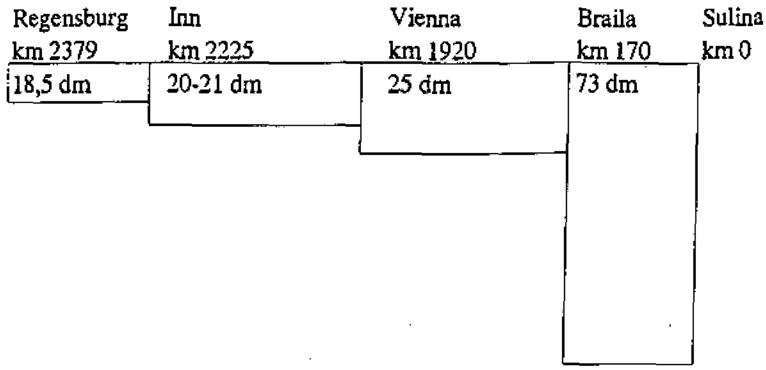
- Evaluate the profits to be gained from the increased traffic and the improvements that would be made to the fleet following the developments, and identify the beneficiaries.

- Compare these profits with the costs of the developments in order to calculate the profitability and their economic and social efficiency.

This assessment was studied within the framework of a programme, "The Danube...For Whom and for What?", defined by the Equipe Cousteau and carried out by Patrice Salini: "The future of navigation on the Danube".

Identification of navigational hindrances and necessary development

The navigational conditions on the Danube are characteristic of those found on a river where large sections have free-flowing currents. Sandbanks, alluvial deposits and rocky beds create thresholds where the depth can be under that recommended by the Danube Commission (see diagram).



Gauges recommended by the Danube Commission (source: Routier du Danube)

The main problems are caused by the Hungarian-Slovak and the Slovak sectors as the recommended depth (25 dm) is only attained 35 % of the days of the year. These problems are further exacerbated as they occur during periods when other sectors of the Danube are navigable.

The main area where a respect of the Danube Commission recommendations represents a clear advantage is on the Vienna-Budapest bottleneck.

The thresholds do not just concern the sector to be developed by Gabcikovo (km 1858-1811), as a number of other sectors lie downstream from this section (see Routier du Danube). They would even be worsened by the creation of the dam, due to a lowered downstream water level and the presence of rocky riverbeds which make dredging difficult.

In itself, Gabcikovo does not resolve navigation problems and this simple assessment should be sufficient to show that Gabcikovo is not a factor in terms of navigation.

However, we need to go into greater detail. The development of the Danube bottleneck requires major work to guarantee the desired depths. According to the Danube Commission, they would need to include a set of 4 dams equipped with double locks, located next to Vienna, Hainburg, Wolsfthal and Nagymaros. These works, excluding Gabcikovo and electricity production investments, would represent a billion dollars, being 707 million, with value updated at 8 %.

These values were calculated for locks and dams corresponding to the characteristics imposed by the Danube Commission, using simple estimation calculations used in France and on the basis of 1990 French prices.

Prospective analysis of the future traffic on the Danube

One of the characteristics of countries giving onto the Danube is the hypertrophy of the transport systems in comparison with western countries. The traffic level is comparable with that in European countries, whilst the GDP is 3 to 5 times lower. To maintain the level of transport intensity (Transport/GDP) at its current level up to 2020 is difficult to imagine. For a country like Czechoslovakia, traffic would then be comparable to that which currently exists in France and this would be enormously expensive and difficult to accept in such a small area. It is far more probable that the transport level will match that of EEC standards.

In addition, it is possible to forecast that the essential transport needs in the future will be for flexible, well organized and rapid transportation systems. This particularly requires the development of road and, to a lesser extent, rail infrastructures to make it possible to meet the needs of the internal markets.

The development of traffic along the Danube will depend on the future of certain branches of activity representing its potential commercial basis. The challenges offered by the future of these strategic factors are detailed in the study prepared by P. Salini, which were used here for the Bratislava and Slovakian regions.

The river traffic in Slovakia represents 8 million tons, of which 2.5 million involves international traffic. The remainder concerns local trade (sand and gravel) over an average distance of 19 km. Slovakia essentially uses the Danube to import minerals and scrap iron from the ex-Soviet Union and to re-export scrap iron and metals to Rei, Izmail and, more particularly, Linz.

The current use of the Danube is therefore concentrated on two market segments: building materials and the Czech steel industry. The latter still receives 80 % of its ore from the ex-Soviet Union and 1.3 million tons is transported by the Danube. Its development (modernization rather than expansion) should increase the quantity of ore imported by boat. Despite this, its future is extremely precarious as only the iron and steel industry in Kosice and eastern Slovakia would appear to remain competitive in today's context. However, its geographical position excludes use of the Danube.

In addition, the Linz iron and steel industry is in competition with the Czech and Slovak iron and steel industries. This leads to a paradoxical situation whereby the two potential traffic flows on the Danube are in contradiction. If the Linz iron and steel industry develops and increases its ore traffic on the river, the Czech and Slovak iron and steel industries as well as its associated traffic would be endangered.

To conclude, it is probable in the future that ore (1.3 million tons) will no longer be transported along the Danube and that there will be a growth in the importation of semifinished laminated products (0.5 to 1 million tons) following the penetration of the Linz iron and steel industry into the Czech and Slovak markets. The growth of local traffic ought to continue as long as the river diversion works have not been completed. However, this local traffic will decline once works are completed (the volume of transported materials between 1981 and 1990 is estimated at 20 million cubic metres for the sector concerning Czechoslovakia).

The transport of cars could grow following the agreement signed between VAG and the Bratislavske Automobilove Zavody company but will nevertheless only represent a low tonnage.

In his conclusions on the future traffic along the Danube, P. Salini states that:

- The development of the Danube artery will be directed towards the North Sea.

- The role played by the improvements to navigational conditions is limited. It is concentrated on the Vienna-Budapest bottleneck and is relatively unimportant beyond that point when seen in relation to the overall traffic movement.

- The potential for development is not entirely sure due to competition from other forms of transport, especially by rail, which will probably increase. The introduction or transferral of traffic is far from sure.

In overall terms, the traffic will increase from 34.7 billion tons/km in 1989 to 55.5 billion tons/km in 2020. Eleven billion tons/km shall be introduced or transferred over to other transportation systems as a result of the developments, and the remainder of the gain will simply be due to economic growth.

Economic evaluation of the developments

Profitability

The overall traffic needs to be broken down into three categories:

- Traffic which will gain very little from the new developments on the Danube, particularly between Vienna and Budapest.

- Traffic which will continue to use the Danube but will benefit from the developments as these will make it possible to use more laden and frequent convoys. This advantage was estimated by examining the difference between the cost price for vessels transporting 2,500 tons and vessels and convoys transporting up to 8,000 tons.

- Traffic introduced or transferred to other forms of transport.

The standard formula is to consider that the advantage is equal to the half product of the divergence of the generalisedtransportation cost by the traffic under consideration.

It is therefore possible to evaluate the overall cost of the advantages for navigation resulting from a theoretically complete development of the river bottleneck.

For the reference year under consideration, 2020, the sum represents 78.3 million dollars, 33.2 for traffic introduced or transferred due to the developments (3rd category) and 45.1 for the advantages linked to increased productivity of the fleets (2nd category).

It should be reiterated that the development works represent a sum of 707 million dollars, with an updated value of 8 %. The chosen hypothesis is the starting up of all development work in 2000, and a progressive increase in traffic over that same period. The cost of Gabcikovo is not taken into account.

We can therefore, using updated values, compare this sum with the advantages offered to navigation. The advantages are evaluated at 180 million dollars, using the hypothesis that only the direct advantages linked to the development of the Vienna- -Budapest sector are taken into account, and at 360 million dollars using the hypothesis that a more overall level of advantages is used (see table).

As a result and up to 2020, the advantages for navigation represent 50 % at best of the amount of the required work.

Updated balances 1992-2020	Previous traffic	New traffic or traffic trought in from others transport sectors	TOTAL
Direct effect of development	1503	30	180
Indirect effect (productivity)	90	90	180
TOTAL	240	120	360

Balances at 8 %		Internal profitability
Overall balance favourable hypothe[illegible] = 360-707 million $	- 347 million $	2,5 %
Balance restricted to direct effects = 180-707 million $	- 527 million $	- 2,6 %

The development of the Vienna-Budapest sector does not represent any direct level of profitability for navigation: the internal profit rate is negative.

The impact of these investments on the overall productivity of the fleet is far from negligible but does not offer any significant profit: a maximum of 2.5 %.

The beneficiaries

The awaited advantages offered by the development of the Vienna-Budapest sector do not include all countries giving onto the D[illegible]nube. The two main beneficiary zones are the *CIS* (*Ukraine* and *Moldavia*) *and Romania* (its agriculture and the po[illegible]) *for exports* and Austria and its iron and steel industrial complex for imports. Over and above these two zones, the Hungarian and Serb economies hope to capture some of these profits.

However, these advantages are only really strategic when it comes to the Austrian iron and steel industry as this is where it positions itself on the central European market, a sector which may well represent *its long term* survival. The only way for this iron and steel *industry*, located 1,700 km from its two supply ports, to retain its advantage is to improve transportation systems. In fact, the RMD canal, far from leading to more traffic on the Danube as has all too often been claimed, will simply create a higher level of competition. The potential of increased traffic towards the East and the West do not add up together; the traffic will find itself divided. A slight difference in fees could lead traffic to use one port rather than another.

We are led to a paradox whereby what the dam-builders have advanced as an economic advantage (improved navigational conditions) will in fact lead to endangering and accelerating the decline of the Slovak iron and steel industry due to the competition offered by Linz. This is a clear example of an oversimplified logic in terms of economic evaluation.

12. THE GABCIKOVO PROJECT AND PRODUCTION OF ENERGY

Introduction

It should first be reiterated that at the very beginning, the project did not integrate the production of electricity. The modifications made at the beginning of the 1970s to introduce this function had major consequences as it raised the total cost by 40 % and largely increased the environmental impacts.

In the documents supplied by the HYDROCONSULT firm analysing the economic value of the dam (4,5), the production of electricity is considered as a net profit. However, this is only true if it meets a quantitative need both now and in the future and if the production is coherent with the most applicable energy strategy. Is this true for Gabcikovo? To answer this question, we need to analyse the country's present and future energy policy.

The data given below is extracted from the "Energy in the Danubian Countries - Current Situation and Outlooks - Energy Policy Proposals" report, written by the International Council on Energy (ICE), within the framework of the Équipe Cousteau programme "The Danube ... For Whom and for What?"

Production and consumption of energy in the Czech and Slovak Republics

Czechoslovakia has major lignite resources (8.4 billion tons, half of which are economically exploitable) and coal (1 billion tons), most of which is found in the Czech Republic. There is little oil, but a natural gas field, estimated at 15-20 billion cubic metres, has recently been discovered in Slovakia.

The exploitable hydroelectric potential is estimated at 10863 GWh, of which 2650 GWh is produced by the Danube. Sixty-eight percent of this potential is located in Slovakia (7360 GWh), including all of the Danube's potential.

Resources in other renewable energy sources is fairly poor, but could be developed in the biomass sector.

Czechoslovakia provides 60 % of its energy consumption, the rest being imported, with nearly all of this (90 %) from the ex-USSR. In terms of electricity, net imports represent 2.6 TWh (109.KWh), being 2.9 % of total production in 1989 for Czechoslovakia and 1 TWh, being 4.1 %, for Slovakia.

The main primary energy source is coal (57 % of total consumption) and then, in order: oil (21.1 %), gas (12.5 %), nuclear (8.7 %), hydroelectricity (0.5 %). Total consumption of primary energy in 1989 represented 73.7 millions toe (ton of oil equivalent), being a consumption per capita of 4.64 toe and greater than that of western Germany (4.44) which is the largest consumer in the EEC.

The primary energy intensity (primary consumption/GNP) is equal to 0.80, being twice that of eastern Germany (0.40) and three times that of Italy (0.26).

Total electricity production in 1990 was 86.8 TWh (for the first time a reduction of the previous year's production: 89.2 in 1989), of which 11 % provided by industry in Czechoslovakia is thermic coal, whilst nuclear energy is more important in Slovakia. Hydroelectric production in 1990 represented 4 TWh in Czechoslovakia and 2.5 TWh in Slovakia being, in both cases, just over 30 % of the economically exploitable potential.

The final consumption of electricity (total consumption minus transport losses and selfconsumption by the stations) in 1989 was 85 TWh, most of which being used by industry (59.2 %).

Similarly to energy, electric intensity is very high: 0.92, being two to three times greater than the values of EEC countries (western Germany: 0.56, Italy: 0.36).

The essential point is therefore the overconsumption of energy and electricity. This is the result of the previous energy policy which was based around production and resulted in a low level of efficiency in terms of production and consumption systems. This overconsumption is a heavy weight to bear in the country's current transformations. It is incompatible with a modern economy.

Forecasts: Analysis and Discussion

The federal energy authorities forecast (1991) two scenarios for the development of consumption: a "high" corresponding to favourable economic conjuncture and a "low" corresponding to a particularly unfavourable conjuncture. These are developed in the following table, to which we have added the corresponding electric intensity values.

According to these scenarios, the electric intensity will reduce a little over the next 15 years but remain far greater than current European values or, in the worst case, continue to remain abnormally high. In both cases, the overconsumption of electricity will represent an unacceptable burden for the economy, which itself has a great potential.

In comparison with the above, the scenario developed by ICE corresponds with the hypothesis that states that the electric intensity in 2010 will be the same as the current European standard (0.50) (see table), with a 2 % GNP growth from 1992 to 2000, then 3 % from 2000 to 2010. This aim is reasonable and could be attained by setting up a rational electricity use programme.

The result is a 23 TWh reduction in final consumption by 2010, being around 30 %. This reduction is even greater in absolute values in terms of production: 26 TWh. If the same reduction rate is applied to Slovak production, a savings of 6.5 TWh is obtained.

The different scenarios for the development of electricity consumption in Czechoslovakia

Final Consumption	1990	2000	2005	2010
High scenario (TWh)	85	88.9	96	
Low scenario (TWh)	85	84.5	87	
Intensity.high scenario (KWh/$)	0,92		0,72	
Intensity.low scenario (KWh/$)	0,92		0,94	
ICE scenario (TWh)	85	65	64	62
Int.ICE scenario (KWh/$)	0,92	0,70	0,60	0,50

Benefits of Gabcikovo

Does Gabcikovo meet the quantitative needs for the future?

As shown above, the Czech and Slovak Republics do not need any more electricity up to 2010 or even beyond. From this point of view, Gabcikovo serves no purpose.

Is Gabcikovo coherent with the most relevant energy strategy?

Priority actions in terms of energy should be aimed towards making the greatest savings. At best, Gabcikovo will only produce between a quarter and a fifth of the savings that Slovakia might be able to attain according to our scenario (see table below). In terms of our calculations, we have excluded the hypothesis of a shared production with the Czech Republic following partition.

	Gabcik.production initial project without Nagymaros 1.7 TWh	Alternative "C" without thresholds 1.15 TWh	Alternative "C" with thresholds 2 TWh
Relation with possible savings up to 2010 in Slovakia (6,5 TWh)	26 %	18 %	31 %

The creation of new production sources has a double negative effect:

- It accentuates overproduction.
- It deviates financing which could be invested in far more important activities, such as modernizing industry.

The initial hypothesis is that residential lighting in Slovakia uses 75 W incandescent bulbs, with one bulb per inhabitant (conditions met in Bulgaria), used for an average of 5 hours a day.

All these lightbulbs are replaced by 18 W "low consumption" lightbulbs producing an equivalent amount of light.

The electricity company makes the initial investment and replaces the lightbulbs. It reimburses itself on the users' bills by not taking the reduced consumption into account (the electricity bill does not go up for the consumers). The given cost of the bulb corresponds to a bulk purchase, but could be reduced if local production was developed or created.

The calculation elements and results are given in the following table

	Slovakia
Number of inhabitants	5,275,000
Power saving in MW (75W-18W x N-inhabitants)	around 300
Energy saving per year in TWh (gained power x 5h x 365days)	0.55
Initial investment in billions of Crowns (1 bulb = 300 Crowns)	1,58
Cost of energy saved per year on the basis of around the sales price to private individuals(1KWh: around 2 crowns) in millions of crowns	1,100

It can be seen that if a billion and a half crowns were invested in Slovakia (around 73 million US dollars), the following energy savings would be made:

- Approximately the power of Gabcikovo in its continual flow configuration. But unlike the dam's production, the savings would nearly all be made during the peak period, as people light their homes in the evening.

- Depending on the configuration, half to quarter of its energy production.

The initial investment is reimbursed in under two years on the basis of the sales price to private individuals during peak period (source: Tariffs of Electrical Energy in Czechoslovakia, April 1991 - Czech Power Work, Prague).

It is clearly more advantageous to invest in the economy rather than in production. A new power station, whether it be gas run (cheapest solution) or nuclear (the most expensive), producing a quantity of electricity equal to that saved, would represent an investment 5 to 10 times greater, whilst retaining an identical service (lighting) to the consumer. The difference could be allocated to the modernization of industry which, in turn, would generate greater energy savings and lead to a greater amount of capital being freed to jumpstart the country's economy.

This type of operation would also make it possible to develop new technologies, producing products that could be exported to the east as well as to the west. Finally, unlike the construction of a new source of production which does no more than bet on future developments, this operation ensures that savings remain the same no matter what developments are in future requirements and production costs.

Gabcikovo can therefore only be of interest as a substitution to an existing source, in other words, replacing thermal or nuclear stations.

The thermal stations in Slovakia produced 9.5 TWh in 1990, including industrial installations (source: Czechoslovakian Statistical Year-Book). Gabcikovo could replace 14 to 25 % of this production.

It might be considered that in the current situation, Slovakia would do better to use its own lignite resources which are sufficient to supply its power stations. The advantage of the substitution is therefore essentially environmentally based.

Therefore, in order to evaluate the situation, there is a need to compare the respective environmental effects of the dam as against a 14 to 25 % reduction of the total pollution generated by the thermal stations. This exercise falls outside the scope of our investigation, but should take into account the fact that the modernization of thermal stations through the introduction of more efficient and less polluting technologies is, in any case, inevitable.

Insofar as nuclear stations are concerned, Slovakia has 4 VVER-430 reactors at Bohunice, two of which will be closed in mid-1992 according to the statement made by the Czech authorities in June 1990. Four reactors, currently being built at Mochovce, are the object of an EDF contract to ensure that they comply with European standards. We do not know what the effects of partition will have on the above points.

In all, the Slovakian nuclear stations produced 12 TWh in 1990.

The risks linked to the operation of old reactors and the problems linked to waste management demand careful examination of all replacement possibilities. Nevertheless, the production level offered by Gabcikovo is largely insufficient and cannot be realistically seen as a replacement. In addition, the current construction of four new reactors completely contradicts this possibility.

Alternatives

Major efforts being made in terms of the rational use of electricity could make it possible to reduce needs and remove some of the energy constraints shackling the economy. There would then be a greater freedom in the choice of energy sources and the weight they would have in balancing the country's energy resources.

Basing itself on its scenario, the ICE proposes a development in the Czech energy balance up to 2010. The broad outlines are as follows:

- Reduced use of coal whilst retaining a certain production level allocated to the production of electricity or heat, using high performance technologies (fluidized bed).
- Development of renewable energies and, in particular small hydroelectric plants, the biomass (which has a potential of 3 million toe).
- Reduced oil consumption, with use limited to transportation.
- Development of gas use, particularly for producing electricity, with diversification of supply sources (Norway, maybe Algeria, the future Iran-Europe gas line, exploitation of reserves discovered in Slovakia).
- No new nuclear reactors should be built after the commissioning of Mochovce; the priority aim for capital should be to modernize industry.

Conclusions

* The Czech and Slovak Republics are characterized by a particularly high overconsumption of energy and electricity which exacerbates the difficulties encountered in developing their economies.

* Efforts made in terms of energy efficiency could allow these countries to attain energy intensities comparable with those that currently exist in Europe by 2010. Electricity consumption would then be lower than its current level:

23 TWh for all Czechoslovakia and 6.5 TWh for Slovakia.

* In this context, the electricity produced by Gabcikovo meets no requirements for the future and is worthless in terms of quantity.

* The capital invested in Gabcikovo has been subtracted from actions that are far more important to the country's economy.Although it is not possible to redirect the initially invested capital, part of the 5.7 billion crowns (1.3 billion francs, 26O million US dollars) recently earmarked for the construction of alternative "C" could have been used to carry out operations to improve the efficiency of economically profitable electricity production installations. This would have led to energy savings at least equal to the Gabcikovo production. The difference could have been earmarked for modernizing industry which, in turn, would lead to greater energy savings and thus provide capital for new investments. This solution would have set up a dynamic favouring the revival of the country's economy.

* The value of Gabcikovo as a source of energy substituting existing sources (thermal and nuclear) can only be evaluated within the framework of an overall redefinition of the country's energy strategy. Nonetheless, it would appear to be relatively unimportant in quantitative terms.

13. SOCIAL IMPACTS OF THE GABCIKOVO PROJECT

Source: WWF,1991

While the environmental and economic consequences of the power station construction are not being adequately examined, the same applies, even more so, to the social consequences of the project.

During the days when the Communists ruled the roost, people had no chance to object and protest. To date, little has actually changed on this score. The former Slovakian Premier Jan Carnogursky declared that, as far as the future is concerned, people have no right to protest. This is tantamount to muzzling any changes which would allow citizens to participate in their government.

Officialdom invariably tries to portray these protests as nothing more than the doings of the Hungarian-speaking minority, which, in the areas in question, is around 70-95% of the population. This minority is reproached for not representing "Slovakian interests". The fact that this is not the case is clearly shown by the many years of criticism and protest mounted by many scientists and environmentalists from all over Slovakia, as well as from other parts of the former Czechoslovakia.

Through this tactic of divide and rule, adopted by various politicians and journalists, artificial lines are drawn which in turn bring about conflict, aggressive behaviour, and territorial tendencies within the Slovak population itself.

Local residents are losing touch with the Danube, a river that has given rise to centuries-old customs and traditions, and which is a decisive factor in their very identity. As a result they are losing a large portion of their homeland habitat.

Above all, the inhabitants of the three villages of Dobrohost, Vojka and Bodiky are feeling excluded and rejected. Stranded between the canal and the Danube, they are watching a rural exodus which may leave their villages completely abandoned in the near future. For them, this project is an "indirect eviction".

14. POLITICAL ASPECTS OF THE GABCIKOVO-NAGYMAROS DAM SYSTEM

Source: Galambos,1992

Introduction

This chapter is a case study on the political dimension of an environmental conflict arising over the construction of the Gabcikovo-Nagymaros dam system on the Danube by the former Czechoslovakia and Hungary. From a political point of view this is a very interesting and complex case: it has caused both domestic and international conflicts. The course of these conflicts was strongly influenced by the political democratization process: the controversy gradually focused on the very nature of the political system in Hungary.

The case, since it has a long history, also provides a unique opportunity to compare decision making in different political regimes and during different historical periods. Three neighboring countries - the former Czechoslovakia, Hungary and Austria - have played the central roles. Furthermore, through the course of events the clashes of national, political, ecological, economic, and bureaucratic interests can be studied.

The Political Background of the Gabcikovo Project

In the nineteenth century certain leading Czech nationalists sought to create a united Czech-Slovakian state, whose borders would reach the Danube, which would connect their country with the sea and with the other Slav nations. For this purpose the new state was to incorporate large ethnic Hungarian territories around the river. The possibility of realizing this plan arose at the Paris Peace Conference at the end of World War I. There it was settled that the southern border of the new statecreated from Bohemia and Slovakia, (which had earlier belonged to the Austro-Hungarian Monarchy), would extend to the Danube, thereby incorporating ethnic Hungarian territories into Czechoslovakia, even though the Czechs and Slovaks had originally wanted to also gêt large Hungarian territories on the other side of the Danube.

Czechoslovakia also tried at the Paris Peace Conference of 1946 to acquire possession of a territory vis-a-vis Bratislava, on the Hungarian side of the Danube. Had Czechoslovakia succeeded, this would have made a unilateral diversion of the Danube by the Slovaks possible. However, neither state was given such a right at the peace conference and Slovakia got only half of the territory it had claimed.

This historical background helps us to understand why the Hungarians have had less enthusiasm for the joint project than Czechs and Slovaks. Soviet pressure and Communist ideology, however, facilitated the realization of Czechoslovak aspirations after 1948.

From 1948 the Soviet Union played a dominant role in the Danube Committee, which had long urged the construction of a barrage system on the joint Czechoslovak-Hungarian section of the Danube, in order to eliminate its shallows. The improvement of navigability has mainly been a Soviet interest, since Soviet ships have transported the greatest amount of goods in this section of the Danube.

The Communist ideology and the Communist economic system were decisive factors in dragging the Hungarians into the joint project. In the years after the war, even leading water management specialists emphasized the serious technical, economic and ecological limitations to utilizing water power in Hungary. But in the early 1950s, the gigantic projects of the Soviet Union, such as the hydroelectric plants at Stalingrad and Khuibishev on the river Volga, set the examples to be followed.

'Transformation of nature' was an important element of Communist - Stalinist - ideology, according to which mankind was able 'to conquer nature' with the help of central planning. Since the 'capitalist' categories of profitability and economic efficiency were disregarded, even these limitations concerning 'transforming nature' ceased to exist during the Stalinist regime. That is why, in the 1950s, Hungary built a huge steel industry without the necessary raw materials, produced cotton in spite of unfavorable natural conditions for cotton growing, and started to build hydroelectric plants on the rivers flowing through its plains.

In the Communist economy, the various Ministries and state-owned companies competed with each other for the limited resources available from the state budget. According to Communist ideology, bankruptcy in a planned economy is impossible: this can only happen under the 'chaotic' conditions of capitalism. Moreover, bankruptcy of a state-owned company would mean that the management, the controlling bureaucracies, or the planners had made serious mistakes. This, however, is something that nobody wanted to admit and therefore the company was granted extra resources from the state to ensure its survival. Economic considerations played no role whatsoever in the redistribution mechanism. On the contrary, the firm which showed the worst financial balance was be rewarded.

This is also true for large investments: once construction has been started, it is easy to get more and more resources to complete the project. Therefore it was better to underestimate considerably the costs and difficulties at the outset, in order to influence decision-makers in favor of the project. If new difficulties should arise in the course of realization, there would be no cause for concern: the same bureaucracy would remove them in order to ensure employment for a growing number of people - especially bureaucrats - for a long time.

This is how the Hungarian water management bureaucracy conducted itself. In order to obtain the necessary support and resources, planners and the water management establishment started to emphasize the energy production side of the project. Since energy production from the planned hydroelectric plants simply could not be competitive because of the unfavorable natural conditions, the costs of the investment had to be curbed through manipulation: for example, the investment costs were reduced by the amount of money provided by the energy sector; other sectors were charged with the expense of the necessary additional investments (e.g. sewage treatment), etc.

After 1968 preparations for the realization of the project were speeded up: in Czechoslovakia the conservative wing of the party hierarchy re-centralized its power after the Soviet invasion. The new First Party Secretary, Gustav Husak - being a Slovak - favored specifically Slovak schemes such as GNDS. In the early 1970s, the two sides worked out a joint plan of investment and a draft contract. The oil crisis of 1973 raised questions concerning energy supplies in both countries, thus giving further impetus to the realization of the plans. In 1977 the two governments signed a bilateral agreement on the construction of GNDS.

Czechoslovakia unilaterally commended the construction work in April 1978, two months before the agreement was ratified by the Federal Parliament. The Hungarians were less enthusiastic: shortly after work began on the Hungarian side, in May 1980, the Hungarian Hydrological Association and the Patriotic People's Front organized a debate in which biologists and engineers sharply criticized the project. Czechoslovakia reacted by speeding up construction. In the early 1980s Hungary experienced the first waves of its deepening economic crisis, therefore the government ordered a review of major national investments and suspended credits for GNDS: its construction came to a virtual standstill. The government unilaterally postponed all work until 1990 and initiated a study on the ecological consequences of the dam system. The water management lobby sought to influence the results of the investigations in accordance with its interests; expert committees were formed again and again, but their findings were distorted by the lobby.

Uncertainty at the highest level concerning the project proved to be fertile ground for public debate and controversy in Hungary. However, these debates and arguments could have no effect during the years of postponement, since the decision had already been made in June 1983 when the Politburo discussed the subject and secretly decided that the project was to be completed. It explains why the government had no other alternative in August 1985 than to re-commit itself to the scheme.

After the Hungarian government decided to continue the project, the growing criticism of scientists and environmentalists was suppressed and published materials about GNDS were censored. Work began at Nagymaros in 1987. However, parallel to the slow blossoming of Hungarian democracy, especially after Kadar's removal in 1988, freedom of speech became less and less restricted. A small number of independent politicians and even some representatives of the opposition succeeded in becoming elected to the Hungarian Parliament during the 1985 elections. In fact, this was the first time that more than one candidate had been allowed to run for one seat in the Parliament. Some of these newcomers initiated the re-examination of the project in the summer of 1988. The proposed debate in Parliament took place in October 1988, but the MPs - under strong pressure from the government and the party leadership - voted for the continuation of the project.

This decision was followed by an even more heated public debate and political struggle - also within the party leadership. The reformist wing of the party was gradually gaining ground, and in November 1988, Miklos Nemeth, a prominent reformist, became Prime Minister. The party reformers needed popular support in their fight against the conservative wing of the party (and were therefore more receptive to the claims of public opinion and the opposition) and mainly used the GNDS case as a political tool in their struggle.

However, the new Prime Minister sent a delegation to Czechoslovakia in February 1989 to sign a protocol concerning the speeding up of the work. But then three months later - in May 1989 - his government unilaterally suspended work at Nagymaros for two months. By then, the reformists had become stronger: they publicly admitted that the 1956 Hungarian uprising was not a 'counterrevolution' - as it had earlier been labelled by the party - and the people killed in it were ceremonially re-buried one month later, in June 1989.

The government asked Parliament to authorize a new round of negotiations with Czechoslovakia on a modification of the 1977 Treaty and to commission expert bodies which would examine the consequences and possible decision alternatives. In June, the Parliament - the same MPs who had voted for continuation in October - approved the government's proposal. In July, Nemeth announced the suspension of all work at the upper dam in Dunakiliti as well.

The still conservative Communist Czechoslovakia reacted with crushing words: its press accused the Hungarian government of submitting to political pressure by the opposition and labelled the decision anti-Socialist and hostile to Czechoslovakia, jeopardizing the 'good neighbor' relations of the two countries. The Slovak leadership demanded completion of the project in its original form, otherwise it would file a claim for compensation.

The case strained the already tense relations between the two countries, resulting from the growing difference between their political systems, even further. Czechoslovakia demanded a huge sum in compensation, saying that the Hungarians had violated the inter-state contract. Hungary rejected the Czechoslovakian demands, arguing that all the benefits and expenses, damage and risks, as well as the costs of preventing damage and reducing risks, must be equally shared between the two countries as had originally been agreed upon.

In September, Czechoslovakia threatened to continue construction alone if the Hungarians withdrew from the project. Czechoslovak politicians and experts spoke of 'new technical solutions' which would make the unilateral diversion of the Danube possible: thus they would not need the weir at Dunakiliti for filling up the reservoir and starting the turbines at Gabcikovo. At this point the tension between the two countries reached its climax. The Hungarians suspected that Czechoslovakia was only bluffing, trying to put pressure on the Hungarian decision-makers by blackmailing them. Still, there was no certainty about this.

In this desperate situation the Hungarian government proposed a compromise to Czechoslovakia. This compromise was greatly resented by the Hungarian environmental movement because, in exchange for the abandonment of the Nagymaros part of the project, it would have allowed Czechoslovakia to complete and use the Gabcikovo dam provided it gave appropriate ecological guarantees. According to the environmentalists, such guarantees simply did not exist. Czechoslovakia was ready to give these guarantees if the Gabcikovo part of the project could be built in accordance with the original plans.

In the autumn of 1989, radical political changes in Czechoslovakia gave the Hungarians high hopes for a solution to the conflict. Therefore, in January 1990 Hungary made a new proposal: instead of employing the compromise which had been proposed by Hungary under pressure in November 1989 as a starting point, the conflict should be solved by the two governments on the basis of the results of scientific investigations to be made by independent experts and international institutions. The Hungarian environmental organizations demanded that no work should be carried out on the site, except maintenance, until free elections had been held in both countries.

The new Czechoslovakian leadership used a dramatically different tone from that of its predecessor. The new attitude - especially represented by Vaclav Havel, the new President of Czechoslovakia - was neither suspicious, nor reserved but much friendlier towards Hungary. Czechoslovak environmentalist movements were no longer denied the freedom of the press, nor their activities prohibited - they could mobilize public opinion. The new government desisted from the unilateral diversion of the Danube and agreed to set up expert committees to investigate the ecological and economic aspects of the projects. In February, Vladimir Lokvenc, a Slovakian commissary of investment, who had fanatically defended the scheme for decades, was dismissed by the Slovakian government.

These were positive steps, but the Hungarians were still not fully satisfied by the behavior of the new Czechoslovak government. Although it was more receptive to ecological concerns than the previous government and readily admitted that the idea of the whole investment had been a mistake, it still insisted on completing construction because of the huge sums of money already invested and because the Slovak contribution to the construction was lacking only one-tenth of the total. According to Slovak decision-makers, the hydroelectric plant at Gabcikovo, after having acquired the necessary secondary installations to protect the environment, ought to produce energy in order to amortize the investment costs. However, they were prepared to accept the less risky, continuous mode of operation, instead of the originally planned peak-time energy generation, which is more disastrous to the environment. Hardliners, who even wanted to put the question of Nagymaros and peak-time energy generation back on the agenda, started to re-gain influence in the Slovak government. Supporters and opponents of the project were fighting each other.

The first free elections took place in the early spring of 1990 in Hungary and in early summer in Czechoslovakia. In Hungary a midright coalition led by the Hungarian Democratic Forum formed the government. Its policy on GNDS is similar to that of the Nemeth government. In Czechoslovakia the Civil Forum won the elections, but unfortunately, this did not result in a radical shift of Czechoslovak GNDS policy. One reason for this is that several members of the previous Communist government joined the victorious Civil Forum and were appointed to high positions in the new government (including top positions in the environment and energy administrations), while their real views did not change much. On the other hand, ex-opposition politicians ceased to criticize the GNDS scheme once they took on 'the burden and responsibilities of power'. A more important reason is that those opposed to the project have had less time (compared to Hungary) to convince decision-makers and the public. At the same time national sentiments have been not against the project, as in Hungary, but for the project - thus it could not become a symbol of the struggle between totalitarianism and democracy. The third reason was that the federal government - which had more than enough trouble with Slovak separatists - did not want to interfere with a Slovak national cause and did not mind if Slovak nationalism was directed against Hungarians instead of the Czechs. Thus the advent of democracy has not swept away the Gabcikovo part of the project and has not brought an end to the Czechoslovak-Hungarian dispute.

Conclusions

The GNDS case is an exceptionally interesting environmental conflict to analyze because the three countries involved have been so different politically during the period examined. Austria represents a Western democracy, while Czechoslovakia and Hungary were Communist countries at the beginning of the story, and both became pluralist democracies by the end. But the pace of democratization was very different in the two countries: in Hungary it was gradual, dating back to 1985 and speeding up only after 1987, while in Czechoslovakia the change was sudden and radical, like an explosion, in December 1989. Comparing the behavior of the three countries in the conflict leads us to interesting observations.

1/ The conflict the has had similar elements in all three countries, regardless of political system: the main conflict is between civil society and groups having economic and political power.

In Czechoslovakia the most enthusiastic supporter of the project has been the Slovak government, enjoying the backing of the federal government. The Slovak water-management bureaucracy, their engineers and experts, companies taking part in construction, politicians, and the apparatus of the Communist Party were also on the supporter's side. In Hungary the same kind of groups were committed to the project, with a difference only on the political level: the project never enjoyed the unanimous approval of the whole party and government leadership, and the bureaucracy was also divided. To a certain extent workers employed on the construction, together with their labor union representatives, were also among the supporters in both countries. In Austria the supporter side consisted of the contracting firms, the Austrian government, representatives of the coalition parties in power (especially the Austrian Socialist Party) and the labor union defending the employment of the Austrian construction workers.

On the opposing side we find the environmental movements, concerned scientists and other representatives of the civic communities of the three countries. The political opposition supported them in all three countries, but more on the basis of political than on environmental considerations (like the ÖVP in Austria, or the Civil Forum in Czechoslovakia, which, after coming to power, 'modified' its approach to the Gabcikovo plant). In Hungary the whole opposition made use of the case in its fight against the political system; even the reformist Communists used it as a tool in their political fight against the more orthodox old leadership.

What is of great interest is to observe signs of transnational cooperation among both the opponents and the supporter forces of the three countries, and a similarity of the structure of the domestic conflicts, regardless of political systems.

2/ Nonetheless, the political system of each country did matter. Although we can find economic short-sightedness and ecologically disastrous projects in all political systems, in the non-market economies of the Communist regimes there have been fewer limits to ruining the environment, because even economic rationality has been overruled by ideological considerations. Moreover, in a non-democratic political system, decisions are made by a small group of people without any social control. The same group also monopolizes information. Society at large has no chance of taking part in the decision-making process, judging the alternatives, or even knowing about them. Citizens are often informed about a decision only after it has been made - if they are informed at all. The possibilities for them to criticize the decisions of the political leadership, to organize themselves in order to express and defend their interests, and their freedom of speech, are very limited or non-existent. Their efforts to express views different to the official standpoint are regarded as hostile and politically dangerous even in the case of non-political subjects. In such systems all issues and controversies tend to become challenges to the legitimacy of the system. Therefore it is easy to commit mistakes, but extremely difficult to correct them.

Environmental protest has thus played an important role in the democratization process in the so-called Socialist countries: in order to be able to defend effectively the citizens' rights to a healthy environment, environmentalists have been forced to fight for freedom of speech, freedom of association, a free press, political pluralism and democracy.

3/ Nevertheless, democracy is not a panacea for environmental problems. In parliamentary democracies, interests are represented through political parties, but for most of them - except perhaps for the Greens - other considerations are often more important than the environmental ones. If they support (or give in to) an environmental cause, they do so mainly for political considerations. The behaviour of the Austrian government in the GNDS case is very illustrative of this: while it was forced to retreat in face of the citizens' protest in the case of ecologically risky projects on Austrian territory, it did not hesitate to finance and support a similar project in a country where the citizens' rights were suppressed. Austria behaved in a neo-colonialist way, making use of the economic hardship and oppressive regime of its poorer neighbor.

Although Hungary and Czechoslovakia have acquired democratic political systems, the danger still exists of their becoming 'environmental colonies' of the richer Western countries (this is true of all the East European countries) because they desperately need Western investment and are economically dependent on the West. Furthermore, changing their economic systems will take a long time. With the restructuring of their economy they face a new wave of industrialization, and it will be extremely difficult for countries in deep economic crisis to give priority to the environment over the allure of money. To prevent this, a well-organized environmental movement and a high ecological awareness of the population are needed.

4/ The fact that this conflict, basically domestic in all three countries, became one between them can be explained by a combination of the different levels of their commitments to the project (according to their expected gains and losses) and their different sensitivity to domestic pressure. Hungary has been the least committed because it has had the most to lose through the project, which served Slovak and Soviet interests more than Hungarian interests. Slovakia has also had a lot to lose, but it has regarded the expected gains as outweighing this: the scheme has suited age-old Slovak national aspirations, so that from a nationalistic point of view, Slovakia could only gain from the project. (In this respect it has been a zero-sum game between Hungary and Czechoslovakia). Austria had almost only gains to expect, while the risks would mainly appear in another country: this why the Austrian government was less sensitive to any pressure from the environmental movements.

In Czechoslovakia the system was so oppressive that the opponents of the scheme could have no serious impact on decision-makers. Hungary in the late 1980s was in the phase of political transition to a democratic system, and was therefore even more sensitive to political pressure than the already established democracies (especially because the reformist Communists recognized the usefulness of the case in their political fight for power). The difference in pace between the political processes of the two Socialist countries added an extra dimension to the conflict: the more and more open environmental and political protest in Hungary endangered not only the completion of the GNDS scheme, but also the regime itself. The activity of the Hungarian environmental movements encouraged corresponding movements in Slovakia. The Czechoslovak party leaders were afraid of the power of example - and they were right. The example of other countries became an important factor in the democratic revolution in Eastern Europe. Since real conflict between civil society and the central leadership could not evolve in Czechoslovakia due to repressive measures, the conflict appeared as an international one: it seemend as if the menace to the regime came from outside, not from within. Today, when both countries have democratic systems, one obstacle in the way of solving the conflict has disappeared, while others, e.g. different national interests, different levels of commitment, still remain.

15. CONSTRUCTION AND OPERATION OF VARIANT C UNDER INTERNATIONAL LAW

Source: Hunter,1992

Slovakia's unilateral diversion of the Danube violates the international law of state responsibility and the rule of equitable use of international watercourses. Slovakia attempts to justify its unilateral action based on Hungary's alleged breach of the 1977 treaty. Under international law, such breach, even if it occurred, does not give Slovakia the right to divert the Danube and inflict irreversible environmental harm on Hungary.

We offer the following brief points explaining the illegality of Slovakia's actions.

I. Slovakia's Unilateral Diversion of the Danube Violates the Principle of State Responsibility

Slovakia's unilateral diversion of most of the Danube, and any resulting environmental damage to the portion of the Danube flowing into Hungary or to any other part of Hungarian territory (including, for example, the groundwater aquifer), violates the basic international principle of state responsibility that one country should not use their territory in such a way as to harm another. This principle, set forth decades ago in the Trail Smelter case, has been reaffirmed by Principle 21 of the Stockholm Declaration on Environment. Principle 21 states:

States have, in accordance with the Charter of the United Nations and the principles of international law, thesovereign right to exploit their own resources pursuant to their own environmental policies, and the responsibility to ensure that activities within their jurisdiction or control do not cause damage to the environment of other states or of areas beyond the limits of national jurisdiction. /1/

/1/ Stockholm Declaration on the Human Environment: Report of the United Nations Conference on the Human Environment, U.N.Doc.A/Conf 48/14 and Corr.1 (1972), reprinted in 11 I.L.M. 1416, 1420 (1972).

This customary law principle has been reaffirmed in numerous documents, most recently the *Rio Declaration* signed at the United Nations Conference on Environment and Development.

II. Slovakia's Unilateral Diversion of the Danube Violates the International Rule of Equitable Use of Shared Watercourses

Slovakia's unilateral diversion of the Danube violates the law of international watercourses as reflected in the International Law Commission's (ILC) Draft Articles of International Watercourses and the International Law Association's (ILA) Helsinki Rules on the Use of Waters on International Rivers. Although Slovakia enjoys the right of use of the Danube, such right must be "equitable" or "reasonable". Article 5 of the ILC Draft Rules demonstrates that States can only use shared watercourses in ways "consistent with adequate protection of the watercourse". Similarly Article 7 reflects the same international principle: "Watercourse States shall utilize an international watercourse in such a way as not to cause appreciable harm to other watercourse States". Equitable and reasonable use assumes that the use causes limited or no environmental damage. Massive diversions, like the Gabcikovo diversion, which cause significant and irreversible damage do not qualify as equitable. Most of the Danube's flow has been diverted. Much of the groundwater hydrology will be affected. Aquatic wildlife habitat and riparian forests will be irreversibly destroyed. This environmental damage clearly constitutes appreciable harm and disqualifies any claim that Variant C is an equitable use.

III. Slovakia's Diversion Illegally Changes the Border With Hungary

Slovakia's diversion of the Danube by construction of Variant C will violate the treaties establishing the borders between the CSFR and Hungary. The borders between the two countries are dictated by a series of treaties spanning most of this century.

Without going into the details of border changes in the different treaties, it is clear in the 1956 Treaty Between the Czecho-Slovak Republic and the Hungarian People's Republic Concerning the Regime of State Frontiers (the 1956 Treaty), that where the Danube sets the border between the two countries, the border is the principal channel of navigation. The border is only to vary with "changes brought about by natural causes" or unless the two countries agree. Article 14 states that "the natural flow of frontier waters in inundated areas may not be altered or obstructed by the erection of installations or structures in the water or on the banks, or by any other works, unless the Parties so agree". Article 19 confirms that no dams can be built without mutual consent. It states that "new...dams...and other hydraulic installations shall not be erected in frontier waters except by agreement between the two Parties".

Slovakia argues that the 1977 treaty supersedes the 1956 treaty, because it established new boundaries once Gabcikovo was constructed. Nonetheless, Variant C contemplates diversion of frontier waters at a place and with structures not contemplated by the 1977 treaty. Whatever the current legal status of the 1977 treaty, the dam and diversion of the Danube now being constructed under Variant C were never agreed to by Hungary and cannot establish a legitimate border change.

IV. Slovakia's Violation of International Law Cannot Be Justified As A Response to Hungary's Actions

Slovakia's main attempt to justify construction and operation of Alternative C is to argue that Variant C is a legal response to Hungary's actions. Even assuming that Hungary has breached the 1977 treaty, however, Slovakia's remedies under the Vienna Convention on the Law of Treaties is either to suspend or terminate the treaty. In either event, Slovakia is not authorized to construct an alternative project in violation of international law.

Recognizing this, Slovakia has relied in previous statements on the draft International Law Commission's Report for State Responsibility to claim that they have a right to break international law as a method of self-help to respond to Hungary's activities. Slovakia argues wrongly that Article 30 provides a justification for building Variant C. Article 30 of the Draft Treaty on State Responsibility states:

Countermeasures in respect of an internationally wrongfulact: The wrongfulness of an act of a State not in conformity with an obligation of that State towards another State is precluded of the act constitutes a measure legitimate under international law against that other State, in consequence of an internationally wrongful act of that other State.

Under customary law, however, such countermeasures or acts of reprisal are available to Slovakia only if Hungary was not willing to make reparations for its activities. Moreover, even if Hungary rejected any offer to pay for its alleged breach of the treaty, Slovakia would still be forbidden under international law from taking countermeasures that result in disproportionate damage to Hungary. Here, the irreversible environmental affects of Variant "C" clearly make it an unacceptable form of reprisal.

In conclusion, Slovakia's unilateral diversion of the Danube violates several principles of international law. International law provides Slovakia with no legal justification for its continuation of Variant C. For Slovakia to be serious about becoming a full member in the community of nations, it should express its fidelity to the principles of international law and comity by reconsidering its approach to the Gabcikovo situation. Slovakia should immediately stop operation of the project and cease its diversion the river. It should then begin serious negotiations with Hungary over how to resolve this dispute or, alternatively, should accede to the jurisdiction of the International Court of Justice for a formal ruling on the legality of Variant C.

16. Alternatives to the Gabcikovo Project - What Should be Done to Resolve the Conflict

Short-term solutions:

PROPOSAL FOR A RESEARCH, MONITORING AND INFORMATION PROGRAM FOR THE GABCIKOVO PROJECT

Source:WWF,1993

On occasion of a meeting on 9 December 1992 in Brussels between representatives of DG 1 of the CEC together with WWF, Equipe Cousteau, IUCN and a member of the Working Group of Independent Experts on the Gabcikovo Project, it was agreed that this paper should be worked out containing the following parts:

A: A list and a concept of independent studies needed to better evaluate the hydro-engineering project and its impacts.

B: A proposal for the Terms of Reference for the monitoring process.

C: A proposal for a public information process responding to the growing requests for objective and comprehensive information on Gabcikovo in Europe.

With respect to the political urgency, the suggested studies were discussed under the condition to produce results within 12 months.

A Studies needed for a *Sound Evaluation* of Gabcikovo

The Gabcikovo case is such a big and complex problem that it can neither be examined nor decided only by one evaluation. It is clear to every involved expert that numerous studies covering very different fields are needed. Until today, the Gabcikovo Project was mainly justified with the needs of river engineering and economic use. With a variety of other topics the wide range of affected fields shall become more objective and quantified. These studies are suggested with respect to the fact that the "normal" procedure with a preceding impact assessment hasn't been done but that at present many effects and damages still can be prevented.

A 1 Update for Existing Studies

In the last years several scientists working at the Slovak and Hungarian Academies of Sciences as well as NGOs produced basic information on impacts of the Gabcikovo Project. However, many of these works have limited data base, partialy because the closure of project data(!) or they do not directly concentrate on Gabcikovo. This is why it is necessary to review and extend these works.

A 1.1 Effects of Gabcikovo on Navigation

"A recent statement of the Danube Commission said that Gabcikovo will not improve navigation (as it is always claimed by the Slovak investor). A WWF study for the Austrian Danube comes to the conclusion that navigation will not grow very much and entails only limited benefits. An Equipe Cousteau study on the same issue shows that alternative investments could be more profitable.

This study should provide a "realistic" look at the economic development of the Danube including a comprehensive (i.e. economic and ecological) comparison of the waterway with other transport options (parallel railway lines) and an evaluation of the future need for shipping transport along the Danube (how much traffic needing what kind of navigable waterway etc.).

A 1.2 Contribution of Gabcikovo to the Energy Supply Sector

"A WWF study on the "Options for an Environmentally Sound Energy Policy for Slovakia" reported a technical saving potential of 40-50 % of the Slovak electricity consumption. However, even assuming full production, Gabcikovo will generate only 6,7 to 7,5 % of Slovakia's electricity production (recent information of investor). Similar results can be found in a study of Equipe Cousteau.

The new study should investigate how much electricity can in fact be produced every year depending on the water scenarios (95%, 50% or 20% of the Danube's water to be left in the original bed) and what are the respective cost-benefit ratios (including maintenance and repairing of all construction parts). In addition, it should be examined what other energy options (e.g. energy saving program, new gas power plants, modernisation of existing power plants) with the same or a higher supply level than Gabcikovo would entail what financial and time needs. Attention should also be given to renewable energy sources (e.g. biomass).

A 1.3 Impacts of Gabcikovo on Hydrology and Water Quality

The effects of dams, side channels and weirs on hydrology are widely known. The experience of similar schemes (e.g. Grand Canal d'Alsace) is important for Gabcikovo. A new Slovak study (Liptakova 1992) investigating the effects of the summer flood 1991 in the Danube sediments near Dobrohost showed that the inundation caused temporary changes in the oxigen and chemical conditions in the soil; in case of a situation where these changes aren't reversed anymore (e.g. due to a permanent flooding) detrimental physico-chemical and by consequence also biological changes in soil and groundwater can be expected.

The PHARE programme presently under way (and concluding only in 1995) is concentrating on a computer model of the hydrological system. In addition, it does not cover the also affected areas outside of Slovakia (in Eastern Austria and Hungary). Beside the needed geographical extension this study should produce quicker results based on available and new field and computer data.

It should also examine the engineer's idea to balance the altered groundwater table by installing numerous pumping stations (also: how many are needed, what are the investment and maintenance costs, electricity consumption and factual effects on the hydrology e.g. the groundwater currents) and look at possible alternatives especially with respect to the natural groundwater variations with their impacts on soil productivity and water quality. Concerning the surface water, the impact of the planned irrigation systems (compared to natural inundations: can they imitate natural hydrology, what construction and maintenance budgets are needed) and of the already constructed transverse dikes on the water flow in the side-arms and of their possibly needed dismantling should be evaluated. In addition, the change of water quality due to the loss of the natural purification system in the wetland and the synchronous pollution processes in the storage lake must be quantified. It should be stated how many sewage treatment plants are needed (location, evaluation of cost and construction time). A special study should investigate the microbiological and chemical processes on the asphalt layer of the channel (elsewhere asphalt releases toxic substances).

Another special study should evaluate the drinking water reservoir (present supply and its problems, possible future supply and risks due to Gabcikovo and other problems like agriculture, municipial and industry sewage).

A 1.4 Ecology/Biology of the Wetlands surrounding Gabcikovo

A number of smaller studies and countless scientific statements have emphasized the European importance of this floodplain ecosystem. However, present knowledge is limited (border region!) and lacks sufficient exchange of information. The general impacts of Gabcikovo can mainly be described from the long year experience with other dam schemes (especially Austrian Danube, Upper Rhine, Rhone). The need for more detailed studies was repeatedly underlined by scientists from the region and abroad. At present, there is biological research under way both in Slovakia and Hungary. Unfortunately, they are yet not coordinated and there is no general exchange of data. The data collected in this process will also serve for the biomonitoring activities.

A 1.4.1 Impacts on Botany, Agriculture and Forestry

The floristic and especially the phytosociological mapping must be completed and intensified. Floodplains have a very high species diversity; its amount and the expected reduction (how many threatened species?) must be quantified. Indicator species can provide important information on the exact state of environment at different locations (including ecophysiological analyses to analyse vitality of plants). This field work should be compared with aerial photographs (which in some parts probably still have to be taken). Forestry has altered large parts of the wetland forests but will also critically suffer from the lowering of the water table.

The yet very high productivity of the wetland will be reduced with the loss of regular inundations and water fluctuations (air exchange in the soil) and should be quantified. Also the possible damages following the diversion of the river have to be investigated. The studies have to be extended to locations far outside of the recent wetland which are similarly depending of the groundwater fluctuations. This mainly concerns agricultural land (this is the grain and fruit belt of both countries!) but also to some other wetlands and forests between the Small Danube (Maly Dunaj), the Old Danube and the Mosoni Danube.

A 1.4.2 Impacts on Zoology, Limnology, Microbiology/Virology

Even more than the botanic it is the zoological knowledge which is rather limited. The species number is only a rough estimation (ca. 5.000!). Knowledge is rather good for birds and fishes and a few other groups but poor for others (e.g. Diplopoda, Chilopoda); it can be expected that a number of new species will be detected during the studies. Similarly to plants, animals serve as important indicators (e.g. fishes, dragonflies, beetles, amphibians, micro-crustaceas). With the loss of inundation and soil moisture the steppe patches within the area will extend their size and importance resulting in a expulsion of the wetland organisms (i.e. many European-wide endangered species); this potential should be quantified. The damages caused by the diversion in October 1992 must be quantified and it should be investigated if the inflowing Raba, Rabca and Lajta rivers can restock some cenoses. The water biology of the Szigetkoz is especially rich and important. Recording of water plants, algae and water fauna (snails, insect larvaes, amphibia and fishes) is incomplete. Analyses of microbiology (eutrophication; abundance of bacteria, virus) and selected chemo-physical parameters are needed to evaluate the state of water quality both in the original wetland and in the channel/storage lake.

A special WWF study (Walter 1989) focused on the bacteriology and virology of the Danube found out that the river section between Gabcikovo and Nagymaros has the highest virological problems (second highest is downstream of Beograd) along the Danube. Infection and health risk (drinking water!) is therefore very high. The conclusion that the damming of the river will extend the living conditions for viruses still has to be checqued within a special study on the virus behaviour in the storage lake area (see also A 1.3).

A 1.4.3 Estimation of Genetic Diversity and Impact of Gabcikovo

The Danube wetland is known as an important genepool in which many species survived which are already extinct elsewhere in Central Europe. Both the Austrian and Czech floodplains along Danube-March-Thaya (planned national parks/biosphere reserves) and the Kopacki Rit (mouth of Drava into the Danube at Yugoslav/Hungarian border) are directly connected with the Gabcikovo wetlands, all three together constitute the most precious floodplain areas in Europe. Many wild genes are or can become important sources for human needs (e.g. nutrition, pharmacology). This is why this wetland is sometimes called "our tropical forest". The operation of the Gabcikovo Project can alter and - in long terms - radically destroy this genepool. Until today, only theoretically based intelligent guesses are available for this area. Needed studies should include EC experts and could provide means to estimate recent losses of genetic diversity and to give information on vulnerability of cenoses.

A 1.5 Review of the hydro-engineering concept and works

One of the major critiques over the last years focused on the quality of the construction and the overall concept of Gabcikovo. Local people witnessed repeatedly drunken workers; controll officers reported from their bad experiences when checking workers; the quality of construction under communist regime is sometimes inferior to western standards, may-be also here. The series of technical problems after the diversion in the last months (bypass weir, Gabcikovo locks) and the ongoing repairing of dams, dikes and other facilities is not necessarily "normal". It must be asked why it is ok that the entire length of the channel (over 25 km) has not one security system. Due to the seismic activity of the region some experts demanded a more solid construction of the scheme. After several years of exposition to rain, frost and heat, the sealing of the channel showed fractures. Following some experts the storage lake enhances the creation of waves too high for ordinary Danube ships.

It should also be investigated if the repeated change in the use of the scheme is tolarable for the actual structure (e.g. the Cunovo weir was build for exceptional flood events but possibly will have to be used permanently).

It is konwn that dams and storage lakes alter the flood situation (especially downstream of a dam). Such an analysis for Gabcikovo should be reviewed.

Beside this it is crucial at present and in the future that the discussed scenarios of hydrologists and ecologists will be commented especially from the technical point of view. Other consulting may be requested from A 1.6 study.

A 1.6. Changes on Geomorphology of the Danube

Sedimentation and erosion are key factors in every natural or near-natural riverine system because they guarantee the local dynamics of this ecosystem which promotes its unique biotope and species diversity. The construction of dams in Austria and Bavaria as well as of the harbour of Bratislava and the exploitation of gravel for the construction of Gabcikovo dikes resulted in heavy changes of these processes: question is to exactly quantify these effects over the last decades and to investigate (other) technical means to stop negative effects (e.g. river bed solidification). The creation of a storage lake will enhance sedimentation upstream of Gabcikovo, erosion will become a more important factor downstream. Former studies provided incomplete and sometimes contradictory results but well founded precise data are of utmost importance in predictions and remedial planning. New survey (geodesy) is necessary and can be done within one year. Questions include the unsolved disposal of polluted sludge of the storage lake as well as the extent of the recent damages on the banks in the old river following the Danube diversion and in the river bed near Cunovo due to the untypical flood process along the floodplain and by-pass weirs (December 1992).

Following Slovak engineers, the shallow section near Palkovicovo (sedimentation area in the Danube) is to be affected by stronger erosion. Some Hungarians doubt this prognosis and expect ongoing or even bigger problems for navigation.

One special study should investigate the (change of the) soil quality and its moisture at different locations both in the wetland and in the adjacent agricultural land (see also A 2.1.2). This includes specific organic compounds and trace metals.

A 1.7 Importance of Microseismic Activities near Gabcikovo

The Gabcikovo scheme is built near a seismic fault and located in a relatively unstable region. Scientific data from Hungarian experts was critisized by Gabcikovo engineers, an independent study on earthquake risks does not exist. These data are crucial for the size and quality of all constructions, especially for the channel and the power plant/locks system of Gabcikovo. Monitoring of microseismic activities is fundamental, subsequent research involves many fields from basic studies to risk analyses and earthquake prediction. On 18 October 1990, such seismological monitoring of the Gabcikovo area was already agreed on by respective experts from CSFR (Geofyzika offices) and Hungary (Geodetical and Geophysics Institute) following a request by Hydroconsult (Gabcikovo constructor). Those experts concluded that a network of at least 5 measuring stations (3 on Slovak territory) with data transmission by telemetry should be established and the project should start within several weeks. However, nothing has happened until today!

A 2 New Studies

Several fields of high importance for an evaluation are yet either barely examined or not regarded at all. It can be expected that the investor and constructors have made such studies but they are not understandable. This gap should be filled up with the following studies.

A 2.1 Comprehensive economic evaluation of Gabcikovo

This complex is of upmost importance and has several implications. Even if the project was economicall feasible during its planning phase in the 1970ies it must be questioned if this is still the case today after the many changes within and outside the project. Today's different perception of investments, recompensation, economic estimation of resources directly or indirectly touched by the project must be reflected if the project is to become politically as well as ecomically acceptable and justifiable.

A 2.1.1 Economic evaluation of the project

Over the last year varying figures were publicly given over the costs and economic benefits of the project (navigation, electricity production). However, many cases are known were a new economic investigation following western standards produced different figures because communist interests overruled economic truth. It cannot be said whether this is true for this project or not. Also, the constructor and investor repeatedly showed figures of profitability which are based on investment and cost figures which could never be reviewed or become understandable. It may be that investments prior to the political changes in 1989 cannot be accounted in the same way as recent investments. However, those and the upcoming investments should be clarified. It is clear that the whole project is still incomplete and that repairing and maintenance costs will be very high in comparison to the economic benefits. This analysis within the project scheme is crucial also for the question of recompensation and privatisation.

A 2.1.2 Economic evaluation of regional side-effects of Gabcikovo

Based on the data from biological, hydrological and other studies it is evident that the project will have an direct and indirect impact on the regional economy. This includes creation of jobs during and after construction both due to the benefits and the negative effects of the project. For instance it is evident that maintenance work for the power plant and the channel with the lake will be needed. However, due to the alteration of water quality drinking water purification stations have to be built at a larger extent than without the project. Depending on the bilaterally agreed groundwater level local drinking water supply, agriculture (incl. fisheries), forestry, industry (river navigation) and the service sector (recreation and tourism) will be affected or not. Possible new investments (supply lines and pumping stations for drinking water, irrigation of fields and Danube side-arms, fertilizers etc.) will have to be paid (as subsidies, recompensation?) by the producer, probably even on a long-term base. The cutting-off of the three Slovakian villages has economic impacts, also e.g. the loss of local transport routes (timber) or tourist attractions (wetland). This study is to quantify these aspects.

A 2.2 Social effects of Gabcikovo

The construction of this scheme changing the Slovakian landscape and affecting also the livelihood on the Hungarian side hasn't been studied yet. It is known for instance that people started to move away from the three isolated villages after the beginning of works. The ignoring and non-involvement of local, affected people was "normal" in previous time and could have been changed in the last year. Possible investors like Hydro Quebec International strongly recommended a participation of local people and detailed information for affected communities. The establishment of a transfrontier community council of 80 villages and cities is important in this respect. The fact that mainly Hungarian people are affected by the project on both side of the rivers supports the possibilities for a political and even violent conflict. If this is to be prevented this study can supply important data for immediate and long-term remedies.

A 2.3 Climatic and meteorological effects of Gabcikovo

Gabcikovo will almost certainly affect the local climate, i.e. the amount and time of wind, fog, frost, heat etc. This is caused by the clear-cutting of forests, the drying up of wetlands, side-arms and oxbow-lakes, the creation of a straight outflow (channel), the concentration of the water body with reduced evaporation surfaces, the loss of obstacles and soil cover etc. This results in measurable changes (e.g. number of frost days) and has economic implications (e.g. heating, irrigation, transport fuel). This study should quantify these factors.

A 2.4 Risk analysis for potential water and soil contamination in the area surrounding Gabcikovo

The damming of the river has not only effects for the original hydrology but it will also affect the soil and underground up to several kilometers away from the scheme. The lifting but also the lowering of the water table can result in mobilisation of various contaminations. It is known since many years that uncounted dampsites of cities like Bratislava or Samorin and large industry complexes (like the oil refinery Slovnaft and other chemical companies) are or could become subject of hydrochemical effects. However, most of these localities are either not detected or of unknown content, others are diffuse (polluted Danube water, agriculture!). In the last years, several wells near the Danube downstream of Bratislava had to be closed. The change of groundwater flows can result in an activation and moving of such contamination sources which can result in pollution of soil and especially surface and groundwater. Due to the special situation below Gabcikovo (a huge drinking water reservoir of over 13 km3) and the widely unknown character of the contamination sources the risk of a major pollution and destruction of the water body is known among experts but not well examined (not even in hydrological studies). Both agriculture and the drinking water supply for millions of people can be affected.

A 2.5 Financing study for needed investments and other costs

Whatever will be the fate of this project it is clear that further investments are needed and will hardly be supplied from Slovak side. Beside the fact that (sooner or later) Hungary will have to pay recompensation for leaving the joint project, a solution aimed at stepping out of the project should be financed to some extend from international new finance sources. It would be very helpful if an internationally experienced adviser consults how to do this.

A 3 Proposal of new solutions based on the studies' findings

During and after the more complexe evaluation of the project it will be necessary to make proposals based on the studies' findings. New ecologically sound and economically/technically feasable solutions for the Danube region are actually the only future-oriented ways and therefore should essentially be discussed in the present situation. This includes answers to the question what to do with the different structures already built in the area and with the number of problems recognised. Also, some results of the "Working Group of Independent Experts" from 23 November 1992 should be discussed under a new time and capacity frame; especially the 0-variant (rehabilitation of the area) has never been thoroughly investigated from economic and river engineering side: this study group should define and request respective investigations and calculations from the involved experts. This work should be done by an interdisciplinary team which can either be composed of experts from the above mentioned studies (i.e. during their study work) or by a new team. Due to the time needs it is suggested to rather prefer the second variant.

A 4 Process of studies

Time: 12 months (1.3.1993 - 28.2.1994)

This is a very minimum amount of time and does actually not provide a sound scientific base. If possible the time should be extended to a longer period (intervals are vegetation periods).

Working mode:

Based on the experience from other studies it is suggested to not let the studies separately going on but to integrate them as much as reasonable. This is especially important for study A 3 but will generally promote a comprehensive result. Therefore it is suggested that one expert of each study subject is regularly joining a core group ("study team") composed of biologists, hydrologists, engineers, economists and others.

It is desired that the public (affected people) will be included in the process.

The involved NGOs (WWF, Equipe Cousteau, SZOPK, Danube Circle) should get regular opportunities to discuss and propose important points to the study team.

Result: It cannot be expected to end up this complexe study with one simple conclusion. However, it can be expected that the experts summarise their detailed results in each study and end up with a few proposals.

A balance between the different arguments should be left to the responsible politicians and/or the International Court of Justice.

B Biomonitoring

The biomonitoring has the purpose to measure the possible changes in the environment following the diversion of the Danube, the damming of the river and its isolation from the underground. It is clear that this cannot prevent ecological damages which partly are visible only several years after the cause or which are caused by several overlaying factors.

Based on the scientific experiences which were gained by Slovak, Hungarian and other international scientists, a needed biomonitoring program for the Gabcikovo area was roughly discussed in the last weeks. It profits from the installation of existing observation stations (e.g. in Slovakia in 1989 with 24 localities including 5 key stations). The proposed system monitors agriculture (soil fertility, crops), forestry (productivity rates), biology and hydrology/hydrochemistry and sediments.

We want to emphasize that the monitoring must be started as soon as possible and within the capability of the system already in place. We recommend that the interrim results should be made available for the public and the political process. The same applies for a control system (this was not the task of this proposal but is crucial especially for any construction activities!) which should be established as well e.g. in form of a bi-or trilateral control station in Cunovo and Gabcikovo power station.

The biomonitoring should be primarily focused on:

B 1 Aquatic fauna and flora

B 2 Analysis of quality and quantity of surface and groundwater

B 3 Monitoring of Terrestrial Vegetation

B 4 Sediment transport and geomorphological changes

C Proposal for an information process for Gabcikovo

The political process in the last years and especially in the last months made it evident that objective information is hard to get and to spread. Within the Gabcikovo debate often contradicting and confusing information led to misperception and wrong interpretation of the real situation.

It is therefore suggested to create one information process which concentrates the most important data and opinions of the involved groups, i.e. Slovak and Hungarian governments , Commission of the EC and NGOs.

We came to the conclusion that TV reports are not the appropriate tool to fulfill the needs but it is rather regular, brief and updated written information together with some background material.

All interested people in Europe (especially in Slovakia and Hungary) should get the same quality of information and in the same time an overview of the present situation. This form of information service also wants to supply a comprehensive overview of the different opinions. In the same time this "Gabcikovo News File" can and should enhance the public debate in a more objective form among the interest groups providing an international forum on the Gabcikovo case which is of European concern. In addition, it offers an opportunity to discuss new ideas and proposals for conflict resolution.

Long-term perspectives:

RESTORATION OF THE LANDSCAPE INTO A STATE OF ENVIRONMENTAL BALANCE

Source:ISTER,1992

According to the cost-benefit analysis of an expert comittee (Hardi et al., 1989), the complete cancellation of the project would be more favorable in the long run from an economic point of view, and for the Hungarians, even in the short run the costs of cancellation and continuation would be about the same. The Hardi Report suggests that a solution could also be found for the international legal aspects: a compensation agreement or litigation between Austria and Hungary. At the same time modification of the Czechoslovak-Hungarian agreement could be initiated, with reference to the points that stipulate the preservation of water quality and other environmental guarantees which have not yet been implemented. A bilateral agreement could be reached in terms of the net difference of gains and losses caused to both sides by the abandonment of the project.

According to the studies carried parallelly by several independent experts (Vegh,1992,ISTER 1992,Liptak,1992) the restoration of the area damaged by the construction of the Gabcikovo Project is quite a real task.

The asphalt and plastic films and other construction materials can be reclaimed. The structures of the so called Variant C should also be pulled down. A relatively simple task is the demolition of the coffer dam at Nagymaros and the restoration of the river bed. The reconstruction of the previously curved shoreline at Visegrád seems to be an important question, since this is one of the essential elements of the landscape of the Danube-bend.

The structures of the weir at Dunakiliti and of the power station Gabcikovo (Bös) cover relatively small areas; their demolition would be rather costly, so they could remain where they are. A tender may be announced for their utilization.

During the reconstruction of the area, the Nagymaros coffer dam and constructions of Variant C have to first be demolished. The next task would be the correction of the wrong regulation, the rehabilitation of the branches and the beginning of the restoration of the forests on the flood-plain. The dismantling of the side channel can be a slower process, and can be coordinated with the soil-regeneration.

The restoration of the shoreline forests upstream from Nagymaros, and other landscape elements could be done later, depending on the available financial means. The damages caused to the population by the construction of the barrage system should be refunded quickly and should be covered by the state budget.

The costs should be divided fairly between the parties. The expenses of those works which were accomplished within the framework of the treaty of 1977 - before that treaty was terminated - and the costs of the restoration tasks should be reasonably divided between Hungary and Czecho-Slovakia (or her legal successor), in equal proportions.

The activities serving the comprehensive, long-term environment protection of the area, (such as the widespread use of alternative, environment friendly agricultural technologies, harmonizing the local natural resources, the processing industry, the agriculture, and - from an ecological point of view - a more favourable land-use, etc.), should fit, as an organic part, into the general transformation process which started withthe political changes. Such fruitful results can be achieved primarily with indirect means, with education, tax-policy, legislation and through the support of the autonomy and grassroots activity of the Csallóköz-Szigetköz region.

A TRILATERAL PROTECTED AREA INSTEAD OF A MONSTER PROJECT

Taking into consideration all the factors summarized in this publication, most of the independent experts and involved NGOs have reached the conclusion that the Gabcikovo Project should be rejected on environmental, ecological, economic and social grounds. SZOPK Regional Organization Central Danube and Slovak Rivers Network husurge an immediate postponement and reevaluation of the entire project. Instead of destroying the landscape which is unique in Europe, it would be eminently possible to lay the foundations for a transfrontier protected area - a trilateral protected area extending into Austria, Hungary, Czech Republic and Slovakia.

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SECTIONS OMITTED

PHOTOS AND ANNEXES OMITTED

Annex 18

COMMISSION OF THE EUROPEAN COMMUNITIES
REPUBLIC OF HUNGARY
SLOVAK REPUBLIC

WORKING GROUP OF MONITORING AND WATER MANAGEMENT EXPERTS
FOR THE GABCIKOVO SYSTEM OF LOCKS

DATA REPORT

- Assessment of Impacts of Gabcikovo Project and Recommendations for Strengthening of Monitoring System

Budapest
November 2, 1993

EXECUTIVE SUMMARY

BACKGROUND

As a follow-up of the 'Special Agreement for Submission to the International Court of Justice of the differences between the Republic of Hungary and the Slovak Republic concerning the Gabcikovo-Nagymaros Project' a Group of Monitoring and Water Management.Experts for the Gabcikovo System of Locks (Working Group) was established by the Republic of Hungary, the Slovak Republic and the Commission of the European Communities (CEC).

The tasks of the Working Group fall in two parts:

* On the basis of available data to assess the impacts of the Gabcikovo Project and to prepare recommendations for strengthening the monitoring system in the area.
* Preparation of recommendations for a Temporary Water Management Regime as well as for necessary discharges, water levels and remedial measures.

The present Data Report deals with the first of the above two tasks, while the Final Report of the Working Group scheduled for the beginning of December 1993 shall deal with the second aspect.

The Working Group has obtained most of the relevant data and information requested from the two Governments. The report is based on this information.

IMPACTS OF THE GABCIKOVO PROJECT

Major general impacts as compared to pre-dam conditions have been identified from the available data with regard to the following aspects:

Discharge

In the Old Danube the discharge has in 1993 been reduced to in average about 400 m^3/s corresponding to about 20 % as compared to the pre-dam condition.

Surface water level

At Bratislava the water levels during low flow periods have increased by 1-2 m as compared to pre-dam conditions, i.e. to a level corresponding to the situation 40 years ago. In the upstream part of the Old Danube the 1993 water levels have been reduced by 2-4 m as compared to pre-dam conditions, and have thus reached a level 2 m below the lowest ever recorded values. In addition, the characteristic natural dynamics of the water level fluctuations have been changed (reduced) significantly.

Sediment transport and sedimentation/erosion

Significant erosion occurred the first 500 m downstream the Cunovo structures under the November 1992 flood event. This material has been deposited downstream in the Old Danube. Sedimentation of fine material/silt can be seen in the Old Danube. Most likely, sedimentation of the total bed load and a substantial part of the suspended load have occurred in the reservoir. However, there are presently not sufficient data to quantitatively assess such impacts.

Ground water level

In June/July 1993 the situation in Slovakia shows that over the entire area the ground water levels have increased or have not been affected. The increases have mainly occurred in the upstream area close to the reservoir, i.e. in the area which has been most negatively affected by the long term trend of decreasing ground water levels. On the Hungarian side, where comprehensive assessments have not been made, it appears that ground water levels have increased close to the reservoir (Rajka - Dunakiliti region). Furthermore, it appears that in the middle part of Szigetköz between Dunakiliti and Asvanyraro ground water levels have decreased in areas close to the main Danube. On both sides the ground water level fluctuations have been reduced significantly.

Electricity production

The Gabcikovo hydropower plant has produced 150 - 200 Gwh/month in 1993. This corresponds to about 10% of Slovakia's electricity consumption.

Executive Summary - page iii

In addition, minor impacts have been observed or no significant impacts can be detected from the available data for the following aspects:

Surface water quality

With exception of November - December 1992, when sudden changes of regime and a high flood event occurred, no significant changes in surface water quality parameters as compared to pre-dam conditions can be detected after damming the Danube.

Ground water quality

In general, no significant ground water quality changes can be identified after the damming of the Danube. One exception is the Rusovce area where some parameters (e.g. Total Dissolved Solids ànd nitrate) have changed due to changes in the flow pattern. No changes in concentrations of heavy metals nor organic micropollutants have been detected.

Flora and fauna

Due to insufficient data availability and due to the long response time of natural systems with regard to flora and fauna, no major general impacts can be documented as yet. However, changes in the abundance of certain species have been observed.

Agriculture

Due to increases of ground water tables on the Slovak territory a slight increase in the capillary water supply for Slovakian agricultural areas has taken place. In Hungary, where comprehensive assessments have not been made, the impacts on agriculture are uncertain.

Forestry

As a result of the changes in ground water levels the forestry has been positively influenced in Slovakia and negatively in Hungary.

RECOMMENDATIONS FOR STRENGTHENING OF MONITORING SYSTEM

The Working Group recommends that the present monitoring system, including the extended programmes specifically aiming at monitoring possible impacts of the Gabcikovo Project, be continued.

In addition, the Working Group recommends that the monitoring system be strengthened in two aspects:

* aspects requiring more measurements, either in terms of measurements of new parameters or more measurements (in time and space) of already measured parameters; and
* aspects where discrepancies between Slovakian and Hungarian data have been detected, and where coordination efforts therefore are required.

For the different parameters the recommended strengthening is as follows:

Discharge

For obtaining firm conclusions on the discharge uncertainties the following checks are required to be carried out by joint Hungarian-Slovakian teams:

* Check on discharge calibration curve at the bypass weir at Cunovo.
* Check on discharge calibration curve at the turbines at Gabcikovo.
* Check of discharge rating curves at Rajka and Dunaremete.

Surface water levels

There is a need for a new monitoring programme on measurements of surface water levels in the side channels on the flood plains both in Hungary and in Slovakia.

Surface water quality

There is a need for a new monitoring programme on measurements of surface water quality in the side channels on the flood plains both in Hungary and in Slovakia.

Sediment transport and sedimentation/erosion

There is a need for establishment of a permanent sediment transport measurement programme comprising both bed load and suspended load measurements at the following locations:

* Upstream the reservoir.
* In the reservoir.
* In the Old Danube.
* In the side channels of the Hungarian and Slovakian flood plains.
* Downstream the confluence at Sap/Palkovicovo.

Furthermore, there is a need for establishment of permanent programmes for monitoring river bed and reservoir topography.

Ground water quality

The intensive monitoring must be continued for the coming years, especially with regard to areas close to the Danube where the infiltration conditions have been changed. Depending on the development of the measured ground water quality parameters it may be required to add more observations in the future.

Flora and fauna

A biomonitoring programme comprising the following elements should be carried out:

* Geobotanical monitoring.
* Mapping of the bird species.
* Investigations on fish populations, Carabide-beetles, grasshoppers and living and dead mussels and water snails.
* Monitoring of plankton in major water bodies.

Forestry

The following monitoring should be carried out:

* Mapping the forest types in the scale 1:10.000.
* Annual measurements of height, perimeter and leaf area at selected "monitoring trees".

TABLE OF CONTENTS

1. INTRODUCTION

1.1 Background and Objectives for the Working Group

As a follow-up of the 'Special Agreement for Submission to the International Court of Justice of the differences between the Republic of Hungary and the Slovak Republic concerning the Gabcikovo-Nagymaros Project' a Temporary Water Management Regime for the Danube has to be established and implemented.

In order to provide reliable and undisputed data on the most important effects of the current water discharge and the remedial measures already undertaken as well as to make recommendations for appropriate measures a Group of Monitoring and Water Management Experts for the Gabcikovo System of Locks (Working Group) was established by the Republic of Hungary, the Slovak Republic and the Commission of the European Communities (CEC). The Terms of References for the Working Group are enclosed in Appendix A.

The Working Group is composed of the following five experts:

CEC: Professor Johann Schreiner (primus inter pares), Director, Norddeutsche Naturschutzakademie, Germany.

Mr. Jan M. van Geest, Director, DHV Environment and Infrastructure, The Netherlands.

Mr. Jens Christian Refsgaard, Chief Hydrologist, Danish Hydraulic Institute, Denmark.

Slovakia: Professor, Dr. Igor Mucha, Faculty of Natural Science, Comenius University, Bratislava.

Hungary: Professor, Dr. Gabor Vida, Head of Department of Genetics, Eötvös L. University, Budapest.

The five experts were assisted by colleagues as listed in Appendix B. The Working Group had its first formal meeting on September 8-9, 1993 in Bratislava. The second meeting was held in Budapest during the period October 27 - November 2, 1993. Field inspections were carried out on October 30 both in Slovakia and in Hungary. In between the two formal meetings comprehensive work on data collection and analyses were carried out by the Slovak and Hungarian experts and interaction with the CEC experts also took place during this period.

The Working Group has to prepare two reports. The present report, which is the first one, comprises an assessment of the impacts of the Gabcikovo project with regard to discharges, surface water levels and quality, sedimentation and erosion, ground water levels and quality, flora and fauna, agriculture, forestry and electricity production. Furthermore, recommendations for strengthening of the monitoring system in the area are given.

The second and final report, scheduled for the beginning of December 1993, will comprise recommendations for the governments for a Temporary Water Management Regime as well as for necessary discharges, water levels and remedial measures to be taken.

The Working Group has obtained most of the relevant data and information requested from the two Governments. The report is based on this information.

1.2 The Gabcikovo Project

The hydraulic structures and their capabilities with regard to water management as per November 22, 1992 are described in ref /1/. Since then developments have taken place with regard to:

(a) Turbines and shiplocks at Gabcikovo.
(b) Variant C structures at Cunovo.
(c) Structures allowing water flow through the side channels on the Slovakian flood plains. This system, which started operating in April 1993 enables 234 m^3/s to be diverted from the power canal to the side channels through an inlet structure at Dobrohorst. At present about 43 m^3/s flow through the system of side channels.
(d) Structures allowing water flow through the side channels on the Hungarian flood plains. This system, which started operating in August 1993, utilizes some of the water coming through the Mosoni Danube and the seepage canal from Slovakia. At present about 10 m^3/s flow through the system of side channels.

A more detailed description of these structures and their water management capabilities will be given in the final report of the Working Group devoted to Temporary Water Management Regime.

2. DISCHARGE

2.1 Available Data

The amount of discharge data in the area is comprehensive. Daily data from the locations listed in Table 2.1 have been analysed. The locations of the stations are shown on the index map in Fig. 2.1

Table 2.1 Discharge stations in the area

Location		Country	Station Code
Danube, Devín		SK	5127
Danube, Bratislava		SK	5140
Danube, Rajka		H	000001
Danube, Dunaremete		H	000002
Danube, Medvedov		SK	5145
Danube, Komarom		H	000005
Danube, Komarno		SK	6850
Danube, Iza		SK	6860
Little Danube, Male Palenisko (intake at Bratislava)		SK	5150
Little Danube, Nova Dedinka		SK	5190
Little Danube, Trstice		SK	5280
Mosoni Danube, Outlet at Cunovo		SK	
Mosoni Danube, Rajka		H	110002
Seepage canal, right side		SK	
Danube, bypass weir Cunovo		SK	
Intake to Slovakian river branches, Dobrohost		SK	
Turbines, Gabcikovo		SK	
Shiplocks, Gabcikovo		SK	

For many of the stations, especially the ones located at the Danube itself, historical time series exist for several decades. In the data analyses presented below mainly the data from the period 1991 - 93 have been considered. However, also the most important long term trends have been analysed.

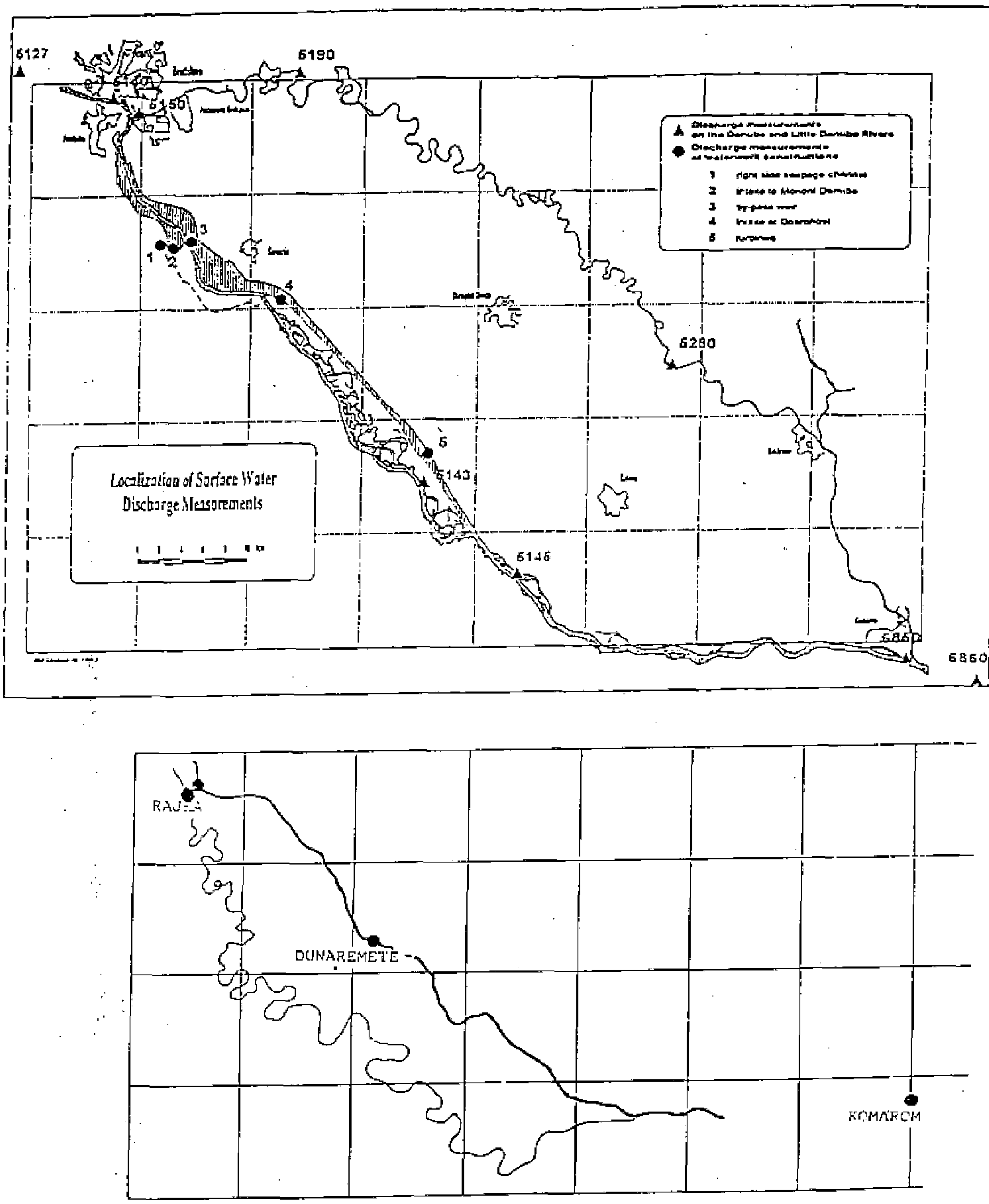


Fig. 2.1 Index map showing locations of discharge stations.

The discharge at the bypass weir at Cunovo is estimated from the setting of the gates. The same procedure could in principle be used also for the inundation weir at Cunovo. However, due to the large width of this weir small uncertainties in water level observation would result in very large uncertainties on the discharge through the weir. Therefore, the discharge is not measured, but has to be estimated from e.g. measured discharge data at Rajka.

At Mosoni Danube historical discharge data exist from the mid 1980's onwards.

In order to assess the impacts of rapid changes of operation of the bypass weir at Cunovo and of the turbines at Gabcikovo hourly discharge values have been analysed for a few selected days.

2.2 Data Analyses - Long Term Trends

The long term trend of the Danube discharge can be evaluated from Fig. 2.2, which shows the Danube discharges (and water levels) at Bratislava for the last 40 years. In addition to the actual data the linear regression line is shown in the figure. Evidently, there is no significant long term trend in the Danube discharge.

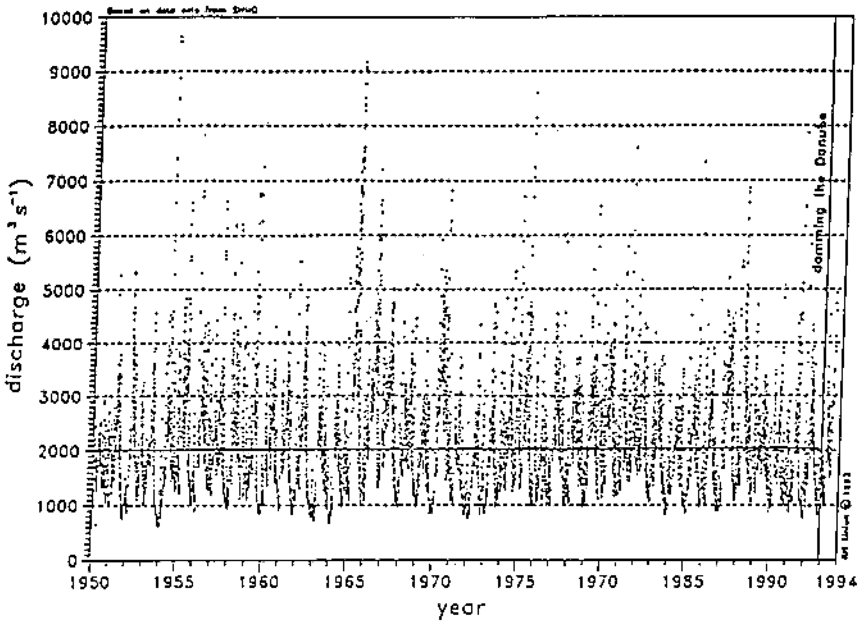
Historical discharge data from the Little Danube, ref. /2/, show a clear decreasing trend from the mid 1970's to 1992. This is a result of a general decrease in Danube water level at Bratislava, cf. Section 3.2.

2.3 Analyses of 1991-93 Data

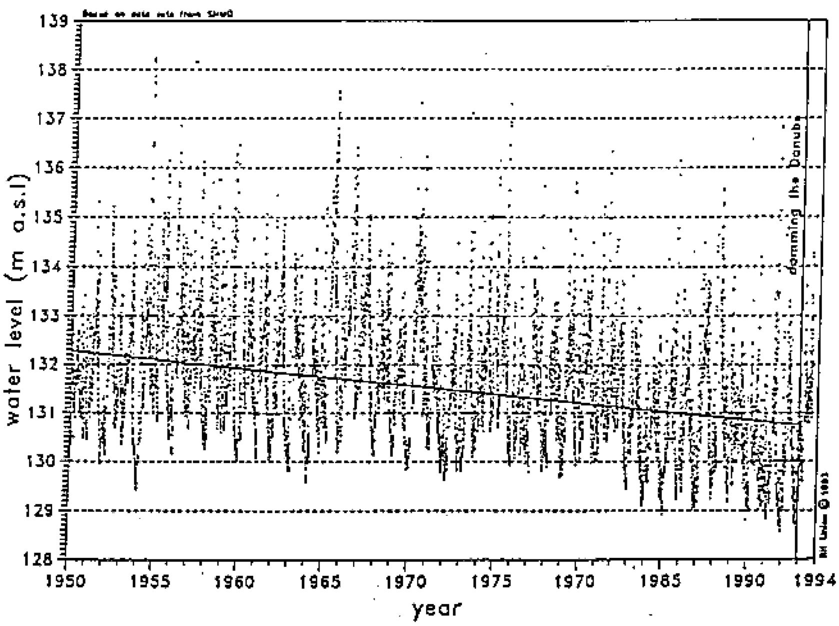
Hydrographs of daily discharges have been plotted for all stations, ref. /2,3/, for the period after January 1991. Furthermore, the monthly average values have been calculated.

Selected hydrographs for the main river system are shown in Fig. 2.3, while discharges to the Little Danube, Mosoni Danube, right side seepage canal and intake to the Slovak flood plains are shown in Fig. 2.4.

A summary of 1993 discharge values stations are given in Table 2.2.

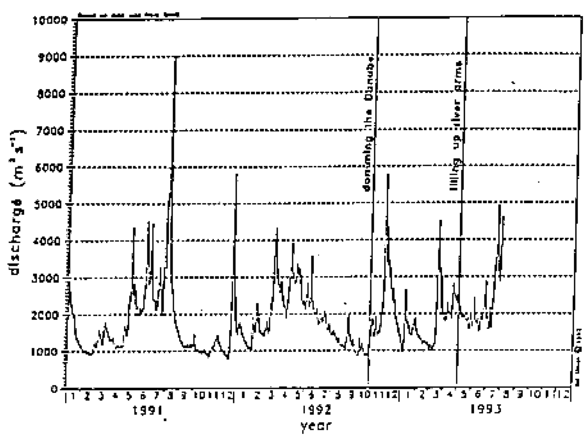


Discharge of the Danube river at Bratislava

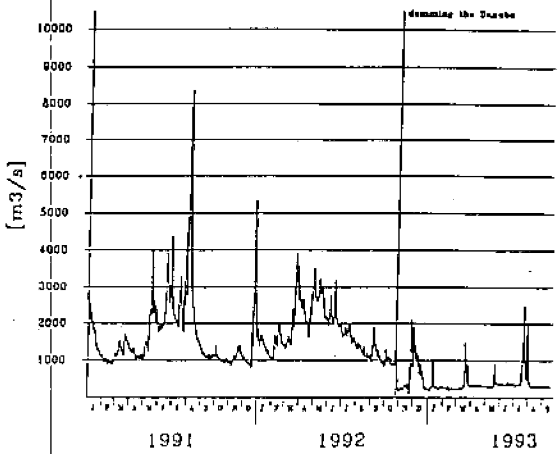


The Danube water level at Bratislava

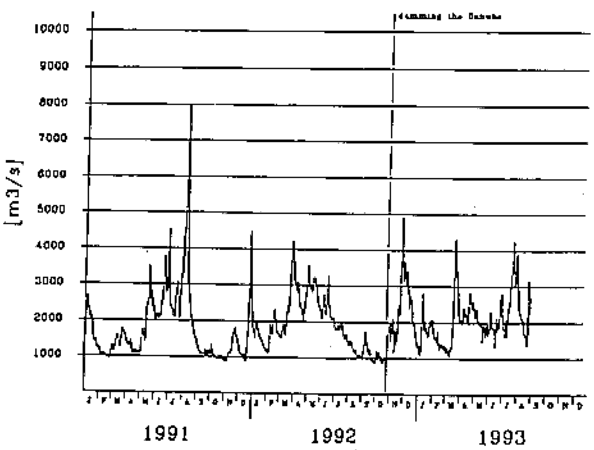
Fig. 2.2 Danube discharges and water levels at Bratislava for a 40 year period.



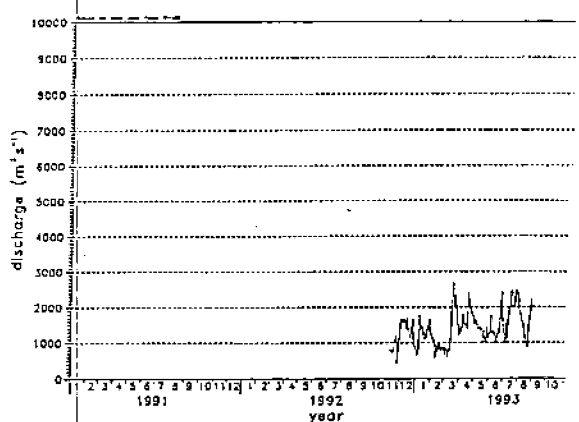
Discharge of the Danube river at Bratislava



Discharge of Danube at Rajka.



Discharge of Danube at Komarom



Discharge through turbines

Fig. 2.3 Discharges at Bratislava, Rajka, Komarom and through the turbines at Gabcikovo 1991-93.

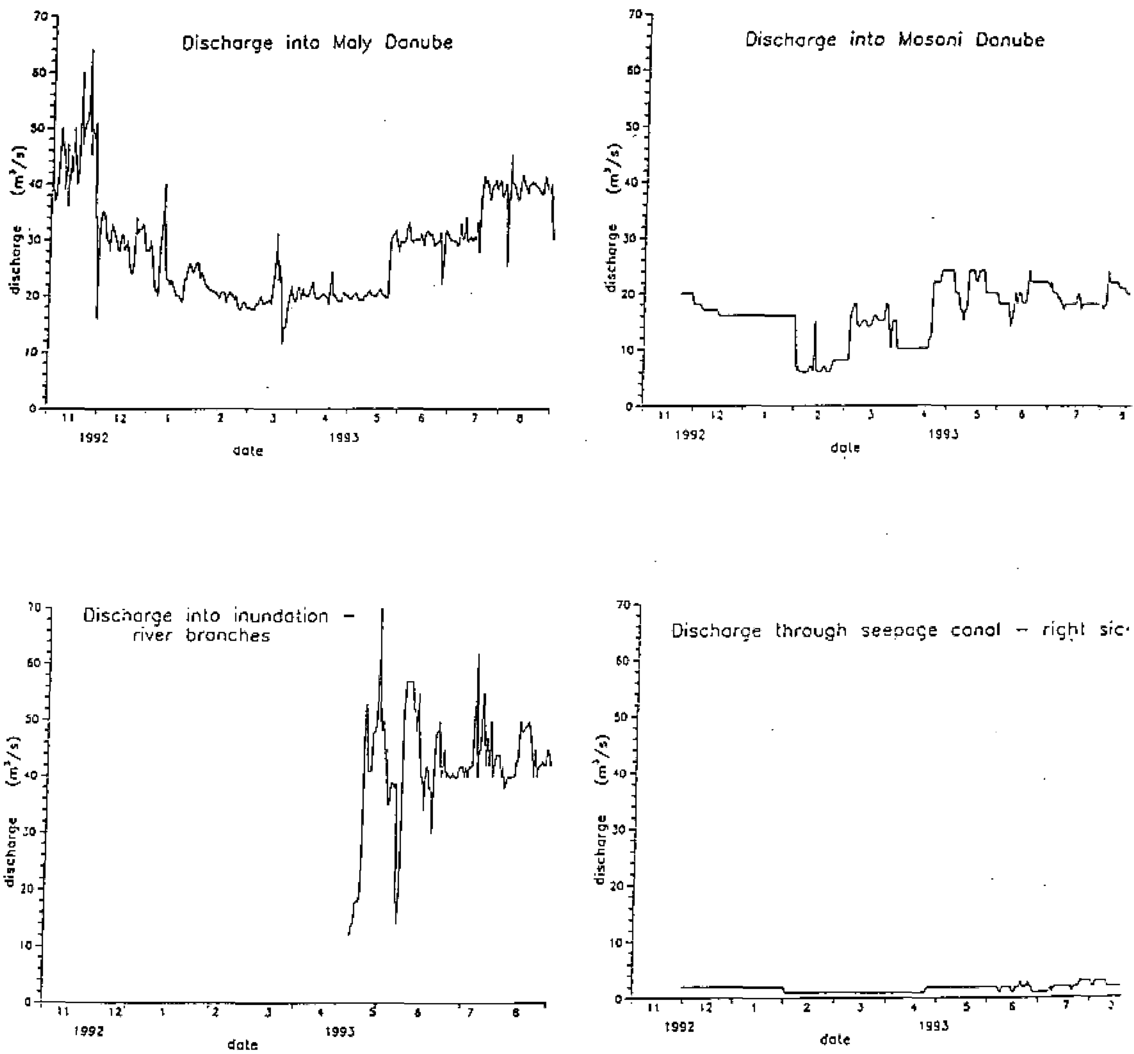


Fig. 2.4 Discharges at intakes to Little Danube, Mosoni Danube, the Slovak flood plain and discharge in the right side seepage canal 1991-93.

Table 2.2 Average monthly discharges in 1993

AVERAGE MONTHLY DISCHARGE (m^3/s)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Ave Jan-Jul
Danube, Devin/Bratislava	1607	1313	2025	2177	1925	1964	2830	2129	1.977
Danube, Rajka	303	225	420	294	354	347	731	314	382
Danube, Dunaremete	298	238	467	319	370	382	789	362	409
Danube, Medvedov	1519	1266	1846	2051	1846	1909	2702	2080	1.877
Danube, Komarom	1760	1480	2100	2270	1950	1950	2660	2140	2.024
Danube, Komarno	1613	1440	2025						
Danube, Iza	1810	1583	2254	2412	2066	1969	2733		2.118
Little Danube, Male Paleniska (intake at Bratislava)	20	17	16	17	19	25	29		20
Little Danube, Nova Dedinka	14	12	11	15	13	17	24		15
Little Danube, Tratice	28	25	25	24	18	19	25		23
Mosoni Danube, Outlet at Cunovo	16	7	14	14	21	20	19	19	16
Mosoni Danube, Rajka	12	9	13	12	20	21	23	23	16
Seepage canal, right side	2	1	1	1	2	2	2	2	2
Danube, bypass weir Cunovo	427	335	364	392	405	444	347	426	388
Intake to Slovakian river branches, Dobrohost	0	0	0	6	38	43	44	43	19
Turbines, Gabcikovo	1209	971	1425	1670	1366	1404	1987	1579	1.433
Shiplocks, Gabcikovo	12	16	16	23	26	32	32	34	22

CONSISTENCY CONTROL OF *MEASURED DISCHARGES*									
Q_{a1}	1.587	1.396	2.009	2.160	1.906	1.939	2.801		1.957
Q_{a2}	1.542	1.220	1.876	2.008	1.807	1.848	2.815		1.874
Q_{a3}	1.531	1.275	1.859	2.063	1.866	1.930	2.725		1.893
Q_{a4}	1.760	1.480	2.100	2.270	1.950	1.950	2.660		2.024
Q_{a5}	1.613	1.440	2.025						
Ave (Q_{a1}..Q_{a5})	1.607	1.342	1.974	2.125	1.882	1.917	2.750		1.942
Std (Q_{a1}..Q_{a5})	95	112	103	115	61	47	72		86
Std/Ave (in %)	6	8	5	5	3	2	3		5
Q_{b1}		335		392		444			
Q_{b2}	303	225	420	294	354	347	731		382
Q_{b3}	298	238	467	319	370	382	789		409

Note: Details are provided in the text

From Fig. 2.3 and Table 2.2 it is evident that the Gabcikovo Project has had a very large impact on the discharge regime in the Danube between the weir at Cunovo and the downstream confluence at Palkovicovo. In this reach (the Old Danube) the discharge has in 1993 been reduced to about 20 % as compared to the pre-dam condition. Fig. 2.5 shows the ratio between the Danube discharge at Rajka and Bratislava from January to August 1993. It is noticed that the Rajka discharge during this period has varied between 11% and 50% of the Bratislava discharge.

From Fig 2.4 it appears that the discharge to Little Danube has been increased with about 10 m^3/s, representing approximately a doubling as compared to the pre-dam conditions. Similarly, the discharge to Mosoni Danube has been significantly increased. Finally it may be noted that with the water intake from the power canal at Dobrohost to the Slovakian flood plains the water flow through the side arms has been very significantly increased as compared to the pre-dam conditions, which most often were characterized by stagnant water.

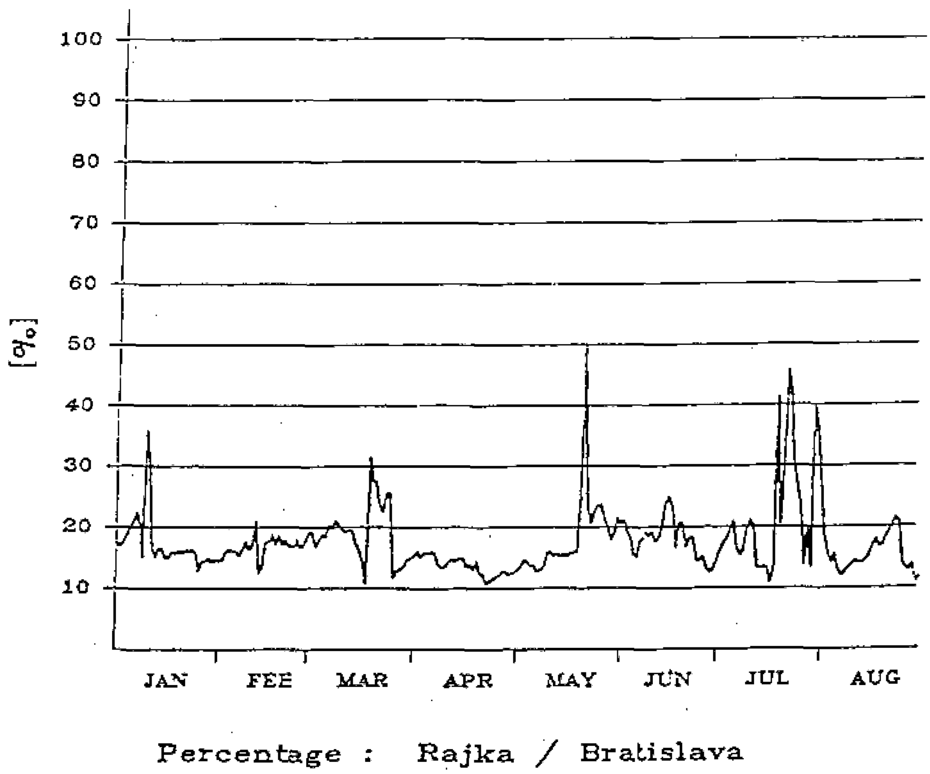


Fig. 2.5 **The ratio of the measured discharges at Rajka and Bratislava for January to August 1993**

An analysis of the uncertainty/consistency of the discharge measurements can be made by considering the following continuity conditions:

(a) Discharges upstream the reservoir compared to discharges through the structures and compared to discharges downstream the confluence.

$$Q_{a1} = Q_{a2} = Q_{a3} = Q_{a4} = Q_{a5}$$

where,

$$Q_{a1} = Q_{Bratislava/Devin} - Q_{Little\ Danube}$$

$$Q_{a2} = Q_{Turbines} + Q_{Shiplocks} + Q_{Dobrohorst} + Q_{Seepage} + Q_{Mosoni\ Danube} + Q_{Rajka}$$

$$Q_{a3} = Q_{Medvedov} + Q_{Mosoni\ Danube}$$

$$Q_{a4} = Q_{Komarom}$$

$Q_{a5} = Q_{Komarno}$ (excluding discharge of river Vah)

(b) Discharge along the Old Danube

$$Q_{b1} =< Q_{b2} =< Q_{b3}$$

where,

$$Q_{b1} = Q_{Bypass\ Weir}\ (+Q_{Inundation\ Weir})$$

$$Q_{b2} = Q_{Rajka}$$

$$Q_{b3} = Q_{Dunaremete}$$

Because the discharge through the inundation weir is not measured equation (b) is strictly only applicable for periods with no discharge through the inundation weir. In other situations only the $Q_{b2} = Q_{b3}$ is valid.

Summary results of this consistency check based on monthly average discharges are given in the second half of Table 2.2. From the table the following findings appear:

* The Danube discharge at Bratislava minus the discharge to Little Danube (Q_{a1}) is except for July larger than the combined discharge at the Cunovo/Rajka and Gabcikovo structures (Q_{a2}). The difference is about 80 m^3/s (5%)

* The Danube discharge at Bratislava minus the Little Danube (Q_{a1}) is constantly larger than the discharge

at Medvedov plus the discharge at Mosoni Danube (Q_{a3}). The difference is about 60 m^3/s (3%).

* The Danube discharge at Bratislava minus the Little Danube (Q_{a1}) is except for July less than the discharge at Komarom (Q_{a4}). The difference is about 70 m^3/s (5%).

* The discharge at the Hungarian station Komarom can be compared to the Slovakian station Iza, which is located a few km downstream with the river Vah joining in between. Considering that the difference between the two stations, about 100 m^3/s, is the same order of magnitude as the average discharge of river Vah, the agreement between these two stations must be characterized as very good.

* The discharge at Komarno (upstream the confluence with river Vah) measured by Slovakia and the discharge at Komarom measured virtually at the same location by Hungary shows a difference of about 70 m^3/s (4%). Based on the above comparison between Komaron and Iza it appears that the discharge data at Komarom are more reliable than those from Komarno.

* The discharge at the bypass weir (Q_{b1}) can be compared directly to the discharge at Rajka (Q_{b2}) for the months February, April and June 1993, where the inundation weir was not used for passing floods. In these three months the discharge recorded at the bypass weir is about 100 m^3/s (30%) larger than the discharge at Rajka.

* The discharge at Dunaremete (Q_{b2}) is, except in January, higher than the discharge at Rajka (Q_{b3}). The difference is in average about 30 m^3/s (7%).

The uncertainties, which should be considered in further assessment of these findings are:

* The following discharges have not been taken into account:
  - Discharge in the left side seepage canal. This is not measured, but can be estimated to be in the order of 5 m^3/s. The main part of this water is diverted to irrigation and the remaining flows to the side channels in the Slovakian flood plain.
  - Infiltration from reservoir and river system to ground water. This is in the order of 18 - 35 m^3/s between Bratislava and Sap/Palkovicovo, downstream of where some of it returns as baseflow.

These two loss terms have to be subtracted from Q_{s1} when comparing with Q_{s2}. Hence, the discrepancy reduces to approximately 50 m^3/s (3%).

* There are the ordinary uncertainties in measuring discharge in rivers, mainly due to uncertainties and instabilities of rating curves.

* The discharge through the bypass weir at Cunovo can be considered especially uncertain because the calibration curve relating the upstream water level and the gate settings to the discharge has been calculated from the designed spillway, which had to be changed just after start of operation due to serious erosion problems.

* The uncertainty on the discharges through the turbines are considered relatively small.

On this basis the following conclusions can be drawn with regard to accuracies in the discharge measurements:

(1) The discharges estimated at the bypass weir are too high. 50-100 m^3/s lower values appear more reasonable.

(2) The accuracy, with which such water balances as $Q_{s1} = Q_{s2} = Q_{s3} = Q_{s4} = Q_{s5}$ can be derived appear to be in the order of $^+/_-$ 2-5 % on a monthly basis.

2.4 Adequacy of the present Monitoring System

The number and location of discharge measurement stations are adequate.

For obtaining firm conclusions on the discharge uncertainties the following checks are required to be carried out by joint Hungarian-Slovakian teams:

* Check on discharge calibration curve at the bypass weir at Cunovo.

* Check on discharge calibration curve at the turbines at Gabcikovo.

* Check of discharge rating curves at Rajka and Dunaremete.

3. SURFACE WATER LEVEL

3.1 Available Data

The amount of surface water level data in the area is comprehensive. Data from the locations listed in Table 3.1 have been analysed. Some of the data are average daily values based on raw data from e.g. hourly manual readings or automatic recorders, while at other stations only immediate water level readings are made once per day. The locations of the stations are shown on the index map in Fig. 3.1

For many of the stations, especially the ones located at the Danube itself, historical time series exist for several decades. In the data analyses presented below mainly the data from the period 1991 - 93 have been considered. However, also the most important long term trends have been analysed.

3.2 Data Analyses for Long Term Trends

The long term trend of the Danube water levels can be evaluated from Fig. 2.2 which shows the Danube water levels at Bratislava for the last 40 years. In addition to the actual water level data the linear regression line is shown in the figure. Evidently, there is a significantly decreasing long term trend in the Danube water levels at Bratislava of about 1.5 m. Between Dunaremete and Gabcikovo the water levels show no clear trend for low flows and a small increasing trend for high flows. The reason for this decrease is described briefly in Section 5.2.

Table 3.1 Water level stations in the area

Location	Country	Station Code	Measurement practise
Danube, Devin	SK	5127, 5128	Automatic recorder
Danube, Bratislava	SK	5140	Automatic recorder
Danube, Bratislava-Rusovce	SK	5141	Manual, daily
Danube, Rajka	H	000001	Automatic recorder
Danube, Dunaremete	H	000002	Manual, 2x per day
Danube, Asvanyraro	H		Automatic recorder
Danube, Nagybajcs	H		Manual, 2x per day
Danube, Gabcikovo	SK	5143	Manual
Danube, Palkovicovo	SK	5144	Manual
Danube, Medvedov	SK	5145	Automatic recorder
Danube, Klizska	SK	6810	Manual
Danube, Zlatna na Ostrove	SK	6830	Manual
Danube, Komarno	SK	6850	Manual
Danube, Iza	SK	6860	Manual
Danube, Radvan nad Dunajom	SK	6870	Manual
Danube, Sturovo	SK	6880	Manual
Flood plain branch, Burjan	H		Automatic recorder
Flood plain branch, Doborgaz	H		Automatic recorder
Flood plain branch, B12	H		Automatic recorder
Little Danube, Male Palenisko (intake at Bratislava)	SK	5150	Automatic recorder
Little Danube, Vlcie Hrdlo	SK	5155	
Little Danube, Pod. Biskupice	SK	5152	
Little Danube, Most na Ostrove	SK	5156	
Little Danube, Malinovo	SK	5185	
Little Danube, Nova Dedinka	SK	5190	Automatic recorder
Little Danube, Jelka	SK	5215	
Little Danube, Jahodna	SK	5195	
Little Danube, Trstice	SK	5280	Automatic recorder
Mosoni Danube, Outlet at Cunovo	SK		Manual
Mosoni Danube, Mecser	H	000017	Automatic recorder
Power canal, upstream Gabcikovo	SK		Automatic recorder
Outlet canal, downstream Gabcikovo	SK		Automatic recorder

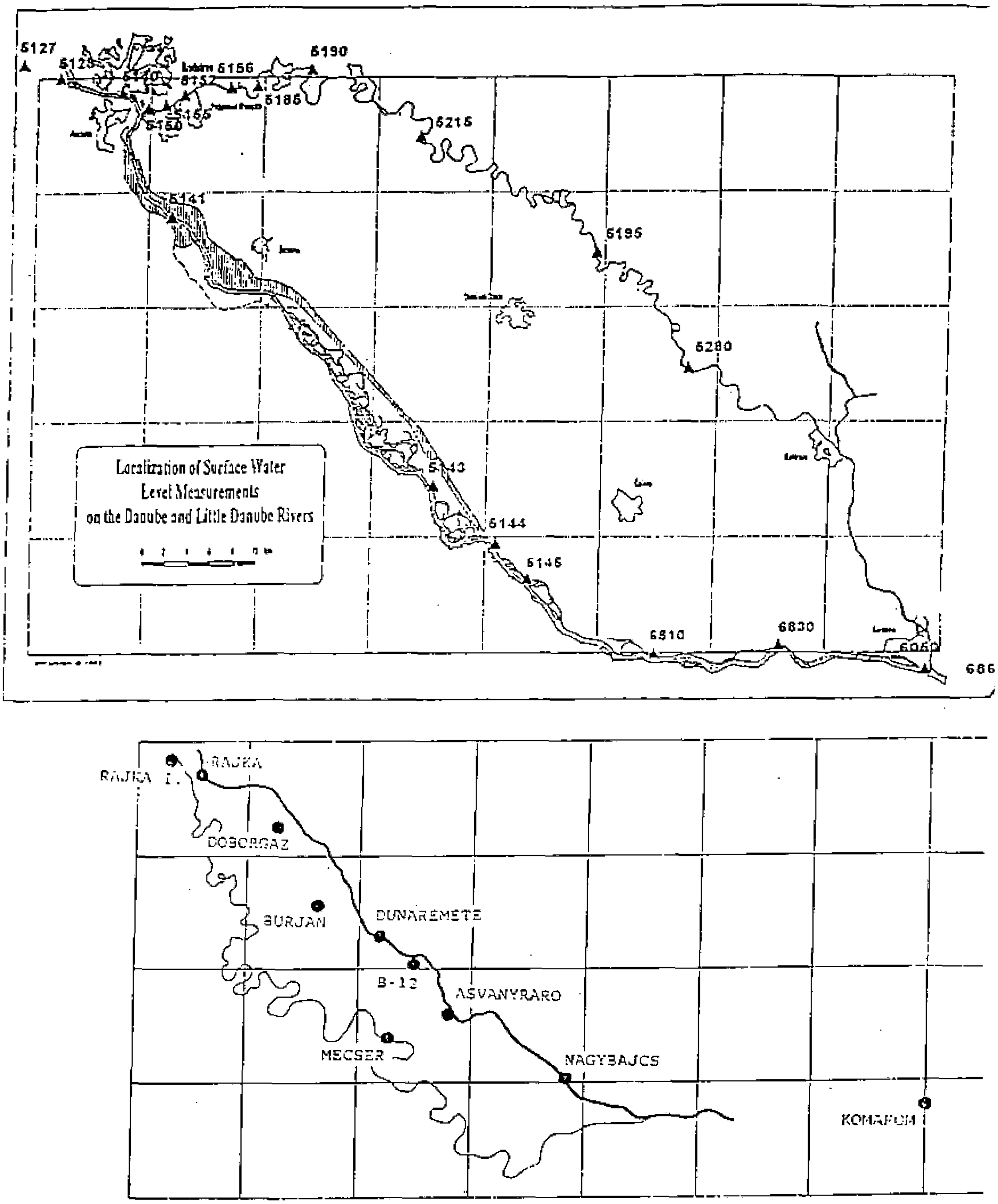


Fig. 3.1 Index map showing locations of water level stations.

3.3 Analyses of 1991-93 Data

Water level hydrographs have been plotted for all stations, ref /2,3/, for the period after January 1991.

Selected hydrographs for the main river system are shown in Fig. 3.2, while water levels in the Little Danube and Mosoni Danube are shown in Fig. 3.3.

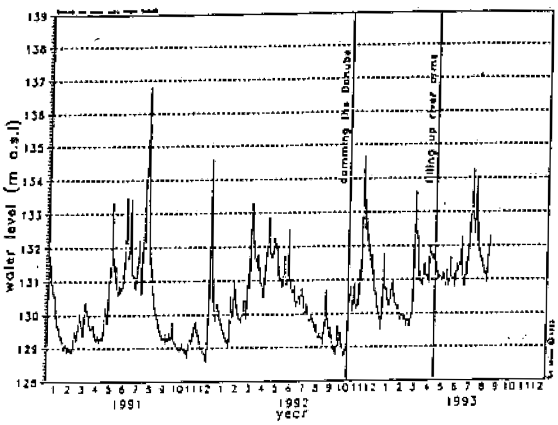
From Fig. 3.2 it is evident that the Gabcikovo Project has had a very large impact on the water level regime in the Danube between Bratislava and the downstream confluence at Palkovicovo. At Bratislava the 1993 water levels during low flow periods have increased by 1-2 m as compared to pre-dam conditions, i.e. the same order of magnitude as the long term decrease during the past 40 years.

From Fig. 3.2 it furthermore appears that the water levels in the Old Danube at Rajka and Dunaremete in 1993 have been reduced by 2-4 m to a level 2 m below the lowest ever recorded values. In addition, the characteristic natural dynamics of the water level fluctuations have been changed (reduced) significantly so that the water level is now more or less constant for several weeks.

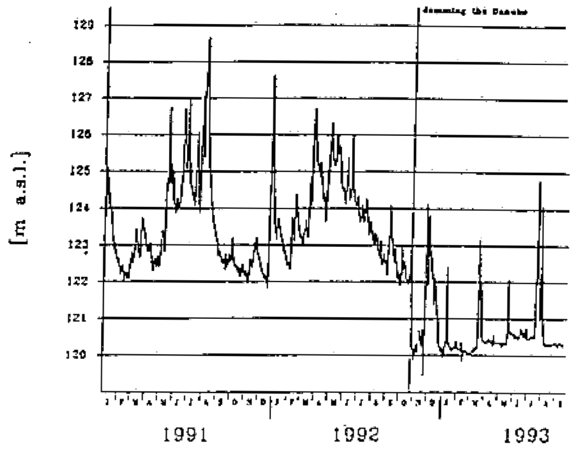
From Fig 3.3 it appears that the 1993 water levels in Little Danube have been increased with 1-2 m as compared to pre-dam conditions. For the Mosoni Danube at Mecser no significant water level changes have occurred.

During the first three months of operation of the weirs at Cunovo unnaturally large and rapid water level fluctuations were generated in Old Danube. Since then the discharge through the weirs at Cunovo have basically been held almost constant except during flood operations where the inundation weir has been used.

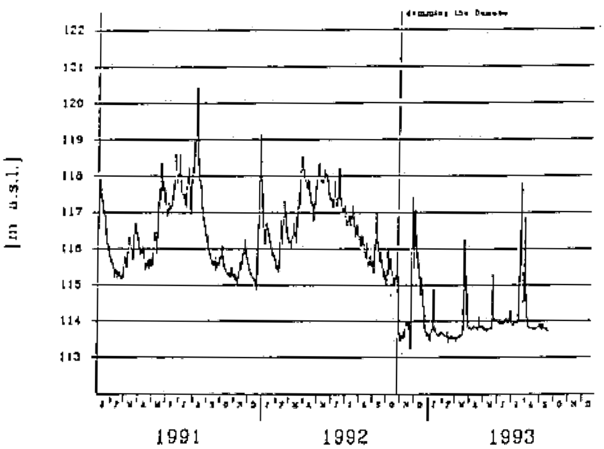
Hourly variations in discharges through the turbines at Gabcikovo are shown for three selected days in Fig. 11.2, from where it appear that the discharge variations from hour to hour typically is in the order of 100 - 300 m^3/s. Such discharge variation will generate downstream water level fluctuations up to 1 m. Larger water level fluctuations were generated on three occasions, 18-19 June 1993, 26-27 September 1993 and 14 October 1993, with the purpose of assisting large ships through shallow water around Nagymaros.



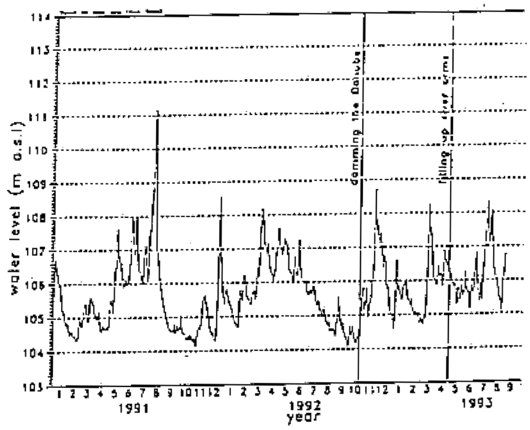
The Danube water level at Bratislava



Water Level of Danube at Rajka

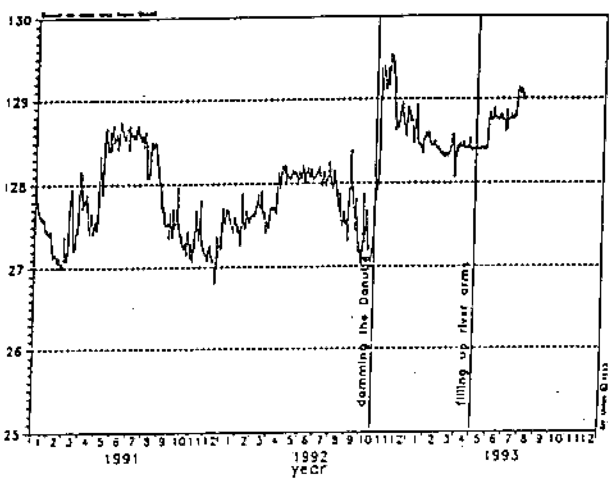


Water Level of Danube of Dunaremete

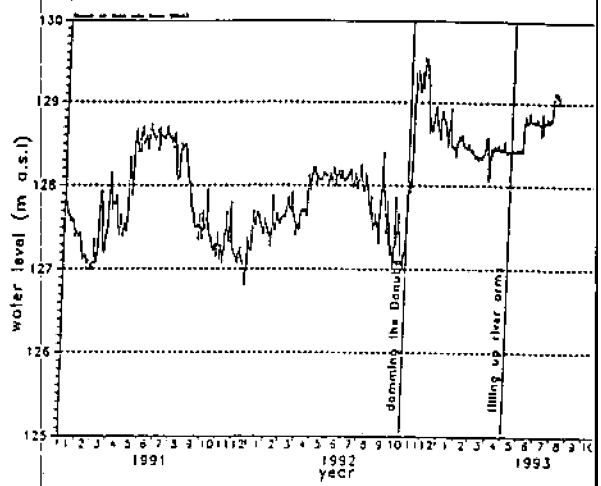


The Danube water level at Komarno

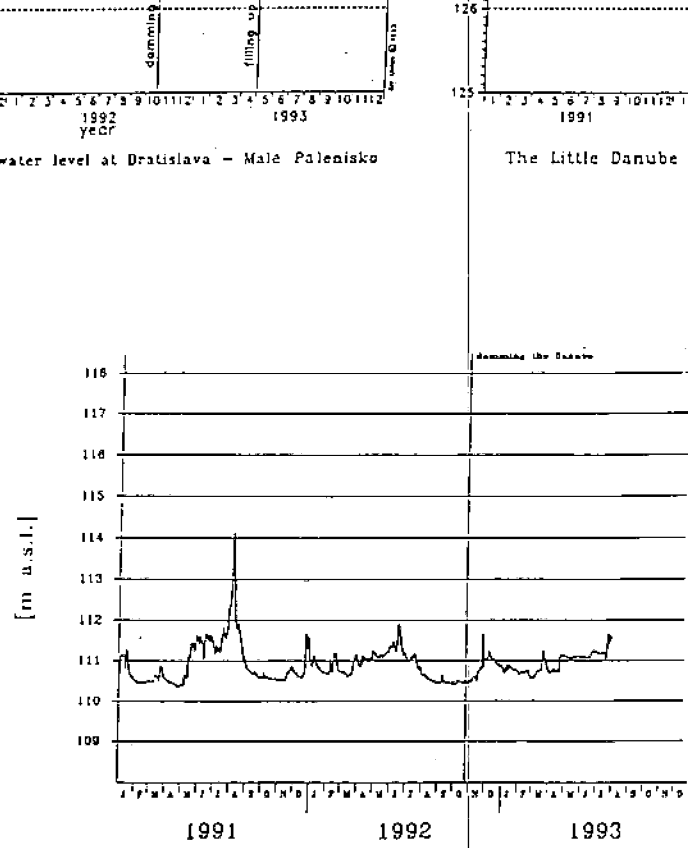
Fig. 3.2 Water levels at Bratislava, Rajka, Dunaremete and Komarno 1991-93.



The Little Danube water level at Bratislava - Malé Palenisko



The Little Danube water level at Trstice



Water Level of Mosoni-Danube at Mecser

Fig. 3.3 Water levels at Little Danube and Mosoni Danube 1991-93.

3.4 Adequacy of the present Monitoring System

In general, the present monitoring of surface water levels appears adequate. However, at present the water levels in the side channels of the flood plains are not monitored on a routine basis on either side of the river.

Furthermore, in areas where rapid water level fluctuations within a day occur it is recommended to substitute the manual observation practice with an automatic recorder.

4. SURFACE WATER QUALITY

4.1 Available Data

The amount of surface water quality data in the area is comprehensive. The station network is shown in Fig. 4.1, while the analysed parameters are listed in Table 4.1. In addition to this routine programme some special measurements of organic pollutants have been made. The routine programme has been carried out in Slovakia for 10-30 years (depending on parameter) and in Hungary for 10-30 years (depending on parameter).

In addition to the above network a program of surface water quality monitoring in the reservoir has been initiated in 1993. This monitoring comprises the key parameters for assessment of eutrophication conditions.

Table 4.1 Surface water quality parameters presented by the Hungarian and Slovakian Data Reports (ref /2,3/).

Parameter	Hungary	Slovakia
$TDS_{(s)}$		X
O_2	X	X
BOD_5	X	X
COD_{Mn}		X
Fe		X
Mn		X
NH_4^+	X	
NO_3^-	X	X
SO_4^{2-}	X	X
Cl^-		X
PO_4^{3-}	X	X
Chlorophyll-a	X	

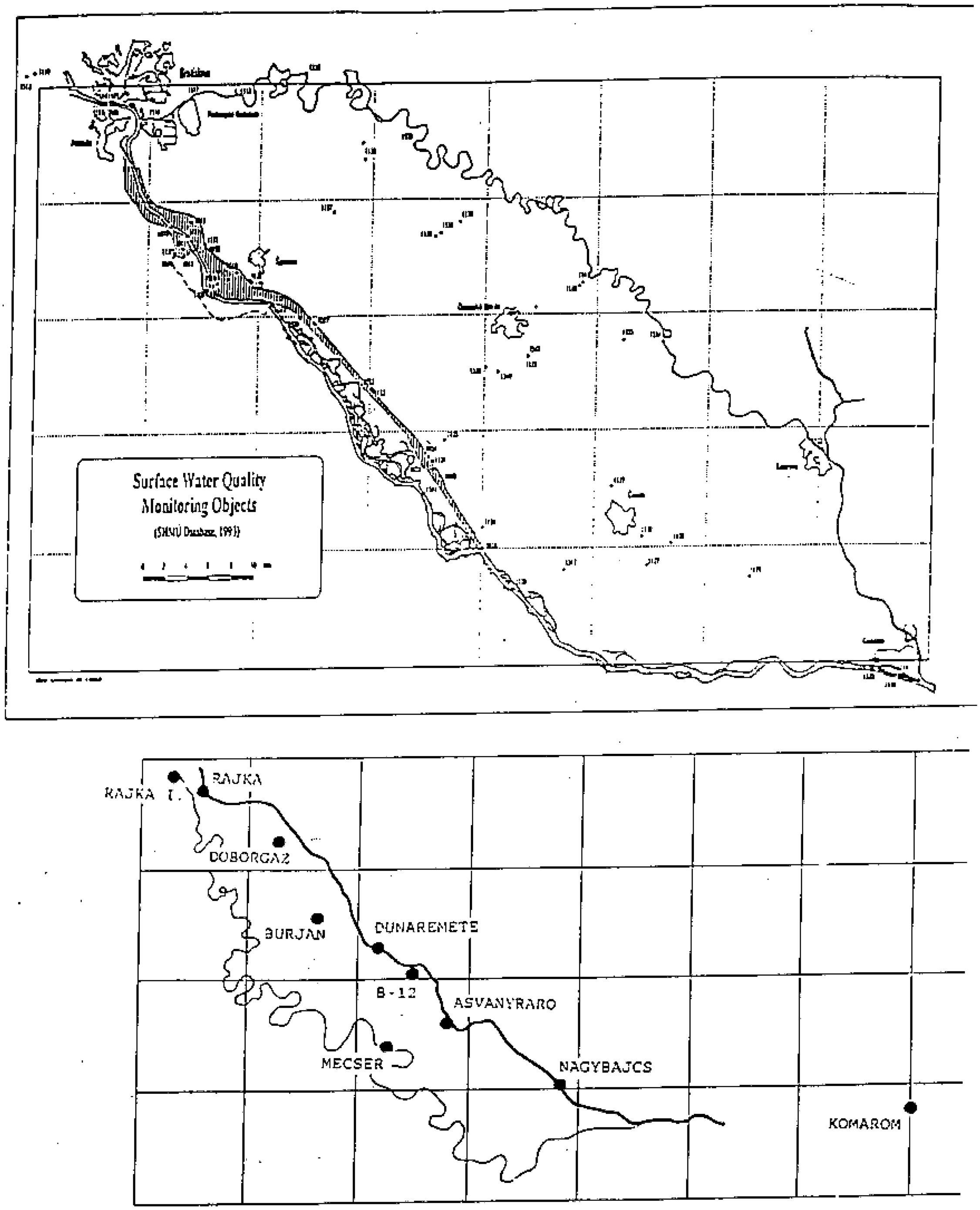


Fig. 4.1 Network for surface water quality observations.

4.2 Data Analyses for Long Term Trends

All the time series of the Slovakian data are plotted in ref /2/. The Hungarian Data Report /3/ provided data from only one station.

The Danube water quality can according to Hungarian classification be categorized as 1st class regarding the majority of the components, as 2nd class regarding Ph, orthophosphate, nitrate, BOD and 3rd class with regard to bacteria and some heavily degradable substances such as e.g. hydrocarbons.

Due to high oxygen content, low organic carbon contents and the very small quantities of fine grained sediments the surface water quality is generally well suited for river bank infiltration, which is the major source of water supply along the Danube between Bratislava and Budapest.

The water quality of the side branches differs from that of the main Danube channel due to the much lower velocities and periods and places with stagnant water. In drier years a negative trend has been observed with high pH, high organic matter and low oxygen contents.

The major sources of water pollution on the Slovak section of the Danube are river Morava and Bratislava.

4.3 Analyses of 1991-93 Data

With exception of November - December 1992, when sudden changes of regime and a high flood event occurred, no significant changes in surface water quality parameters as compared to pre-dam conditions can be detected after damming the Danube. (See also Section 8.3).

4.4 Adequacy of the present Monitoring System

The present monitoring system appears adequate as far as the Danube and the reservoir is concerned. However, there is a need for monitoring of surface water quality in the side channels in the flood plains.

5. SEDIMENT TRANSPORT AND SEDIMENTATION/EROSION

5.1 Available Data

The data available on sediment transport and erosion aspects are limited.

In Slovakia, a comprehensive monitoring and analyses programme was carried out in the 1950's and 1960's, but limited field data have been collected since then. During the period September 1992 to August 1993 a sediment transport field monitoring programme was conducted in connection with the "Danubian Lowland - Ground Water Model" PHARE project. This programme comprised amongst other regular measurements of suspended transport at Bratislava and Medvedov as well as analysis of bed material at different locations in the reservoir.

In Hungary river cross sections are regularly surveyed for the main Danube. Such measurements have also been made in 1993 for comparison with pre-dam conditions (September 1992). However, these data are presently only partly processed. Furthermore, Hungary usually carry out suspended sediment sampling in three sections (Rajka, Dunaremete, Medve) each year simultaneously with the discharge measurements. Occasionally, bed load measurements are carried out in the same sections. In 1992 this was done once, while in 1988-89 there were 13 measurements in this river stretch. Bed material sampling was done approximately for every 1-1.5 km of the river (evidence sections).

5.2 Data Analyses for Long Term Trends

The main channel has been significantly lowered due to erosion caused by a combination of several man made factors:

- dam construction in Austria in the last decades resulting in a sediment (in particular bed load) deficit;
- excavation of gravel;
- bed erosion due to the very high velocities in the straightened and narrowed navigation channel; and
- prevention of bank erosion due to fortification of river banks.

Until the damming of the Danube, erosion took place between Bratislava and Dunaremete. Similarly, sedimentation occurred downstream of Sap/Palkovicovo.

In some places the river bed has been lowered more than two meters since the 1960's, leading to lower ground water levels, occasional drying out of river branches (e.g. downstream of Bratislava) and less flushing of most river branches. The lowering of the riverbed during the past 30 years has been particularly large between Bratislava and Rajka. It is estimated to be about 0.8 meter at Gabcikovo and near Bratislava about 1.5 meter.

According to Hungarian measurements the quantity and concentrations of suspended load on the Danube reach at Rajka has shown a decreasing trend during the past 30 years, see ref /1/.

5.3 Analyses of 1991-93 Data

Qualitatively, the effect of the damming at Cunovo is highly significant on the sedimentation/erosion balance in the Old Danube. Two counteracting processes are important. On the one hand, most of the transported material of the river have already settled upstream in the reservoir (all bed load and 60% of the suspended load according to Slovakian predictions, ref /2/). On the other hand, the water velocity has been reduced very much. The sedimentation is therefore likely to continue and result in finer bed sediments. This will have some implications for the permeability of the river bed.

For quantitative analyses few data exist enabling some tentative but no firm conclusions regarding the impacts due to the Gabcikovo Project.

During the November 1992 flood approximately 2-3 mill m^3 of sand and gravel material were eroded in the first 500 m downstream the inundation weir where the bed protection works were not yet completed. This material has been deposited downstream in the Old Danube. The 2-3 mill m^3 may be compared to the amount of dredged material (for navigation purposes) between Cunovo and Medvedov, which according to ref /2/ is 2.9 mill m^3 over the last 45 years.

As a preliminary conclusion from the Hungarian surveys of river cross sections it can be stated that in some parts of the Old Danube river bed downstream Cunovo (around 1850 rkm and 1811 rkm) there is 1-2 m high freshly sedimented material. This is supported from the observations made during the Working Group's field visit, where a new island of deposited material could be seen in the middle of the river bed.

In Fig. 5.1 suspended sediment concentrations taken in 1993 are compared to pre-dam data. At the two stations in the Old Danube, Rajka and Dunaremete, virtually the same sediment concentration levels have been found after the damming as compared to the pre-dam conditions. However, as the discharges have been very much reduced a significant change in the relationship between discharge and sediment concentration is noticed. Finally, it appears that the impacts for the station downstream the confluence, Medve, may not be significant on the present (small) data basis.

5.4 Adequacy of the present Monitoring System

There is a need for establishment a permanent sediment transport measurement programme comprising both bed load and suspended load measurements at the following locations:

* Upstream the reservoir.
* In the reservoir.
* In the Old Danube.
* In the side channels of the Hungarian and Slovakian flood plains.
* Downstream the confluence at Sap/Palkovicovo.

Furthermore, there is a need for establishment of permanent programmes for monitoring river bed and reservoir topography.

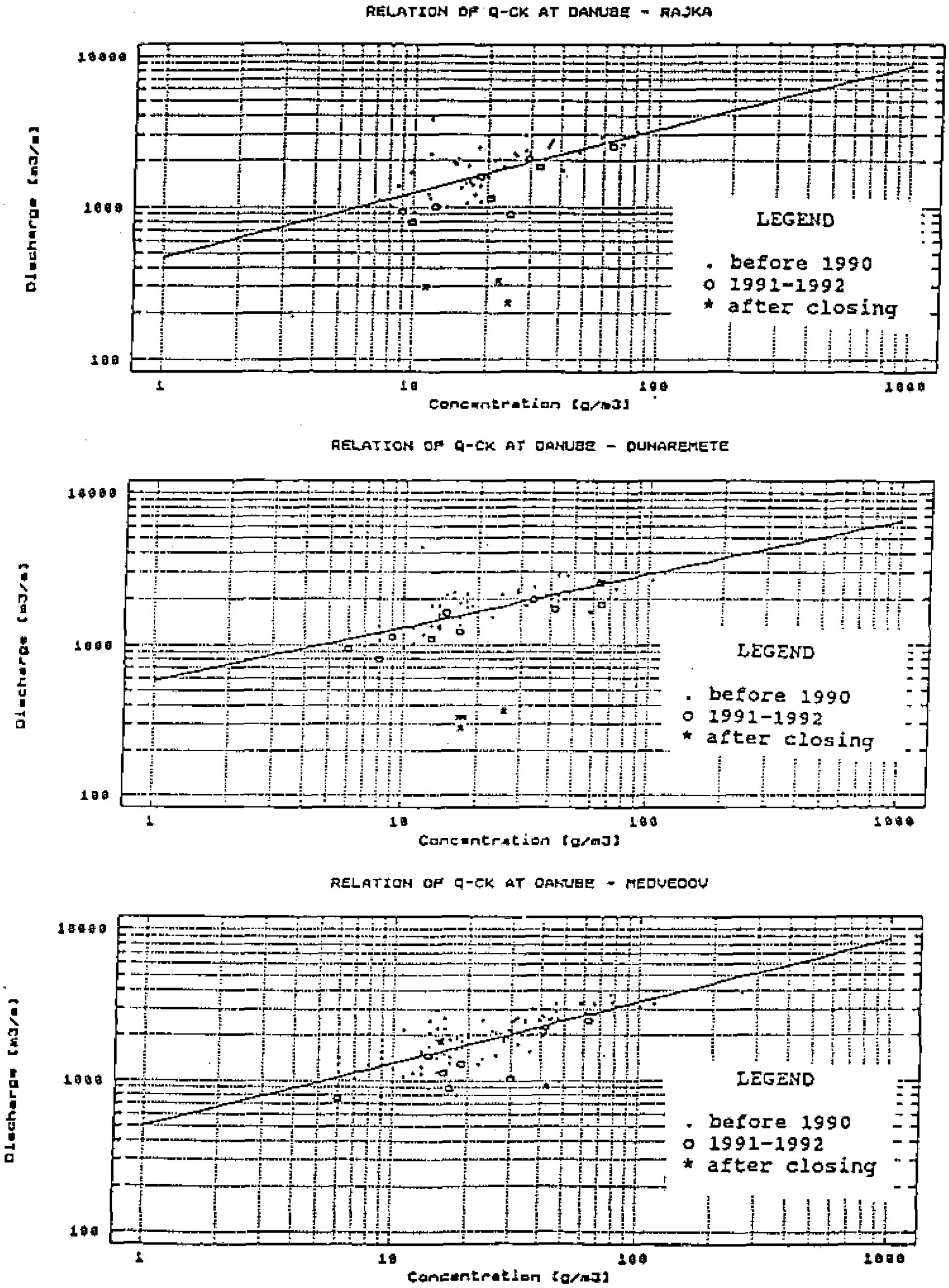


Fig. 5.1 **Measured data of suspended sediment concentrations and discharges at Rajka and Dunaremete in the Old Danube and at Medve in Danube.**

6. GROUND WATER LEVEL

6.1 Available Data

The amount of ground water level data in the area is comprehensive. The network of observation stations is shown in Fig. 6.1. On the Slovak side monitoring is carried out on a weekly basis for about 300 stations and by use of automatic recorders for more than 100 stations. On the Hungarian side the monitoring is carried out mostly by use of automatic recorders. For many of the observation wells historical time series exist for several decades.

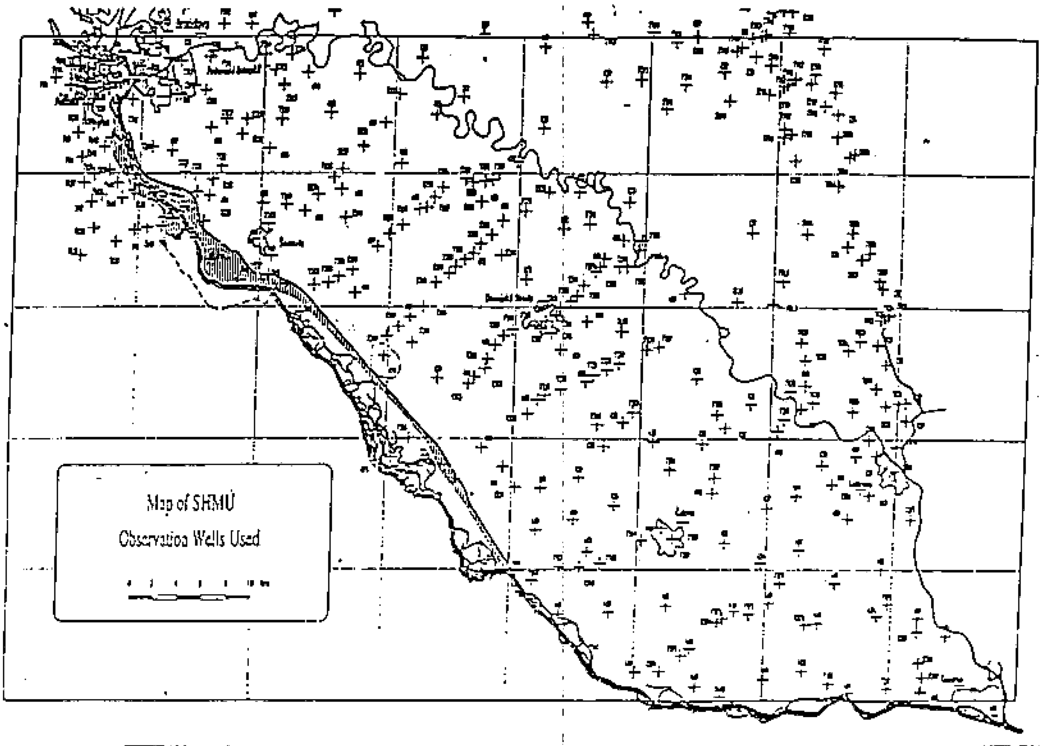
6.2 Data Analyses for Long Term Trends

The ground water regime is to a large extent determined by the permeability of the river channels and the variations in river water table. In the reach between Bratislava and Komarno an estimated 10 - 20 m^3/s infiltrates to gravel aquifers on the Slovakian side and 8 - 15 m^3/s between Rajka and Medve on the Hungarian side. This constitutes one of the largest ground water resources in Central Europe. Due to the very large permeabilities in the gravel aquifer the ground water flow rates are very high (1 - 3 m/day).

The depth of the ground water table, shown in ref /1,2,3/, ranged in the pre-dam condition from more than 5 meters close to Bratislava to around 1 m at Medve. The trend over the past 30 years is illustrated in Fig. 6.2 showing river water level at Bratislava together with ground water levels from five wells located with distances from 0.8 km to 12 km on a transect perpendicular to the Danube on the Slovakian side.

As indicated in Fig 6.2 and documented in ref /1,2/ the ground water levels have decreased ranging from about 2 meters around Bratislava to about zero at Komarno. This decrease is due to erosion of the river bed.

A very important feature of the ground water regime is the large ground water level fluctuations generated by the dynamics of the river water table. This is illustrated in Fig. 6.2, where the fluctuations in the wells located close to the Danube are largely determined by the fluctuations in the river water levels, while ground water level fluctuations further away from the river mainly depend on the annual variation in recharge from rain and snow. Because Szigetköz is narrower than Zitny Ostrov the ground water fluctuations over the entire Szigetköz is dominated by the Danube.



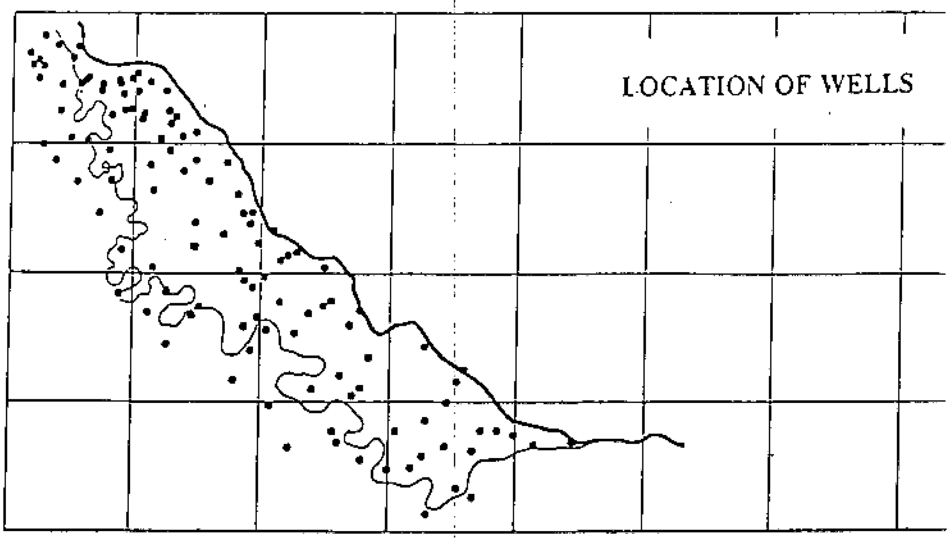


Fig. 6.1 Index map showing network of ground water observation wells.

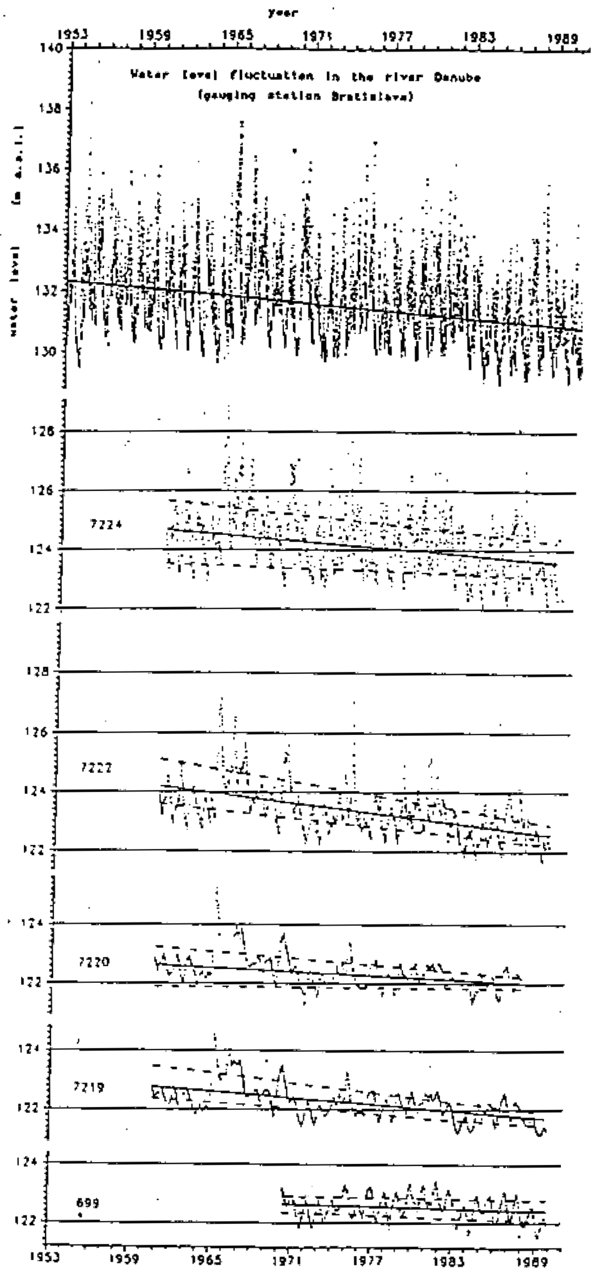


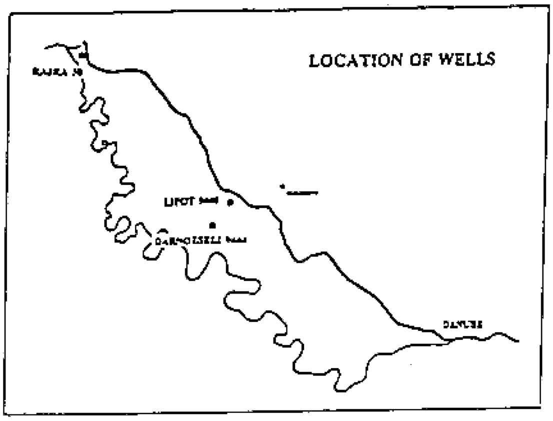
Fig. 6.2 Danube water levels at Bratislava and ground water levels from four selected wells located with different distances from the river.

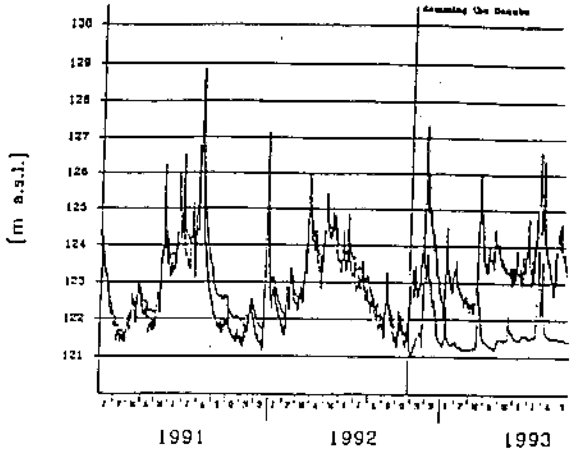
6.3 Analyses of 1991-93 Data

Ground water level hydrographs have been plotted for al stations, ref /2,3/, for the period after January 1991. Du to the large and rapid ground water level fluctuation generated by the Danube it is not possible to accuratel assess the impacts of the Gabcikovo projects by direct comparison of observed ground water levels for short periods before and after the damming. Therefore, both the Hungarian and the Slovakian experts have developed regression models for computations of ground water levels corresponding to the pre-dam condition.

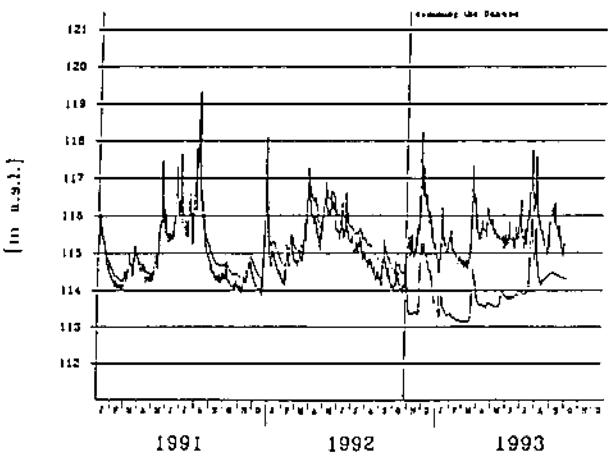
Selected hydrographs are shown in Figs. 6.3 and 6.4. Fig 6.3 shows the ground water levels at three wells in Hungary. The three wells are located at 50 m, 400 m and 4000 m distance from the Danube, see map. At the two wells located closer to the Danube (Rajka and Lipot) the ground water levels were in the beginning of 1993 reduced by 1.5 - 2.0 m corresponding to the decrease in the Danube water level. After May 1993 the reduction at Lipot decreased to about 1.0 m. At Darnozselli the reduction is initially about 0.4 m and after May gradually changes to about 0.2 m. The timing of this reduced impact coincides with inundation of the side channels in the Slovak flood plains. However, the exact reason for this reduced impact (i.e. increased ground water levels) after July 1993 has not been documented. In all cases the ground water level fluctuations have been reduced significantly.

Fig. 6.4 shows similarly the ground water levels at three wells in Slovakia. The good agreement between observed and computed values in the pre-dam conditions is noted. The effect of the damming is clearly seen in all three wells. At well 694, located close to the reservoir, the ground water level has increased by 2-3 m. At the other two wells, located 10-15 km away from the reservoir in the flood plain area and just behind the intake canal, respectively, the ground water level initially decreased significantly. However, after discharging water into the side channels in the Slovakian flood plain from May 1993 onwards the ground water levels have increased above those corresponding to pre-dam conditions. This demonstrates that a considerable recharge now takes place from the side channels. This has become possible because the running water has removed the fine material, previously clogging the bed of these river arms. In all cases the fluctuations have been reduced significantly.

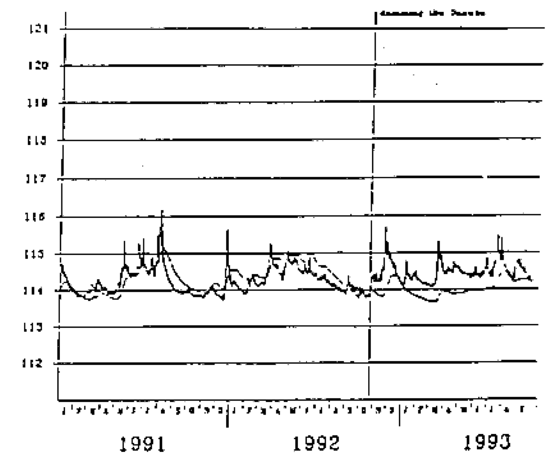




Measured and modelled values - WELL F



Measured and modelled values - WELL L9440



Measured and modelled values - WELL D9

Fig. 6.3 Measured and computed ground water levels from three wells in Hungary 1991-93. The computed levels correspond to pre-dam conditions.

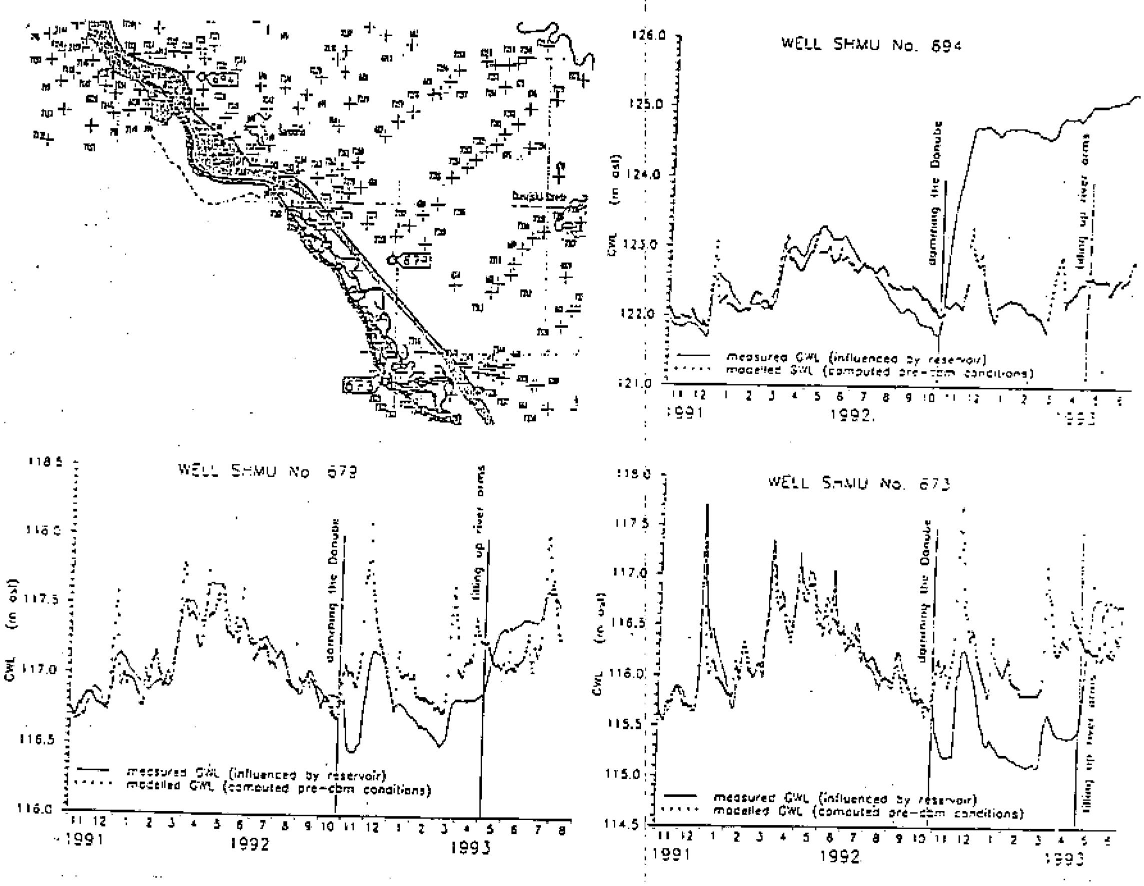


Fig. 6.4 Measured and computed ground water levels from three wells in Slovakia 1991-93. The computed levels correspond to pre-dam conditions.

For the Slovakian area the ground water levels measured o March 3, 1993 are shown in Fig. 6.5 together wit calculation of the changes at that time of ground wate levels due to the Gabcikovo Project. Similarly, condition on June 30, 1993 are shown in Fig. 6.6. Hungary was no able to produce similar maps. Instead a map previousl presented, ref /4/, showing an estimate of the ground wate level changes as per February 8, 1993, is given in Fig. 6.7.

By comparison of Fig. 6.5 and 6.6, which represent conditions before and after putting water to the side channels on the Slovakian flood plain, it is evident that a good hydraulic connection between the side channels and the ground water system has been established. Thus, a substantial ground water recharge takes place from the side channels resulting in up to 1.5 m increased ground water levels.

From the most recent map in Fig. 6.6 it is noticed that the ground water levels on all the Slovakian territory have increased or have not been affected. The increases have mainly occurred in the upstream area close to the reservoir, i.e. in the area which have been most negatively affected by the long term trend of decreasing ground water levels.

As a similar comprehensive analysis has not been made for the Hungarian data, the conclusions with regard to impacts on ground water levels in Hungary are less certain. However, by considering Fig. 6.4 and 6.7 it appears that the ground water levels have also increased close to the reservoir (Rajka - Dunakiliti region). In the middle of Szigetköz between Dunakiliti and Asvanyraro the ground water levels have decreased in areas close to the Danube.

6.4 Adequacy of the present Monitoring System

The present monitoring of ground water levels is adequate.

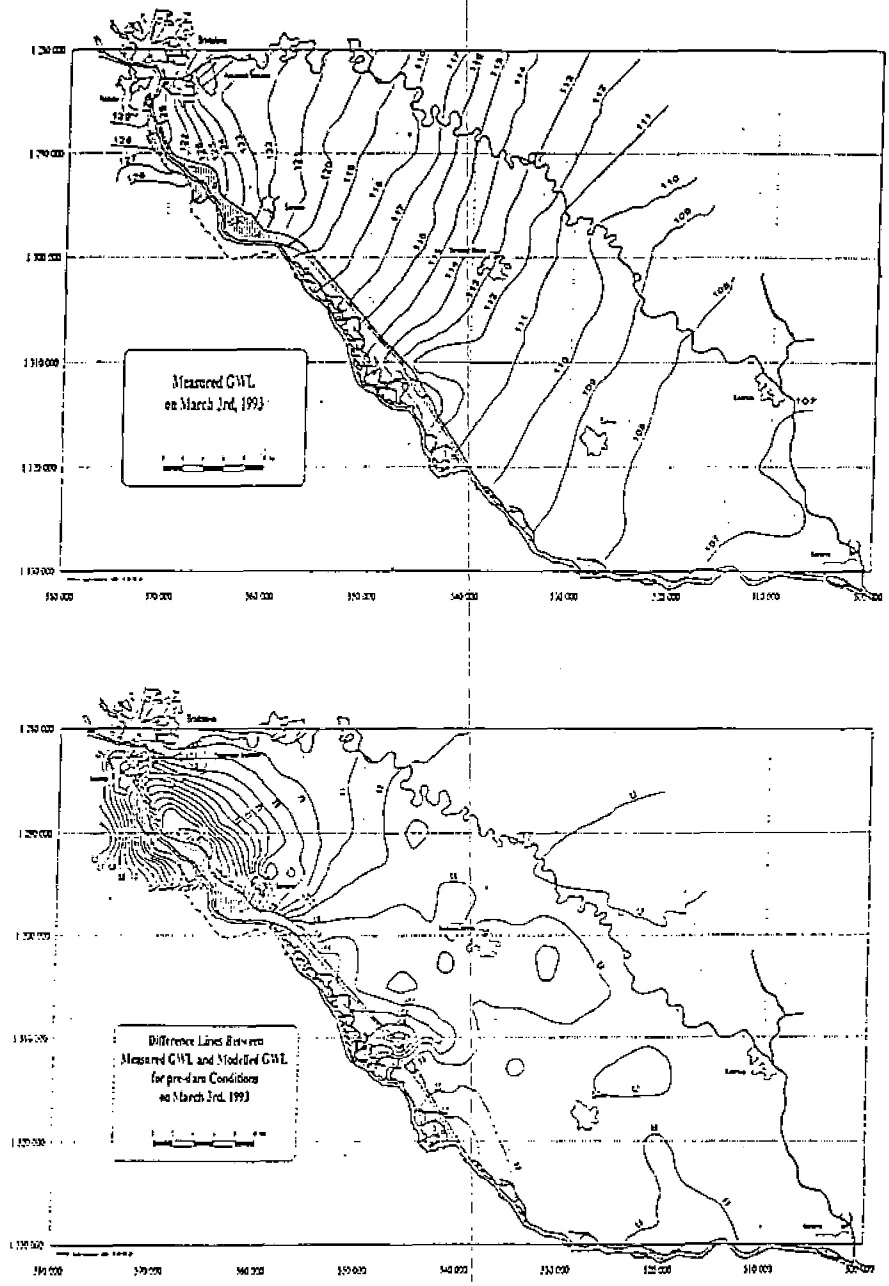
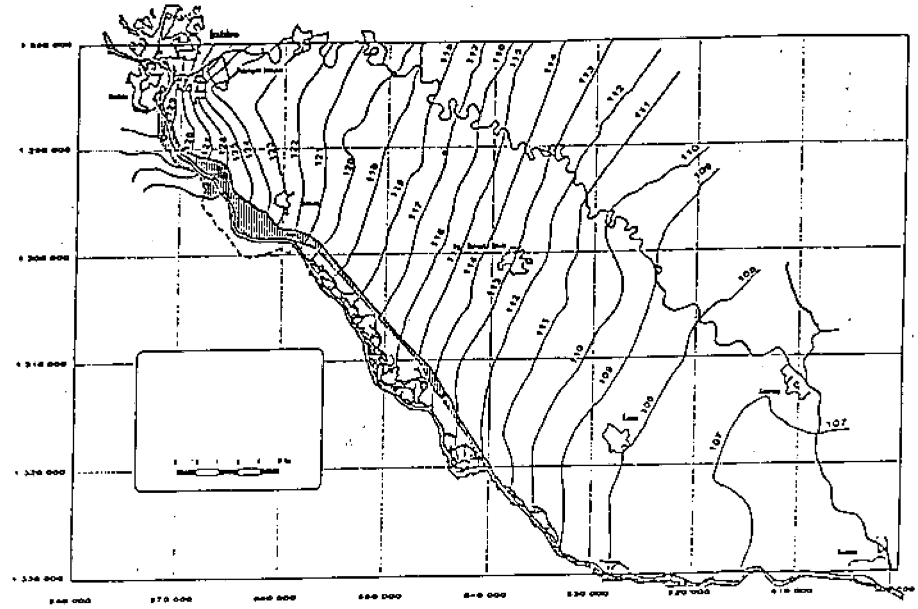
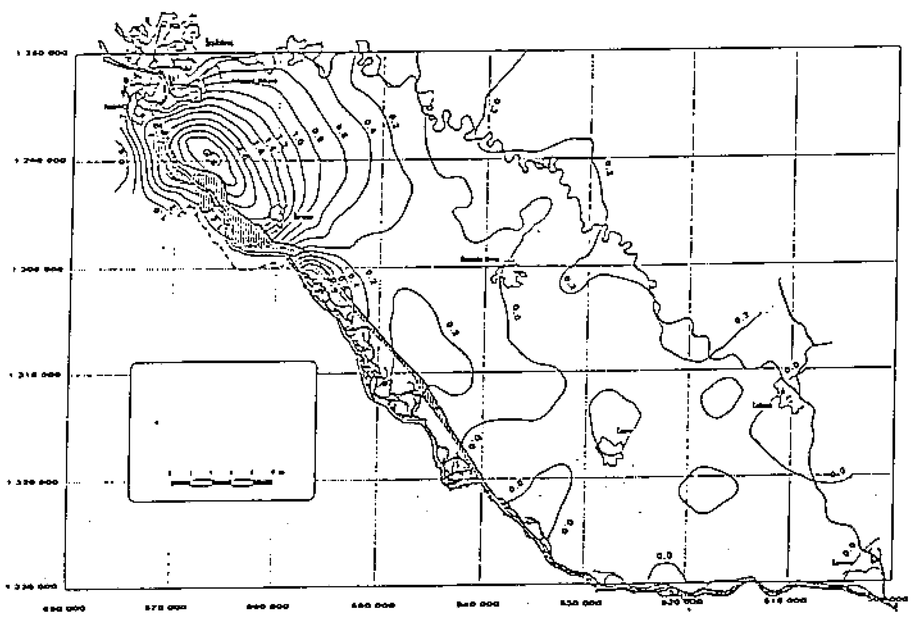


Fig. 6.5 Ground water levels measured on March 3, 1993 together with calculated changes as compared to pre-dam conditions for Slovakia.

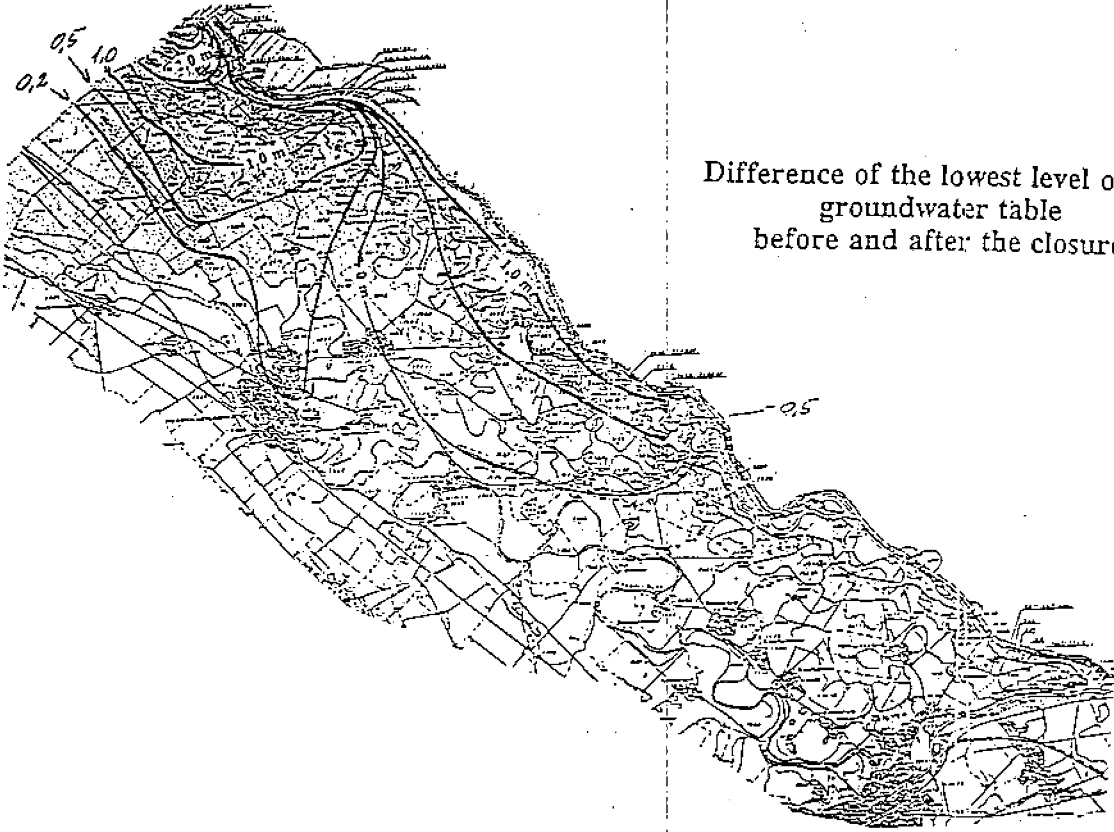


Ground water level measured on June 30, 1993.



Increase of ground water level after 8 months since damming the Danube (June 30, 1993).

Fig. 6.6 Ground water levels measured on June 30, 1993 together with calculated changes as compared to pre-dam conditions for Slovakia.



Difference of the lowest level of the
groundwater table
before and after the closure

Fig. 6.7 Estimated changes in ground water levels on February 8, 1993 as compared to pre-dam conditions for Slovakia.

7. GROUND WATER QUALITY

7.1 Available Data

The amount of ground water quality data in the area is comprehensive. The network of observation stations are shown in Fig. 7.1.

In Slovakia a systematic monitoring has been carried out since 1983 on a bimonthly basis. After the damming of the Danube an extended monitoring programme with fortnightly sampling has been made in a number of wells located close to the Danube. Under the ordinary monitoring programme the following parameters are analysed: TDS_{105}, O_2, BOD_5, COD_{Mn}, Fe, Mn, NO_3^-, SO_4^{2-}, Cl^- and PO_4^{3-}. Under the extended monitoring analyses are made for more than 100 parameters including heavy metals and organic micropollutants. The Slovakian Data Report (ref /2/) shows plots of all data from the ordinary monitoring programme plus a summary of data from a single well under the extended monitoring programme.

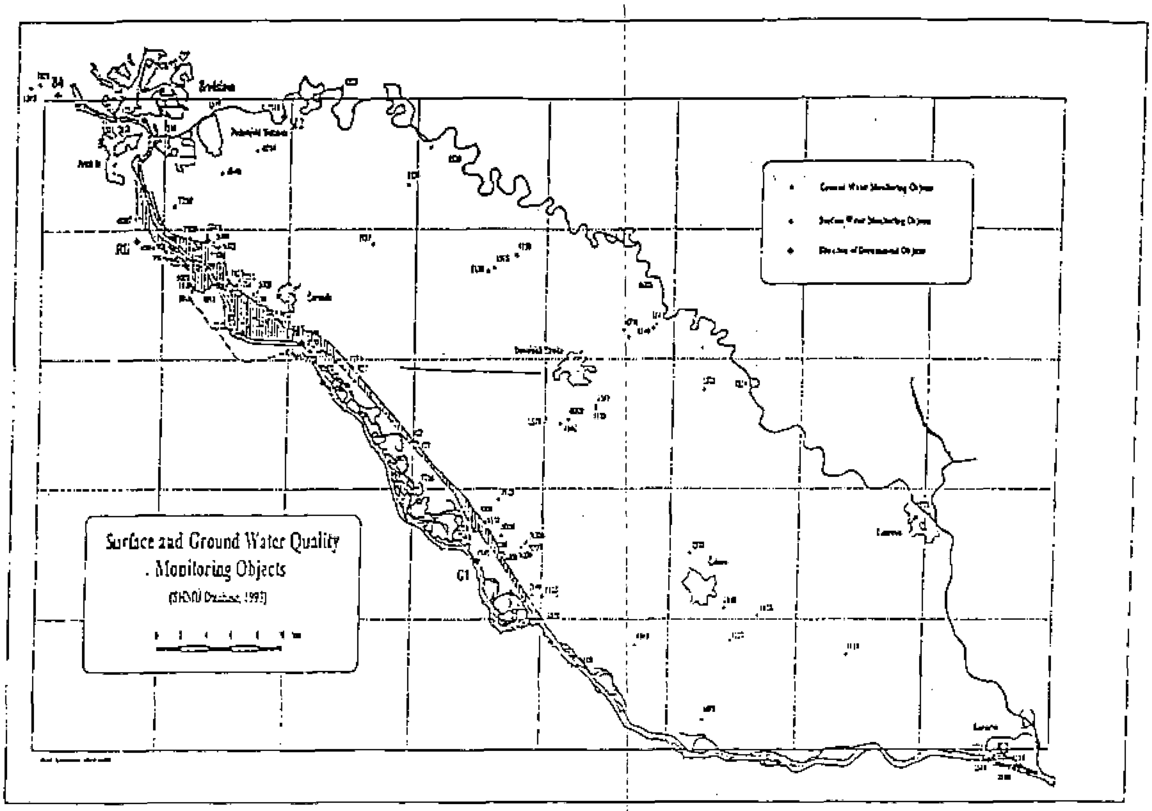
In Hungary a large amount of data is being collected on a fortnightly basis. 23 parameters are measured. The Hungarian Data Report (ref /3/) shows no ground water quality data.

7.2 Data Analyses for Long Term Trends

The ground water quality in the area dominated by the infiltration from the Danube is generally in a good state. Thus, the quality of the ground water abstracted from the water works located close to the Danube is generally excellent.

For the areas farther away from the river, where the ground water recharge partly originate from infiltration in agricultural and industrial areas, there are some problems with ground water pollution from point sources (e.g. from Slovnaft oil refinery starting in the 1960's,landfills and dumping sites) and from agrochemicals.

The data from the Slovakian ordinary monitoring programme reveal with a few exceptions no long term trends. In a couple of wells the NO_3^- concentrations show an increasing trend and in the Rusovce area, where examples of an increasing trend for TDS_{105} and a decreasing trend for the Mn concentration can be found.



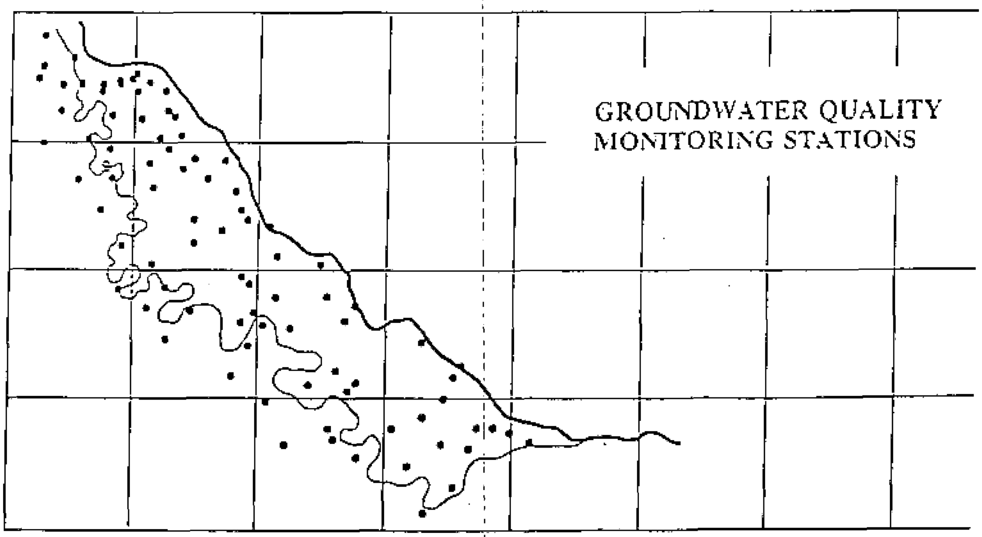


Fig. 7.1 Index map showing network of ground water quality observation wells.

7.3 Analyses of 1991-93 Data

In general no ground water quality changes can be identified after the damming of the Danube. One exception is the Rusovce area where decreases in TDS_{105} and NO_3^- can be found. These changes can be explained by a changed flow pattern in this area, which now receives its water from infiltration in the reservoir, while it in the pre-dam conditions was flowing from the inland towards the river.

The extended monitoring programme of ground water quality in Slovakia shows occurrence of organic micropollutants in some of the observation wells but not in any of the production wells used for abstraction of drinking water. There is no trend over time in these concentrations, which originate from old pollution of the ground water system.

According to the Hungarian Data Report (ref /3/) no significant changes have been detected in the ground water quality.

7.4 Adequacy of the present Monitoring System

The present monitoring of ground water quality appears adequate. However, because of the relatively slow ground water transport process, it should be emphasized that the intensive monitoring must continue for the coming years, especially with regard to areas close to the Danube where the infiltration conditions have been changed. Thus it cannot be guaranteed that a permanent situation, whether changed or unchanged as compared to pre-dam conditions, is obtained all over the area the first few years.

8. FLORA AND FAUNA

Biological field research has been done for several decades in the influenced area. There exist general overviews about the occurence of 1.000 plant species on the Slovakian and 820 plant species on the Hungarian territory. Approximately 2.800 animal species are detected on the Hungarian territory. It can be expected, that the same amount of species are found by Slovakian investigations.

It is considered that these numbers are significantly lower than the real numbers, because not all the taxa of fauna and flora were investigated (and could be investigated without enormous efforts).

8.1 Available Data

There exist investigations on the occurence of the different taxa with quite different methods. Biomonitoring stations are shown in Fig. 8.1 and described in Table 8.1 and Table 8.2 for the Hungarian and Slovakian areas, respectively.

Concerning higher (vascular) plants the Slovakian Data Report (ref /2/) provides a phytocoenological map of the forests from 1960. The Hungarian Data Report (ref /3/) shows species lists of single investigation plots.

Hungary and Slovakia present in their data reports an overview of the zoobenthos and zooplankton in the main channel and in the arm system with species lists. There is an estimation on species number, biomass and the saprobity (a biologically based water quality scale ranging from 1 to 4 with 1 representing the best condition) in the Slovakian data report. The Hungarian report deals with the abundance of the different species in a 20-l-sample.

From the fish species both the Slovakian and Hungarian reports list 65 as the present number. The Slovakian report contains an estimation of the ichtyomass in different habitats.

There are less data about the terrestrial fauna. Species lists exist in Slovakian report from Collembola, Acarina, Araneae, Chilopoda, Carabidae, Staphylinidae, Curculionidae, Rhopalocera, amphibians, reptiles, bats and mammals.

Monitoring areas of flora and fauna in the territory of the Gabčíkovo Project

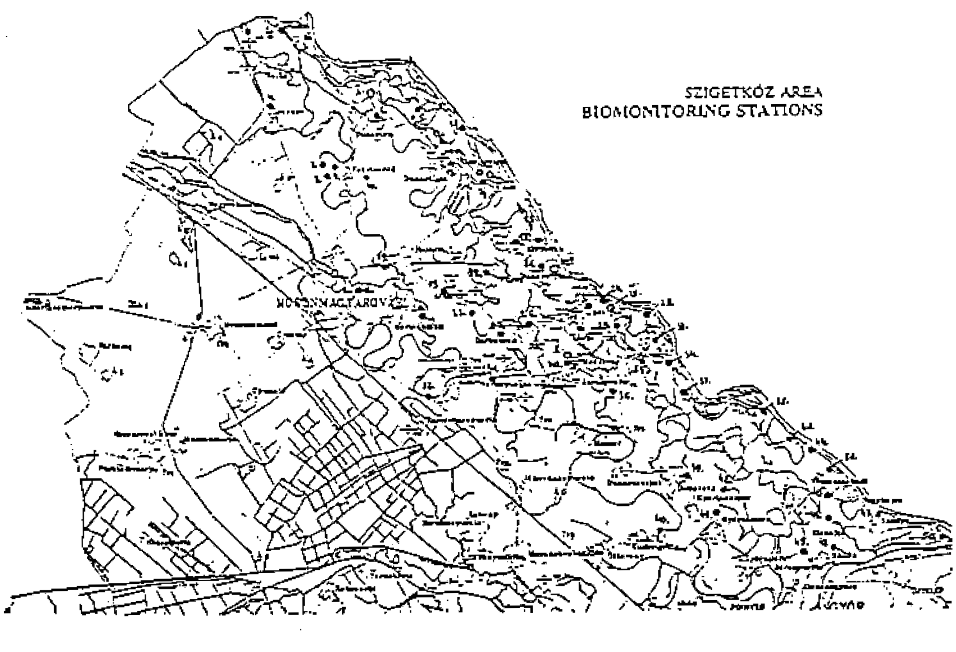


Fig. 8.1 Biomonitoring stations in Slovakia and Hungary

Table 8.1 Flora and fauna groups recorded in Hungarian biomonitoring stations 1989-1992

Animal/vegetation groups	Methods	Intensity of investigations	Number of biomonitoring station (Fig. 8.1)
Vegetation	BRAUN-BLANQUET method 20x20m + complete flora	once/year	I, II, III, IV, V
Mollusca	Hand sorting, separating from litter by sieves and washing the soil	once/year	3, 8, 9, 11, 13, 14, 15, 17, 19, 20, 23, 24, 28, 29, 30, 36, 40, 45, 46
Crustacea and Rotatoria	Plankton net of 100 um mesh size	generally monthly	23, 24, 26, 27, 28, 30, 34, 38
Macrozoobenthos	Standard FBA Pond Net, kick and sweep method	generally monthly	23, 24, 26, 27, 28, 30, 34, 38
Odonata	Hand singled, eye observation	bimonthly	2, 4, 6, 7, 10, 12, 13, 15, 16, 18, 19, 22, 27, 31, 32, 39, 42, 43
Heteroptera (aquatic and semiaquatic)	Water net	halfyearly	3, 5, 14, 15, 21, 23, 28, 36, 42
Neuropteroidea	Netting and beating of the branches of trees and shrubs, light trap	halfyearly	7, 8, 13, 16, 23, 24, 35, 36, 43, 48, 49
Coleoptera	Sweeping and beating the vegetation, shifting forest litter and debris. Collecting with mercury-vapour bulbs, hand searching (singling), pitfall trapping	From march till July monthly, once in autumn	1, 2, 8, 9, 10, 11, 17, 21, 24, 25, 30, 33, 36, 39, 41, 42, 43, 48, 50
Trichoptera	Lamping with mercury-vapour bulbs, hand singling	10 days/months	3, 5, 6, 15, 16, 17, 21, 24, 37, 39, 48
Lepidoptera	Singling with nets, light and sugar baits. Lamps used were three different types of UV lamps (125 and 250 W mercury-vapour bulbs and 160 W mixedlight bulbs)	generally monthly	1, 10, 12, 13, 16, 20, 21, 23, 31, 32, 35, 36, 42, 46, 50, 51,
Acari (Oribatida)	Samples from litter and humus soil with roots, soil moss and lichenes, bark moss and lichenes, mouldering trees, brick of grass	once/year	8, 9, 10, 14, 17, 24, 30, 48
Pisces	Electric fishing	bimonthly	3, 5, 6, 7, 11, 14, 15, 17, 24, 28, 34, 36, 37, 41, 44
Amphibia	Field observation	in spring and autumn	
Aves	Transect methods, spot recording (Danish method)	from March till July and winter	5, 9, 10, 12, 21, 23,33, 47, 50
Mammalia	100 snap traps for 3 days	seasonally	6, 8, 9, 10, 13, 23, 35, 39, 45, 46

Table 8.2 Flora and Fauna recorded in the Slovakian Monitoring Areas

	Biomonitoring area		Main monitoring species (taxa)
1.	"Ostrov Kopac" - Pod. Biskupice	P: A:	Populus alba, Impatiens parviflora Clausilia pumila, Pterostichus strenuus, Mantis religiosa, Minois dryas
2.	"Rusovske ostrovy" Rusovce	P: A:	Populus nigra, Acer negundo, Fraxinus excelsior, Impatiens parviflora Helicella obvia, Pupilla muscorum, Lycaena dispar
3.	"Ostrovne lucky" - Cunovo	P: A:	Salix fragilis Clausilia pumila, Carychium minimum, Truncatellina cylindrica, Zygaena viciae
4.	"Topolove bony"- Pod. Biskupice	P: A:	Quercus robur, Cornus mas Clausilia pumila, Microtus arvalis
5.	"Horna vrbina"- Hamuliakovo	P:	Robinia pseudoacacia, Solidago gigantea, Populus nigra
6.	"Dunajske kriviny" - Mliecno	P: A:	Impatiens parviflora, Salix alba Zonitoides nitidus, Bembidion varium, Hyla arborea, Triturus cristatus dobrogicus
9.	"Bodicka brana" - Bodiky	P: A:	Impatiens glandulifera, Impatiens parviflora Hypochthonius rufulus, fishes and aquatic evertebrata
10.	"Kralovska luka" - Bodiky	P: A:	Leucojum aestivum, Aster novi-belgii, Trapa conocarpa, Nymphaea alba Bembidion ustulatum, Tanysphyrus lemnae, Misgurnus fossilis, Stizostedion lucioperca
13.	"Gombarovske" - Vrakun	P:	Carex nigra, Carex acutiformis, Thalictrum flavum
14.	"Istragov"- Gabcikovo	P: A:	Salix fragilis, Impatiens glandulifera, Leucojum aestivum, Phragmites australis Cochlicopa repentina, Bembidion femoratum, Gymnocephalus baloni, Leuciscus idus
15.	"Ereed"- Palkovicovo	P:	Salix fragilis, Leucojum aestivum, Aster novi-belgii
18.	"Sporna sihot" - Medvedov	P: A:	Impatiens parviflora, Solidago gigantea, Populus alba, Ulmus sp., Cirsium arvense, Carex hirta Zonitoides nitidus, Amara aenea, Pterostichus vernalis, Bembidion varium, Philonthus fuscipes, Cyprinus carpio, Stizostedion volgense
19.	"Mohyla"- Dolny Bar	P:	Iris pseudacorus, Phalaris arundinacea
21.	"Karab"- Bohelov	P:	Orchis palustris, Eriophorum angustifolium, Carex nigra
23.	"Stary les"- Klucovec (Cicov)	P:	Leucojum aestivum, Aster novi-belgii, Impatiens parviflora, Populus alba, Salix fragilis

Used Methods:

a) Flora and vegetation
- semiquantitative and quantitative numeric methods
- basic dendrometric parameters
- losses of leaves (leaf area index) of forest stand

b) Fauna
- current quantitative and qualitative methods used for evaluation of given taxonomic groups of fauna (areal method, transect method, sampling after isolines and individual sampling)

Time and intensity of investigations:
Biomonitoring of flora and fauna is done on all biomonitoring areas from 1990 to 1992. Investigations are done mostly twice per year, adequately to the state of observed biotopes

Hungary can provide data about the following taxa: Mollusca, Rotatoria, Crustacea, Odonata, Heteroptera, Neuropteroidea, Coleoptera (61 families), Trichoptera, Lepidoptera, Acarina (Oribatida), Pisces, Amphibia, Aves, Mammalia (small mammals).

8.2 Data Analyses for long Term Trends

It can be estimated that forestry and agriculture together with regulation measures in the Danube and construction of dikes have caused changes in flora and fauna in former times but the data base does not allow to analyze the long term trends for most of the taxa. On the other hand in some cases it provides a good basis for analyzing the trend in the past (e.g. the phytocoenological map of 1960) and for monitoring the development in the future (e.g. investigation plots for higher plants on the Hungarian territory if these are fixed in the field).

Long term analysis with a good data base can be done with fish species. From 56 native fish species 4 are now extinct, 13 species were introduced by man.

8.3 Analyses of 1991-1993 Data

On the one hand the data base and on the other hand the long response time of natural systems only allow to quantify the influence of Variant C structures on flora and fauna on single aspects:

* For construction of the Gabcikovo scheme 3.180 ha out the 10.356 ha of Slovakian floodplain forests were seized. On the Hungarian territory the loss of alluvial forests is estimated to 1.200 ha.

* Derived from investigations of zoobenthos and zooplankton saprobity in the main channel varied in 1990-1992 between 2.5-3.0; in 1992 between 2.6-3.3.

* An increase of the relatively number of ecologically plastic, eurytopic species, introduced species and expansive species of fish is observed. The relatively number of already threatened species, mostly stenotopic species decreased.

Biomass data from nonvertebrates were in general not taken as basis for analyzing short term changes because these values normally do not allow a clear diversion of effects of the Variant C structure and parameters like temperature, amount of light or amount of rainfall.

8.4 Adequacy of the Present Monitoring System

At present a huge amount of data are collected. There is a need for application of more quantitative and semiquantitative methods that deal with (under monitoring aspects) good indicator taxa in suitable sites. The present monitoring system should be strengthened at least with the following investigations:

1. Geobotanical monitoring plots in different habitats where changes in the environmental conditions could be expected. For describing the abundance the BRAUN - BLANQUET-method should be used.
2. Mapping of the bird species in a grid system with 1-km^2 - plots covering the whole area potentially influenced by the Variant C.
3. Quantitative investigations on fish populations in selected reaches of the reservoir and the old Danube and in selected side branches/oxbow lakes by electrical fishing
4. Quantitative investigations on Carabide-beetles with BARBER-traps in different habitats undisturbed by forestry and agriculture (e.g. forests and sand banks)
5. Quantitative investigations on grasshoppers in grassland monitoring plots mowed 1 or 2 times a year (yearly at the same time)
6. Quantitative investigations on living and dead mussels and water snails in selected monitoring plots in the reservoir, the Danube and oxbow lakes/side branches.
7. Qualitative, and if possible also quantitative, monitoring of the rotary and crustacean plankton in major water bodies including the reservoir, the intake canal and the Old Danube.

The monitoring plots should be mapped in detail (1:100 - 1:1.000). Investigation plots 10x10m or 25x25m should be durable marked in the field so that the survey can be repeated on the exactly same place.

9. AGRICULTURE

The annual rainfall and evaporation amounts are of the same order of magnitude; however with significant different seasonal variations. Thus it is required with some additional water supply to the vegetation during the summer season. This extra water supply has traditionally been possible throughout the area by vertically upwards flow in the capillary zone from the ground water table to the root zone. The necessary conditions for this are that the ground water table is not too deep and that no (capillary breaking) gravel layer is located in between.

9.1 Available Data

For assessing the possible changes in capillary water supply for the agricultural production data is required on depth to ground water table and depth to gravel layer.

This information is provided by the Slovakian Data Report (ref /2/), while the Hungarian Data Report (ref /3/) does not provide any data nor analysis on this issue.

9.2 Data Analyses for Long Term Trends

Due to the general decline of the ground water table in large parts of the area during the past 40 years the conditions for capillary water supply to the root zone have decreased and the irrigation water requirements have increased correspondingly.

9.3 Analyses of 1991-93 Data

Due to the increase of ground water tables in large parts of the Slovakian area the conditions have improved. According to an estimate given in ref /2/ the requirements for irrigation from external sources is expected to decrease by about 25 % as compared to the pre-dam conditions.

No specific analyses on this issue is provided in ref /3/ for the Hungarian area. In part of the Hungarian agricultural area ground water levels have increased, while in other areas close to the main Danube the ground water levels have decreased. However, without specific analyses the impacts on agriculture in Hungary cannot be predicted with certainty.

9.4 Adequacy of the present Monitoring System

The present monitoring system is adequate as far a irrigation requirements are concerned.

10. FORESTRY

10.1 Available Data

For the Slovak territory (ref /2/) there exists a map of groups of forest types (according to Zlatnik) from 1960 in the scale 1:50,000 derived from maps in the scale 1:10,000. This represents the state before starting construction works. The distribution of groups of forest types (in %) before and after construction of the Gabcikovo dam is shown. The summarized mean annual increment of thicknes, tree height, mean losses of leaves and leaf area index from 24 monitoring areas are shown for 1991 and 1992.

The Hungarian Data Report (ref /3/) shows results of measurements of perimeter growth of 117 trunks all located in the Dunasziget area. Additional data from the Dunakiliti area could be provided.

10.2 Data Analyses for long Term Trends

Forest types change under natural conditions according to changes of the site parameters. In economically used (commercial) forests these changes are modified by selection of planted tree species. The first so-called profit forms of poplars were planted at the end of the 19th century. However these measures might represent the site conditions.

10.3 Analyses of the 1991-1993 Data

Changes in distribution of groups of forest types and its tree species composition before (1976) and after (1993) construction of the Gabcikovo dam are shown in Table 10.1 and in Fig. 10.1. for the Slovakian area. Similar figures for the Hungarian forest areas are shown in Table 10.2.

In a short time view changes in composition of tree species caused by changes in site conditions cannot be observed. Other indices must be used for monitoring short term changes.

Table 10.1 Changes in distribution of forest types in Slovakia and its tree composition *before* (1976) and after (1993) construction of the Gabcikovo dam.

groups of forest types	distribution (planary and percentage) of groups of forest types			tree composition	
	before construction	after construction	difference	origin	present
Corneto - Quercetum (CoQ)	185 ha 1,8%	30 ha 0,4%	155 ha	oaks, limetree, cornel, (elm)	oak, limetree, maple, cornel
Ulmeto - Fraxinetum carpineum (UFrc) hard floodplain forests	3,380 ha 32,6%	1.833 25,6%	1,547 ha	elm, oak, ash, domestic poplars, limetree, maple, (hornbeam)	ash, oak, maple domestic poplar cultivar poplars, limetree
Ulmeto - Fraxinetum populeum (UFrp)	4,000 ha 38,6%	2,850 ha 39,7%	1,150 ha	elm, oak, ash, domestic poplars, aspan,	cultivar poplars
Querceto - Fraxinetum (QF)	1,482 ha 14,3%	1.386 ha 19.3%	1,150 ha	oak, ash, domestic poplars, aspan,	cultivar poplars
total area of transitional floodplain forests	5,482 ha 52,9%	4,236 ha 59,0%	96 ha		
Saliceto - Alnetum (SAL) soft floodplain forests	1,300 ha 12,7%	1,077 ha 15,0%	232 ha	willows, alder, domestic poplars,	willows, alder, domestic poplar: cultivar poplars,
TOTAL	10,356 ha	7,176 ha	3,180 ha		

Therefore, in the Slovakian Data Report the leaf area index is used as important production-ecological characteristic and the loss of leaves in the middle of August are used. They show a significant increase of the leaf area index from 1991 to 1993 near the reservoir (Rusovce) and a decrease of the mean loss of leaves in August in the same area. There are no comparable data from the area between the reservoir and Sap/Palkovicovo and from outside the influenced area (to exclude climatical effects).

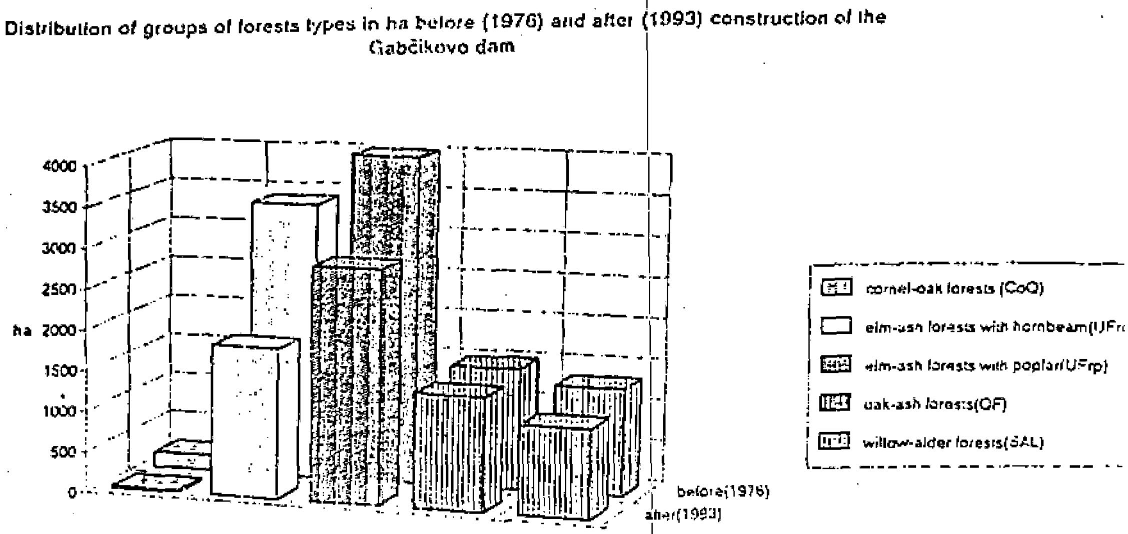


Fig. 10.1 Distribution of forest groups in Slovakia before (1976) and after (1993) construction of the Gabcikovo dam.

Table 10.2 Changes in Distribution of Main Forest Habitats (according to the Zurich-Montpellier-System) in Szigetköz between 1960 and 1990.

Main forest habitat	ha 1960	% 1960	ha 1990	% 1990
ULMENION /Fraxino-Ulmeto-Quercetum roboris; with subrelictum Querceto robori-Carpinetum	1892	22	797	11
SALICION ALBAE-FRAGILIS /with 1-2 % Alnetum glutinosae	3612	42	1668	23
cultivar ROBINIETUM + PINETUM	946	11	870	12
cultivar POPULETUM/ euroamericana hybrids	2150	25	3915	54
TOTAL	8600	100	7250	100

Changes are not due to Gabcikovo System constructions, but to economic considerations

In the Hungarian Data Report it is estimated (without evident data base) that roughly 5 % of the floodplain trees already died. The perimeter growth data were taken in Dunasziget area and near Dunakiliti. Both show a significant decrease in 1993. There are no comparable data from outside the influenced area (to exclude climatical effects)

10.4 Adequacy of the Present Monitoring System

The present monitoring system should be strengthened in the following way:

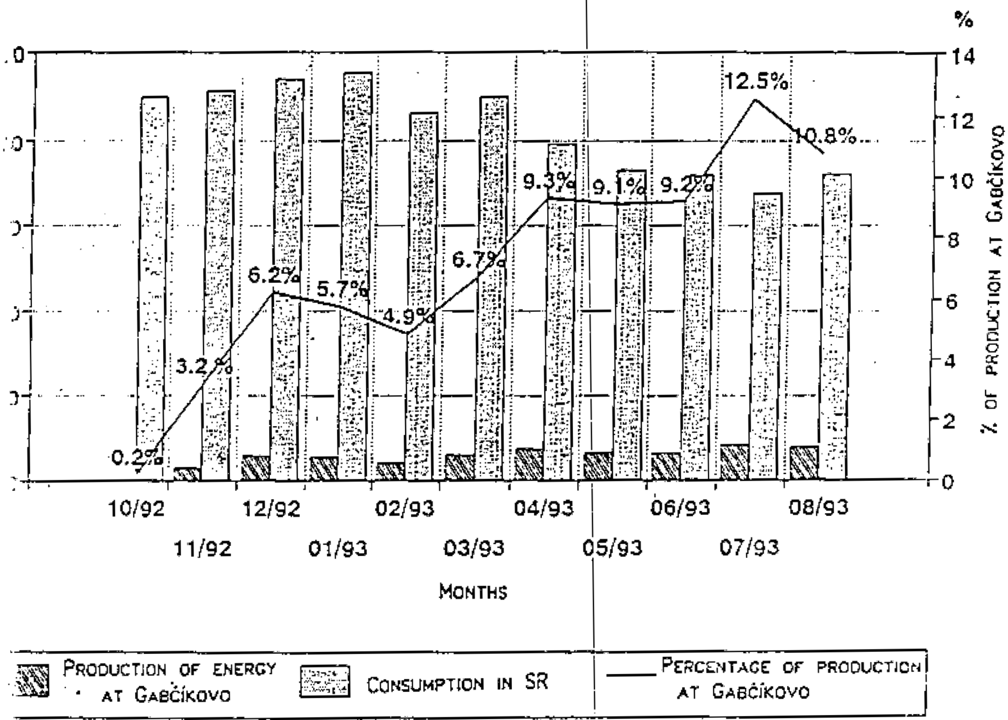
1. Mapping the forest types in the scale 1:10.000

2. Selection of "monitoring trees" (n x 10^3 Salix alba and Populus x euroamericana CV. I 214) all along the Danube on both sides from Bratislava to Sap/Palcovicovo with annual measurements/observations of height, perimeter in 1.3 m height and leaf area index.

ELECTRICITY PRODUCTION

The electricity production at Gabcikovo is shown in Fig. 11.1. The same figure shows the ratio between the Gabcikovo electricity production and the total electricity consumption in Slovakia as a graph.

The electricity produced at Gabcikovo goes into the Slovakian electricity distribution network.



1.1 Electricity production at Gabcikovo and its share of the total electricity consumption in Slovakia.

An illustration of the hourly variation of electricity production and the discharge through the turbines is shown for three typical days in Fig. 11.2.

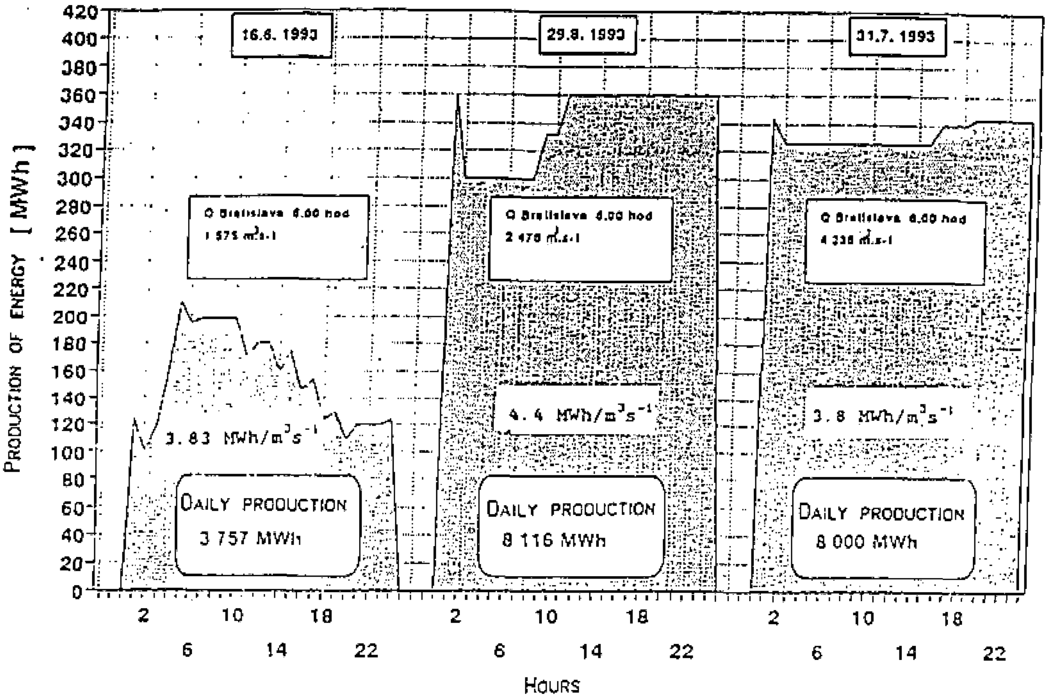


Fig. 11.2 Hourly variation in discharge and electricity production for three typical days.

12. OTHER PARAMETERS

The international navigation through the shiplocks at Gabcikovo has functioned since its opening on November 9, 1992. During this period the locks have been closed for 14 days.

The numbers of ships and shiplock openings are shown in the Slovakian Data Report (ref /2/). The monthly average numbers of openings of shiplocks and of ships passing have been shown for January - August 1993 in Table 12.1. It is seen from the table that for the first eight months of 1993 there has been in average 12 openings of ship locks per day and in average 31 ships have passed the locks per day.

Table 12.1 Monthly numbers of shiplock openings and ships passing at Gabcikovo, January - August 1993.

Numbers as average per day	January	February	March	April	May	June	July	August	Average Jan-Aug
Shiplock openings	5.9	8.1	7.9	11.4	12.8	15.6	15.6	17.0	11.8
Ships passing	16.1	27.9	26.2	30.7	26.5	37.2	38.7	46.3	31.2

13. SUMMARY ASSESSMENT OF IMPACTS FROM THE GABCIKOVO PROJECT

The impacts of the Gabcikovo Project to the various parameters described in the above Chapters 2-12 may be categorized in two main groups, namely those where major general impacts have been identified and those where for various reasons no major general impacts as compared to the pre-dam conditions can be detected from the available data.

13.1 Aspects where major general impacts have been observed

As described in the above Chapters significant general impacts have been identified for the following parameters:

* discharges;
* surface water levels;
* sediment transport and sedimentation/erosion;
* ground water levels; and
* electricity production.

The impacts are summarized in the following.

Discharge

The Gabcikovo Project has had a very large impact on the discharge regime in the Danube between the dam at Cunovo and the downstream confluence at Sap/Palkovicovo. In this reach (the Old Danube) the discharge has in 1993 been reduced to in average about 400 m^3/s corresponding to about 20 % as compared to the pre-dam condition.

As an effect of the project the discharges in the Little Danube and the Mosoni Danube have been increased by 10 - 20 m^3/s, so that Mosoni Danube now permanently carries discharge. Finally, water is being provided to the side channels on both the Slovakian and Hungarian flood plains through new structures.

Surface water level

The Gabcikovo Project has had a very large impact on the water level regime in the Danube between Bratislava and the downstream confluence at Sap/Palkovicovo.

At Bratislava the water levels during low flow periods have increased by 1-2 m as compared to pre-dam conditions, i.e. to a level corresponding to the situation 40 years ago.

In the upstream part of the Old Danube the 1993 water levels have been reduced by 2-4 m as compared to pre-dam conditions, and have thus reached a level 2 m below the lowest ever recorded values. In addition, the characteristic natural dynamics of the water level fluctuations have been changed (reduced) significantly.

Sediment transport and sedimentation/erosion

Significant erosion occurred downstream the Cunovo structures under the November 1992 flood event. This material has been deposited downstream in the Old Danube. Sedimentation of fine material/silt can be seen in the Old Danube. Most likely, sedimentation of the total bed load and a substantial part of the suspended load have occurred in the reservoir. However, there are presently not sufficient data to quantitatively assess such impacts.

Ground water level

The Gabcikovo Project has had a significant impact on the ground water levels in the region. Initially the ground water levels were reduced very much close to the Old Danube and increased significantly close to the reservoir. The inundation of the side channels on the Slovak flood plains has subsequently significantly increased the ground water levels in the Slovak area.

In June/July 1993 the situation in Slovakia shows that over the entire area the ground water levels have increased or have not been affected. The increases have mainly occurred in the upstream area close to the reservoir, i.e. in the area which have been most negatively affected by the long term trend of decreasing ground water levels. On the Hungarian side, where comprehensive impact assessments have not been completed, it appears that the ground water levels have also increased close to the reservoir (Rajka - Dunakiliti region). Furthermore, it appears that in the middle part of Szigetköz between Dunakiliti and Asvanyraro the ground water levels have decreased in the areas close to the main Danube.

On both sides the ground water level fluctuations have been reduced significantly.

Electricity production

The Gabcikovo hydropower plant has produced 150 - 200 Gwh/month in 1993. This corresponds to about 10% of Slovakia's electricity consumption.

13.2 Aspects where minor impacts have been observed or no significant impacts can be detected from the available data

As described in the above Chapters no general significant impacts could be detected on the basis of the available data for the following parameters:

* surface water quality;
* ground water quality;
* flora and fauna;
* agriculture; and
* forestry.

For some of the parameters significant local changes have been identified. For other parameters the data availability and/or the time period have not been sufficient to derive firm conclusions. Finally, for some parameters no significant general impacts are expected.

The conclusions found for each of the parameters are summarized in the following.

Surface water quality

With exception of November - December 1992, when sudden changes of regime and a high flood event occurred, no significant changes in surface water quality parameters as compared to pre-dam conditions can be detected after damming the Danube.

Ground water quality

In general, no significant ground water quality changes can be identified after the damming of the Danube. One exception is the Rusovce area where some parameters (e.g. Total Dissolved Solids and nitrate) have changed due to changes in the flow pattern. No changes in concentrations of heavy metals nor organic micropollutants have been detected.

Flora and fauna

Due to insufficient data availability and due to the long response time of natural systems with regard to flora and fauna, no major general impacts have been identified. However, on the following aspects significant impacts have occurred: removal of about 4,500 ha floodplain forest under the construction phase; saprobity values in the Old Danube have slightly increased; and some changes in the occurrence of certain species have been noticed.

Agriculture

Due to increases of ground water tables on the Slovak territory a slight increase in the capillary water supply for Slovakian agricultural areas has taken place. In Hungary, where comprehensive assessments have not been made, the impacts on agriculture are uncertain.

Forestry

The leaf area index and the perimeter growth are positively correlated and the loss of leaves in the middle of August is negatively correlated to increase of ground water levels. Hence, the impacts on forestry depends on the impacts on ground water levels, i.e the forestry has been positively influenced in Slovakia and negatively in Hungary.

14. RECOMMENDATIONS FOR STRENGTHENING OF MONITORING SYSTEM

A comprehensive monitoring programme has been carried out on a routine basis for many years (decades) in both countries. Furthermore, extended programmes have been established to monitor in greater details the conditions after the damming of the Danube.

The Working Group finds the present monitoring system, i.e. the extended programmes in both countries, generally to be relevant and recommend it to be continued. In many fields the present monitoring system appears adequate, while in other fields there are clear needs for a strengthening.

The strengthening comprises two different components, namely:

* aspects requiring more measurements, either in terms of measurements of new parameters or more measurements (in time and space) of already measured parameters; and

* aspects where discrepancies between Slovakian and Hungarian data have been detected, and where coordination efforts therefore are required.

14.1 Aspects requiring more Measurements

Surface water levels

There is a need for a new monitoring programme on measurements of surface water levels in the side channels on the flood plains both in Hungary and in Slovakia. At stations, where substantial fluctuations within a day occur, it is recommended to substitute manual measurement practises with automatic recorders.

Surface water quality

There is a need for a new monitoring programme on measurements of surface water quality in the side channels on the flood plains both in Hungary and in Slovakia.

Sediment transport and sedimentation/erosion

There is a need for establishment of a permanent sediment transport measurement programme comprising both bed load and suspended load measurements at the following locations:

(1) Upstream the reservoir.

(2) In the reservoir.

(3) In the Old Danube.

(4) In the side channels of the Hungarian and Slovakian flood plains.

(5) Downstream the confluence at Sap/Palkovicovo.

Furthermore, there is a need for establishment of permanent programmes for monitoring river bed and reservoir topography.

Ground water quality

The intensive monitoring must be continued for the coming years, especially with regard to areas close to the Danube where the infiltration conditions have been changed. Depending on the development of the measured ground water quality parameters it may be required to add more observations in the future.

Flora and fauna

The present monitoring system should be strengthened with the following investigations:

(1) Geobotanical monitoring plots in different habitats where changes in the environmental conditions could be expected. For describing the abundance the BRAUN - BLANQUET-method should be used.

(2) Mapping of the bird species in a grid system with 1-km^2 - plots covering the whole area potentially influenced by the Variant C.

(3) Quantitative investigations on fish populations in selected reaches of the reservoir and the old Danube and in selected side branches/oxbow lakes by electrical fishing

(4) Quantitative investigations on Carabide-beetles with BARBER-traps in different habitats undisturbed by forestry and agriculture (e.g. forests and sand banks)

(5) Quantitative investigations on grasshoppers in grassland monitoring plots mowed 1 or 2 times a year (yearly at the same time)

(6) Quantitative investigations on living and dead mussels and water snails in selected monitoring plots in the reservoir, the Danube and oxbow lakes/side branches.

(7) Qualitative, and if possible also quantitative, monitoring of the rotary and crustacean plankton in major water bodies including the reservoir, the intake canal and the Old Danube.

The monitoring plots should be mapped in detail (1:100 - 1:1.000). Investigation plots 10x10m or 25x25m should be durable marked in the field so that the survey can be repeated on the exactly same place.

Forestry

The present monitoring system should be strengthened with the following investigations:

(1) Mapping the forest types in the scale 1:10.000

(2) Selection of "monitoring trees" (n x 10^2 Salix alba and Populus x euroamericana CV. I 214) all along the Danube on both sides from Bratislava to Sap/Palcovicovo with annual measurements/observations of height, perimeter in 1.3 m height and leaf area index.

14.2 Aspects requiring coordination Efforts

For obtaining firm conclusions on the discharge uncertainties the following checks are required to be carried out by joint Hungarian-Slovakian teams:

(1) Check on discharge calibration curve at the bypass weir at Cunovo.

(2) Check on discharge calibration curve at the turbines at Gabcikovo.

(3) Check of discharge rating curves at Rajka and Dunaremete.

Budapest, 2. November 1993

Johann Schreiner

Igor Mucha

Gabor Vida

Jan M. van Geest

Jens Christian Refsgaard

15. REFERENCES

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- Surface and Ground Water Regime in the Slovak Part of the Danube Alluvium
- Surface Water and Ground Water Quality, Part 1/2
- Surface Water and Ground Water Quality, Part 2/2
- Ground Water Level Data, Part 1
- Ground Water Level Data, Part 2
- Sediment Transport and Sedimentation/Erosion (in Slovak)
- Irrigation water and agriculture
- Floodplain forests influenced by construction of the Gabcikovo dam
- Electricity Production and Navigation

Bratislava, October 15, 1993.

/3/ Data Report prepared by Hungary as input to the present Working Group. Volume on
- Summary Report

Budapest, October 21, 1993.

/4/ Hydrographic data taken in the period taken after the closure of the Danube. Ministry of Environment and Regional Policy, Hungary, Budapest, may 1993.

APPENDIX A: Terms Of References for the Working Group

COMMISSION OF THE EUROPEAN COMMUNITIES
DIRECTORATE-GENERAL
EXTERNAL ECONOMIC RELATIONS

Brussels, 26 August 1993
Service/I-3/hcs

Establishment of a Group of Monitoring and Water Management Experts for the Gabcicovo system of locks

I. Introduction

In order to provide reliable and undisputed data on the most important effects of the current water discharge and the remedial measures already undertaken as well as to make recommendations for appropriate measures the Republic of Hungary and the Republic of Slovakia will establish a Group of Monitoring and Water Management Experts (Group of Experts).

The Group of Experts shall consist of one expert appointed by Hungary and one expert appointed by Slovakia. Three independent experts appointed by the Commission of the European Communities will participate in the Group. The meetings will be chaired by one of the EC experts. The EC experts will have expertise in hydrology, including monitoring of hydrological data, ecological issues and water based constructions. The Slovak andd Hungarian experts can be supported by associate experts if necessary.

The monitoring will cover the whole area surrounding the Gabcikovo system of locks, and monitoring and measuring systems will be established both at Slovak and Hungarian territory.

No recommendations or activities arising from the establishment of the Group of Experts or its operation will effect, or reflect upon, any of the issues of legal liability which, in accordance with the Special Agreement, must be determinated by the International Court of Justice.

The Group of Experts will submit reports and recommendations based on consensus between the experts. In cases of disputes in the Group of Experts the Slovak and Hungarian experts as well as the EC experts can submit separate reports and recommendations.

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2. Objectives

The Group of Experts will:

I. Collect and assess data on all relevant aspects and effects of the current water discharge including the effects of the various remedial measures already put in place. The data to be collected will be defined by the Group of Experts within three days after its formal establishment. The methodology to be applied in the subsequent data analysis will be defined by the Group of Experts in connection with its first report 17 days after its formal establishment. The data to be collected will at least include:

* water discharge at all relevant places;

* surface water level and quality including sedimentation at all relevant places.

* ground water level and quality;

* impact on flora and fauna in the region;

* impact on agriculture and forestry;

* electricity production

* other possible essential aspects.

The data collection will be based on the existing data currently at the disposal of both sides as a result of regular measuring made jointly or separately by each side. Further the Group of Experts will decide on new or harmonised monitoring procedures and identify possible need for additional monitoring to be carried out in the future.

II. On the basis of the data collection (I) prepare recommendations for submission to the two Governments on the following aspects, with a view to safeguard the environment and the ecological conditions in the region:

A. A Temporary Water Management Regime including a detailed manual with specifications for the day-to-day operation and different water discharge situations:

B. The necessary water discharge and water level in the old riverbed and in the adjacent area and remedial measures to be taken.

c. The establishment of a Water Management and Monitoring Committee for the operation of the Temporary Water Management Regime. The main task of the Water Management and Monitoring Committee would be to:

- propose modifications in the Temporary Water Management Regime or new remedial measures to be taken on the basis of the operational experience and continued monitoring,

- initiate and supervise additional studies, measurements and research required; and

- prepare recommendations for urgent measures to be taken in case of emergency situations.

3. Activity and time schedule

The Group of Experts will work in accordance with the annexed time and activity schedule.

4. Mode and place of operation

A detailed activity and meeting plan will be prepred at the first meeting in the Group of Experts. Place of meetings will alternate between Slovakia and Hungary and secretarial support will be provided by the host country.

5. General

All proceedings, data collected by and recommendations from the Group of Experts will be confidential until the two Governments and the Commission decide otherwise. The Experts will make no public statements on the work of the Group.

DATE	ACTIVITY
September 8, 1993	First meeting to develop a detailed action and meeting plan.
September 13,1993	Report by the EC Experts on the need for clarification or adjustments in the Working Document
September 30,1993	Report on the assessment of existing data, the preliminary findings from analysing the data and the recommendations regarding modifications to the present monitoring practice. The report will be submitted to the two Governments and the Commission.
November 19, 1993	Final report, including recommendations for: 1. Temporary Water Management Regime, including a detailed manual with specifications for the day-to-day operations and different water discharge situations; 2. The necessary water discharge and water level in the old river bed and in the adjacent area and remedial measures to be taken; 3. The establishment of a Water Management and Monitoring Committee re. item 2.II.C.

APPENDIX B: Members of the three Delegations assisting the Working Group

Members of the Working Group

Johann SCHREINER, EC (primus inter pares)
Jan M. van GEEST, EC
Jens Christian REFSGAARD, EC
Gabor VIDA, Hungary
Igor MUCHA, Slovakia

Associate experts from Hungary

Sándor BOLLA, Lake Fertö National Park, Sopron

Károly BAROSS, North Transdanubian District Water Authority, Györ

Adrienne HAJÓSY, Ministry for Environmental and Regional Policy, Budapest

Lajos HORVÁTH, North Transdanubian District Environmental Authority, Györ

Pál LIEBE, Water Resources Research Center, Budapest

Ferenc MÉSZÁROS, Hungarian Natural History Museum, Budapest

Zoltán NAGY, North Transdanubian District Environmental Authority, Györ

Jenö SASS, Water Resources Research Center, Budapest

János SZEKERES, Water Resources Research Center, Budapest

György TÓTH, Hungarian Geological Survey, Budapest

Associate experts from Slovakia

JUDr. Ludek KRAJHANZL, Law Expert, Prague

Ing. Stefan MOLNAR, Office of Governmental Plenipotentionary for G/N, Bratislava

Ing. Ferdinand KUBICEK, Dr Sc, Institute of Ecobiology, Slovak Academy of Sciences, Bratislava

Annex 19

COMMISSION OF THE EUROPEAN COMMUNITIES
REPUBLIC OF HUNGARY
SLOVAK REPUBLIC

WORKING GROUP OF MONITORING AND WATER MANAGEMENT EXPERTS FOR THE GABCIKOVO SYSTEM OF LOCKS

REPORT ON TEMPORARY WATER MANAGEMENT REGIME

Bratislava
December 1, 1993

EXECUTIVE SUMMARY

BACKGROUND

As a follow-up of the 'Special Agreement for Submission to the International Court of Justice of the differences between the Republic of Hungary and the Slovak Republic concerning the Gabcikovo-Nagymaros Project' a Group of Monitoring and Water Management Experts for the Gabcikovo System of Locks (Working Group) was established by the Republic of Hungary, the Slovak Republic and the Commission of the European Communities (CEC).

The tasks of the Working Group fall in two parts:

* On the basis of available data to assess the impacts of the Gabcikovo Project and to prepare recommendations for strengthening the monitoring system in the area.
* Preparation of recommendations for a Temporary Water Management Regime as well as for necessary discharges, water levels and remedial measures.

The present Data Report is the Final Report of the Working Group dealing with the Temporary Water Management Regime. The first aspect was dealt with in the Data Report, finalized in Budapest on November 2, 1993.

The Working Group has obtained all the relevant data and information requested from the two Governments. The report is based on this information.

ELABORATION OF FIVE SCENARIOS

In the present report five scenarios with different characteristics on discharge regime and remedial measures have been elaborated. All the five discharge regimes are dynamic and characterized by the below average values. The five scenarios and their most important impacts can be summarized as follows:

Scenario 0: November 1993 Situation

* Old Danube: 400 m^3/s
* Slovakian side branches: 40 m^3/s
* Hungarian side branches: 10 m^3/s

The key impacts are as also described in the Data Report:

* The environmental conditions on the Hungarian inundation area are bad due to lack of water.

* The flow velocities and water levels in the Old Danube are too low for providing suitable living conditions for typical flora and fauna.

* The lack of connections between the main channel and the side branches prevents migration of wetland species.

Scenario 1: Increased water supply to the Hungarian Side Branches

* Old Danube: 400 m^3/s

* Slovakian side branches: 50 m^3/s

* Hungarian side branches: 50 m^3/s

* 1-3 floods of more than 3500 m^3/s are expected to occur each year in the Old Danube.

The key impacts as compared to Scenario 0 are:

* Improvements of the environmental conditions for the Hungarian inundation area.

Scenario 2: Increased Discharge in Main River and in Hungarian Side Branches

* Old Danube: 800 m^3/s

* Slovakian side branches: 50 m^3/s

* Hungarian side branches: 50 m^3/s

* 1-3 floods of more than 3500 m^3/s are expected to occur every year in the Old Danube.

The key impacts as compared to Scenario 1 are:

* Improvements of the main river environment to a level where species requiring higher flow velocities (e.g. fish) have suitable living conditions.

Scenario 3: Construction of some Underwater Weirs

Scenario 3 is basically identical to Scenario 2 except for construction of a number of underwater weirs.

The key impacts as compared to Scenario 2 are:

* The connections between the main channel and the side branches on both sides are maintained or even improved as compared to pre-dam conditions.

* For discharge not exceeding 1000 m^3/s the flow velocities in the Old Danube are not sufficient for

maintaining the typical flora and fauna.

Scenario 4: Full Capacity of Variant C Structures used for Water Supply of the Main River and the Branches

In Scenario 4 as much water as technically possible will be diverted into the Old Danube and the side channels. However, this will technically not be possible until after the summer of 1996.

CONCLUSIONS

None of the described scenarios are free from key environmental problems. Furthermore, different scenarios result in different environmental problems, which are not directly comparable. Scenario 2 and Scenario 3 show that some environmental problems can be reduced by increasing discharge and remedial measures.

In addition to the environmental aspect also economical aspects should be considered. In this respect it may be noticed that the value of the present electricity production of 2000 GWh/year is in the order of 50 - 100 million ECU/year. For comparison the electricity production will be reduced by about 30 % in Scenario 2 and 3. The costs for implementation of the remedial measures range between 2 and 12 million ECU depending on the scenario.

RECOMMENDATIONS BY THE EC MEMBERS OF THE WORKING GROUP

None of the described scenarios can be recommended without modifications. Therefore the three EC members of the Working Group will recommend a combination of elements from different Scenarios.

Objectives

The overall objective of the recommended Temporary Water Management Regime is a minimization of any irreversible developments.

The primary objectives are to enable as good environmental conditions as possible within the given discharge constraints, whereas the secondary objective is electricity production.

Discharge regime

* Old Danube: 800 m^3/s
* Slovakian side branches: 50 m^3/s

* Hungarian side branches: 50 m^3/s

* 1-3 floods of more than 3500 m^3/s are expected to occur every year in the Old Danube.

Remedial measures

* Improvement of the daily discharge capacity of Variant C structures from the present 600 m^3/s to 940 m^3/s by May 1994.

* For environmental purposes an underwater weir at RKM 1835 enabling direct contact between the main river and the Slovakian side branches at one upstream point of the Slovakian floodplain.

* For operational purposes an underwater weir at RKM 1845.5. This underwater weir will significantly improve the reliability of the day-to-day water supply through the inundation weir and it will ensure water supply to the Hungarian floodplain.

Day-to-day Operation

Improved operation rules for the day-to-day operation of the water management within the above given discharges has be implemented in order to obtain as good environmental conditions as possible.

Environmental Impacts

The recommended Temporary Water Management Regime is believed to ensure that minimum irreversible environmental developments take place during the few years the temporary regime is supposed to last.

It is furthermore recommended to maintain a detailed environmental monitoring including taking the steps to strengthening the present monitoring system as recommended in the Data Report.

Design Review of Spillway of Inundation Weir

The spillway of the inundation weir is a key issue in terms of discharge possibilities, reliability, time schedule and costs. As no comprehensive design exists for its daily use a design review is recommended to be carried out by an independent, specialized institute.

TABLE OF CONTENTS

1. INTRODUCTION

1.1 Background and Objectives for the Working Group

As a follow-up of the 'Special Agreement for Submission to the International Court of Justice of the differences between the Republic of Hungary and the Slovak Republic concerning the Gabcikovo-Nagymaros Project' a Temporary Water Management Regime for the Danube has to be established and implemented.

In order to provide reliable and undisputed data on the most important effects of the current water discharge and the remedial measures already undertaken as well as to make recommendations for appropriate measures a Group of Monitoring and Water Management Experts for the Gabcikovo System of Locks (Working Group) was established by the Republic of Hungary, the Slovak Republic and the Commission of the European Communities (CEC). The Terms of References for the Working Group are enclosed in Appendix A.

The Working Group is composed of the following five experts:

CEC: Professor Johann Schreiner (primus inter pares), Director, Norddeutsche Naturschutzakademie, Germany.

Mr. Jan M. van Geest, Director, DHV Environment and Infrastructure, The Netherlands.

Mr. Jens Christian Refsgaard, Chief Hydrologist, Danish Hydraulic Institute, Denmark.

Slovakia: Professor, Dr. Igor Mucha, Faculty of Natural Science, Comenius University, Bratislava.

Hungary: Professor, Dr. Gabor Vida, Head of Department of Genetics, Eötvös L. University, Budapest.

The five experts were assisted by colleagues as listed in Appendix B. The Working Group had its first formal meeting on September 8-9, 1993 in Bratislava. The second meeting was held in Budapest during the period October 27 - November 2, 1993. Field inspections were carried out on October 30 both in Slovakia and in Hungary. The third and final meeting was held in Bratislava during the period November 28 - December 1, 1993. In between the formal meetings comprehensive work on data collection and analyses were carried out by the Slovak and Hungarian experts and interaction with the CEC experts also took place during this period.

The Working Group had to prepare two reports. The first one, denoted the Data Report, was finalized on the second meeting in Budapest on November 2, 1993. The Data Report comprised an assessment of the impacts of the Gabcikovo project with regard to discharges, surface water levels and quality, sedimentation and erosion, ground water levels and quality, flora and fauna, agriculture, forestry and electricity production. Furthermore, recommendations for strengthening of the monitoring system in the area were given.

The present report is the second and final report of the Working Group. It contains recommendations for the governments for a Temporary Water Management Regime as well as for necessary discharges, water levels and remedial measures to be taken.

The Working Group has obtained all the relevant data and information requested from the two Governments. The report is based on this information.

1.2 Temporary Water Management Regime

The dispute concerning the Gabcikovo-Nagymaros Project has been submitted to the International Court of Justice (ICJ). Pending the final Judgement of the ICJ there is a need to establish and implement a Temporary Water Management Regime (TWMR) for the short term period until a final regime is implemented. Thus it can be expected that the TWMR will be applied for a period of 3 - 5 years.

The present report deals exclusively with the TWMR and does not address the permanent, long term solutions. It is outside the terms of References of the Working Group to analyse and predict long term impacts. Such assessments will for some aspects require more thorough studies.

2. DESCRIPTION OF EXISTING WATER SYSTEMS

2.1 Variant C Structures

2.1.1 Brief description of structures and status of works

The structures for the Gabcikovo part of the Gabcikovo-Nagymaros project are completed in both countries with some exceptions, for example the closure of the Danube river at Dunakiliti, deepening of the outlet canal and measures in the Danube downstream Sap/Palkovicovo.

Variant C consists of a complex of structures located in Slovakia. A sketch of the Variant C structures is shown in Fig. 2.1. The structures include the following elements:

(1) Hydropower station and ship locks at Gabcikovo.
(2) Dam closing the Danubian river bed.
(3) By-pass weir controlling the daily flow into the river Danube.
(4) Inundation weir.
(5) Intake structure for the Mosoni Danube.
(6) Intake structure for Slovak inundation area at power canal at Dobrohost.
(7) Earth barrages/dikes connecting structures
(8) Ship lock for smaller ships (24 m x 125 m).
(9) Spillway weir.
(10) Hydropower station.

Structures 1 + 6 are part of the original project. The construction of the structures 2 - 5 and 7 are included in Phase 1 of Variant C, while the remaining 8 - 10 are a part of Phase 2 of Variant C. The main part of Phase 1 structures have been completed by now, while Phase 2 is scheduled for construction 1993-96.

The progress of the work up to November 21, 1992 has been reported in ref /1/, and the status as per May 1993 is reported in ref /3/. The present status is as follows:

(1) Hydropower station (HEP) and ship locks at Gabcikovo

The HEP is designed for peak power production. The planned 8 turbines have a nominal capacity of 4,000 m^3/s. At present five turbines and generators are installed. The sixth turbine and generator are in stock, while the remaining two turbines are planned for completion in future. The maximum capacity is approximately 610 m^3/s per turbine. At the designed operational water level of 131.1 m asl. (reference Baltic msl) the design head is 19 m in average.

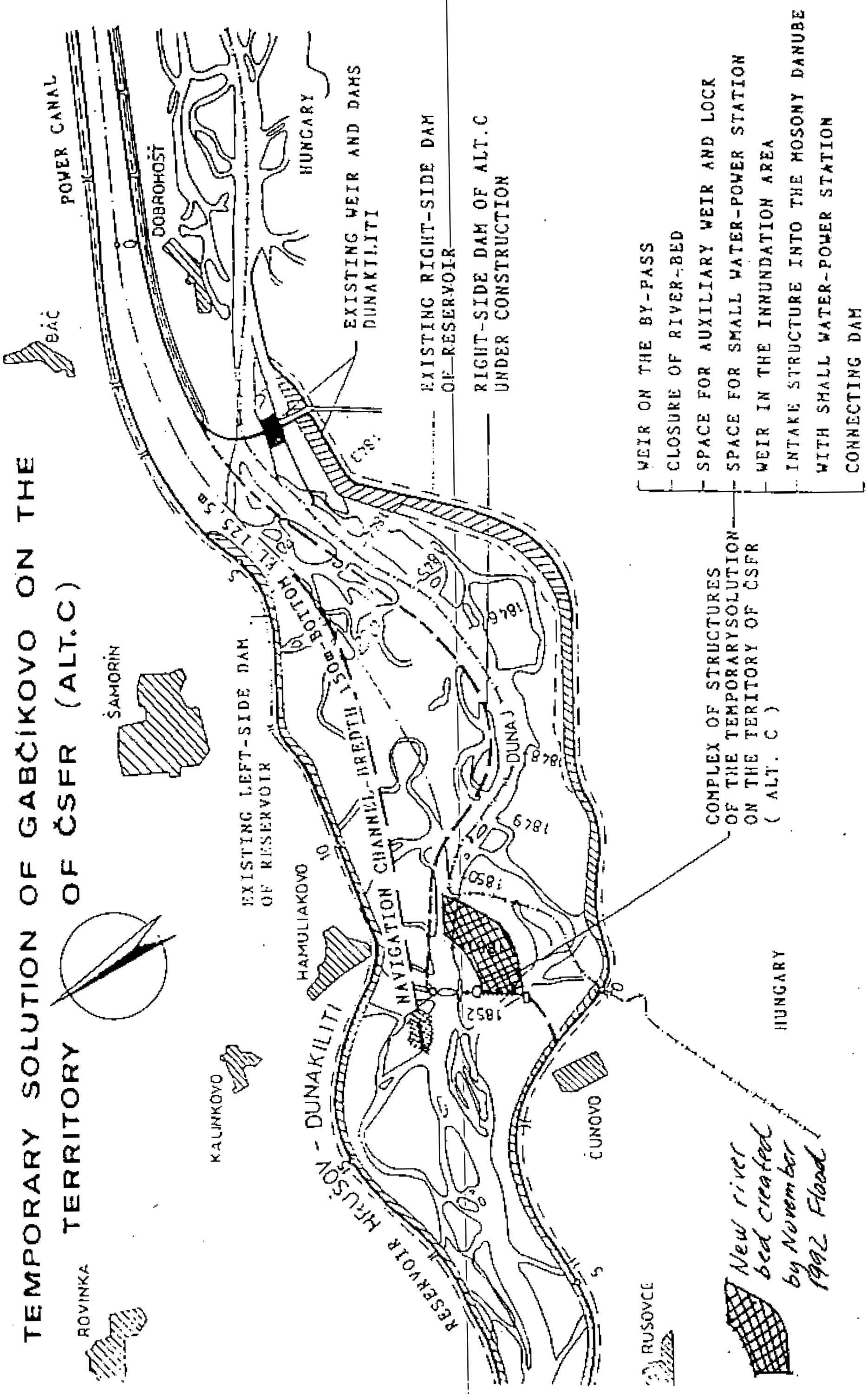

Fig. 2.1 *Sketch of the Variant C Structures*

The two ship locks (each 34 m wide and 275 m long) have been in operation since November 1992. They have a total hydraulic capacity of 1970 m^3/s when open. The capacity of the canal in flood situations is approximately 4500 m^3/s, limited by the velocity in the power canal.

(2) Closure of the Danube

The closure of the Danube river bed started on October 23 and was completed on October 27. All works including protection works, a vertical clay-cement protection wall (for preventing seepage) and a system for technical monitoring (of seepage) are now completed.

(3) By-pass weir controlling the flow into the river Danube

The daily flow into the river Danube from the reservoir is lead via this weir.

The weir consists of four tainter gates each 18 m wide with sill level at 126.5 m asl. The maximum hydraulic capacity of the weir was originally designed at 1460 m^3/s. However, due to a fault in design, the discharge is limited in all cases to 600 m^3/s. Otherwise the spillway will be destroyed. The weir, including machineries, is completed and in operation.

(4) Inundation weir

The weir consists of 20 tainter gates each 24 m wide with sill level at 128.0 m asl. Each of the gates has a hydraulic capacity of 230 m^3/s (total capacity of the weir is 4600 m^3/s) at the maximum water level of 131.1 m asl. The capacity at a water level of 129.0 m asl is estimated to be 60 m^3/s per gate.

The inundation weir and the bottom protection were originally designed for use only in flood situations (few days per year). This design was in October/November 1992 modified as a result of the London Meeting with the aim to allow daily use. Along the Danube right bank a spillway was being constructed and the downstream bed was planned to be protected with additional 100,000 m^3 stone. This work was scheduled to be completed by January 1, 1993.

The flood on 25 November 1992 changed the whole area downstream the weir. Between two and three mill m^3 of soil, sand and gravel were eroded. Hence, also the protection dike disappeared. Just behind the weir scour holes of 11 m depth developed locally and caves were formed underneath some downstream parts of the weir. The average surface level downstream the weir dropped by 5-6 m to about 122 m asl.

At present the spillways of the openings 1, 2, 3 and 4 are completed for flood purposes, whereas the spillways of the other 16 openings are not yet completed.

The right embankment of the canal between the inundation weir and the Danube needs fortification. At present 80 % of this work is completed.

Since the November 1992 flood, the weir has been used only in connection with flood events in January, March, May, July and August 1993.

(5) *Intake structure at entrance to the Mosoni Danube*

A supply canal on Slovak territory is connected to the Mosoni Danube on Hungarian territory. This structure has since November 1992 supplied 20 m^3/s to Mosoni Danube. In the intake structure for the Mosoni Danube a small hydropower station with two turbines is planned to be installed with a bypass capacity of 25 m^3/s corresponding to a water level of 131.1 m asl and 20 m^3/s at 129 m asl. The turbines and generators will be installed next year. Their combined capacity will be 40 m^3/s.

(6) *Intake structure into Slovak inundation area at power canal at Dobrohost.*

The intake structure located in the power canal allows for a maximum discharge of 234 m^3/s to be supplied to a river arm in the left bank of the floodplain downstream the Dunakiliti weir close to Dobrohost. A canal connecting the structure and the downstream river arm on the Slovak side has been dug. The structure has been in operational use since the end of April 1993. The entire works are not yet completed and hence the maximal capacity at present is 140 m^3/s.

(7) Earth dams/dikes connecting structures

A dike between the downstream part of the reservoir and the left bank of the Danube connecting the Cunovo structures with the righ bank of the power canal has been constructed.

On top of the structures (dam, dikes, weirs) a road has been constructed for connecting the three villages in the area between the power canal and the Danube with Bratislava. The part of the road on top of the inundation weir is not yet ready. Instead a temporary earth road on top of the spillway is being used.

(8) Ship lock
(9) Spillway weir
(10) Hydropower station (HPS)

Between the by-pass weir and the inundation weir a temporary dike has been established with a crest level of 133.8 m asl. Behind this temporary dike the structures (8), (9) and (10) are planned under Phase two of the Variant C. At maximum water level the hydraulic capacity of the ship lock and spillway weir will be 4000 m^3/s. The capacity of the HPS has not been decided but is likely to be about 1300 m^3/s. The sill level of the spillway weir will be at 120.5 m asl., which is the same as in the existing river bed.

2.1.2 Slovak plans for future works near the inundation weir

The following works are planned:

(a) The road on the top of the inundation weir is planned to be opened in May 1994.

(b) The remaining part of the protection works on the right embankment of the canal between the inundation weir and the Danube is scheduled to be completed in May 1994.

(c) It is planned to start the reconstruction of the spillways of the 16 remaining openings in May 1994. These works are scheduled to be completed in July 1995 (for flood conditions).

(d) It is planned to fortify the left embankment of the canal between the inundation weir and the Danube. The fortification is planned to be carried out during the coming 14 months.

(e) To prevent erosion of the canal between the inundation weir and the Danube, it is planned to excavate the bed of the canal to a level corresponding to the average bottom level of the Danube (122 m asl.). This excavation is scheduled to be carried out over the coming 14 months.

(f) The construction of Phase 2 is planned to be carried out during the next three years. Water discharge will be possible ½ year before the completion.

The discharge capacity of the Variant C structures for daily use as it develops with the gradual completion of the remaining parts of the structures according to the Slovak plans are shown in Table 2.1. As appearing from the table more discharge than the presently maximum of 600 m3/s is not planned to be possible before the Phase 2 weir become operational in the summer of 1996.

Table 2.1 Discharge capacity of the Variant C structures for daily use according to Slovak project plans

	November 1993	Summer 1996
By-pass weir	600	600
Phase 2 weir		5300
TOTAL	600	5900

2.1.3 Daily use of the inundation weir

The spillway behind the inundation weir is not designed for daily use. It is estimated that it will be possible to use it for passing a limited amount of discharge even for daily use. The following options are available (as pointed out in Appendix E):

(1) Using four openings of the inundation weir which are constructed alternatively and hence have a spillway in a better condition. The discharge capacity is limited to 340 m^3/s, and it is necessary to inspect the fortifications each week and make frequent repair work. The implementation time is six months and the maintenance costs are estimated to 1.0 mill ECU/year.

(2) Reinforce the spillway for daily use. The discharge capacity will be limited to 1350 m^3/s. Maintenance will be required. The implementation time is one year. The construction cost is estimated to 3.3 mill ECU. The maintenance costs are estimated to 5 mill ECU/year. These maintenance costs will be significantly reduced by a downstream water level higher than 124.0 m asl.

To execute each of the two options the plans mentioned in 2.1.2 should be modified.

The discharge capacity for daily use assuming is as shown in Table 2.2 if additional work is carried out according to options (1) or (2) above.

In general the time schedule will depend on weather conditions.

Table 2.2 Discharge capacity of the Variant C structures for daily use assuming additional works carried out

	Nov 1993	May 1994 1)	Dec 1994 2)	Summer 1996 1)	Summer 1996 2)
By-pass weir	600	600	600	600	600
Inundation weir	-	340	1300	340	1300
Phase 2 weir	-	-	-	5300	5300
TOTAL	600	940	1900	6240	7200

1) Assuming execution method (1) above.
2) Assuming execution method (2) above.

2.2 Main River

River cross-sections are regularly surveyed for the main Danube by Hungary. Such measurements have also been made in 1993 for comparison with pre-dam conditions (September 1992). These data are presently partly processed and eight cross-sections are shown in Figs 2.2-2.4 for present and pre-dam conditions.

As evident from the figure significant changes have occurred in the six cross-sections shown in Figs 2.2 and 2.3, where the river bed now generally is higher than in pre-dam conditions. The main reason for this is believed to be the erosion of 2-3 mill m^3 of sand and gravel material from just downstream the inundation weir during the November 1992 flood and subsequent deposition of this material further downstream. The cross-sections from Rajka (RKM 1848.4) and Dunaremete (RKM 1825.5), Fig 2.4, show only small changes of the same order of magnitude as usually occurred from one year to another in pre-dam conditions.

The relationship between discharge, water level and cross-sectional average flow velocities are shown in Table 2.3 for Rajka and Dunaremete, where discharge and water level measurements are made regularly. The figures in the table originate from a rating curve, which has been derived directly from measurements. From this table it is noted that only very small changes have occurred at the two sites. This indicates that the changes in river cross-sections in general have had only very small influence on the flow conditions in the Old Danube.

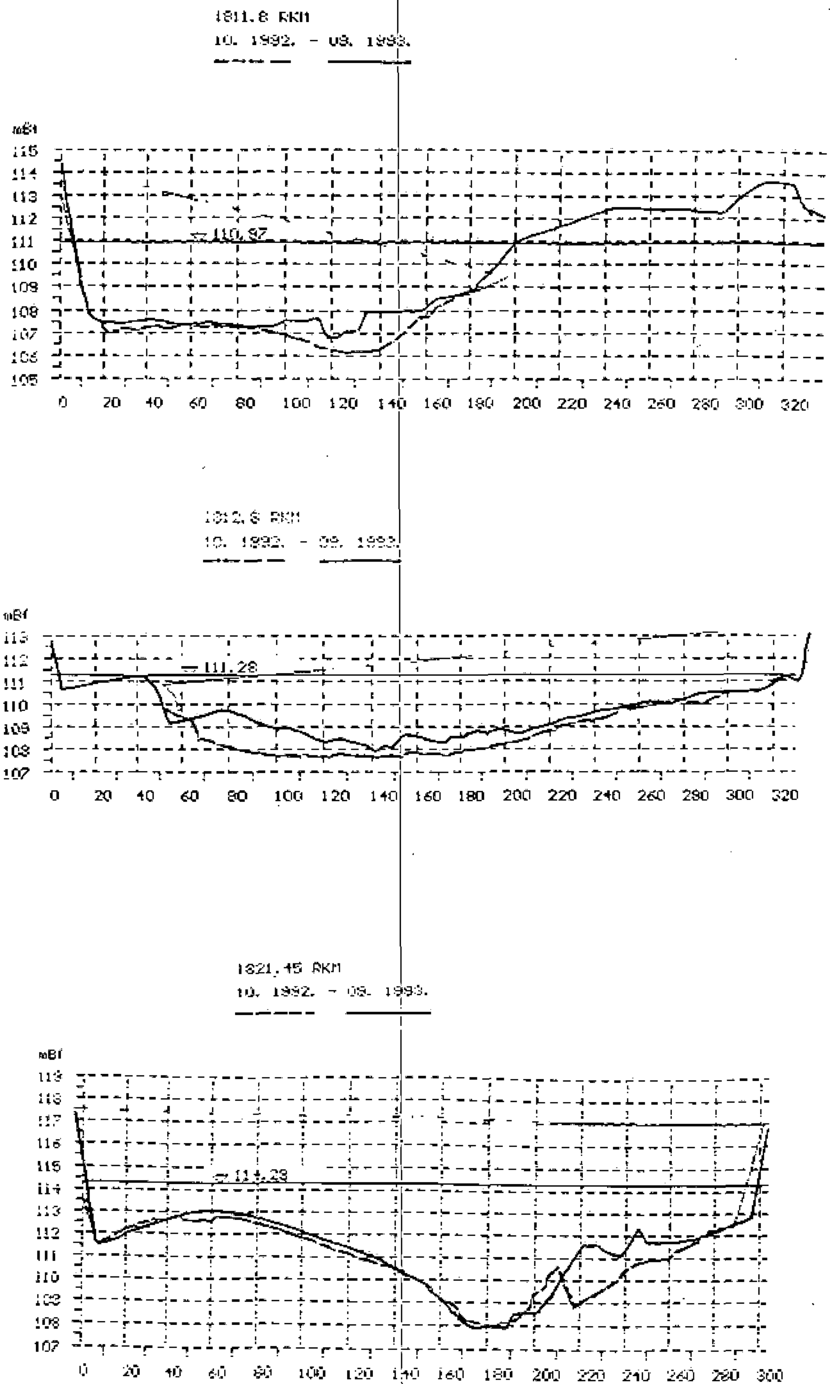

Fig. 2.2 *River cross-sections measured at three sites (Rkm 1811.8, Rkm 1812.8 and Rkm 1821.45) before and after the damming of the Danube*

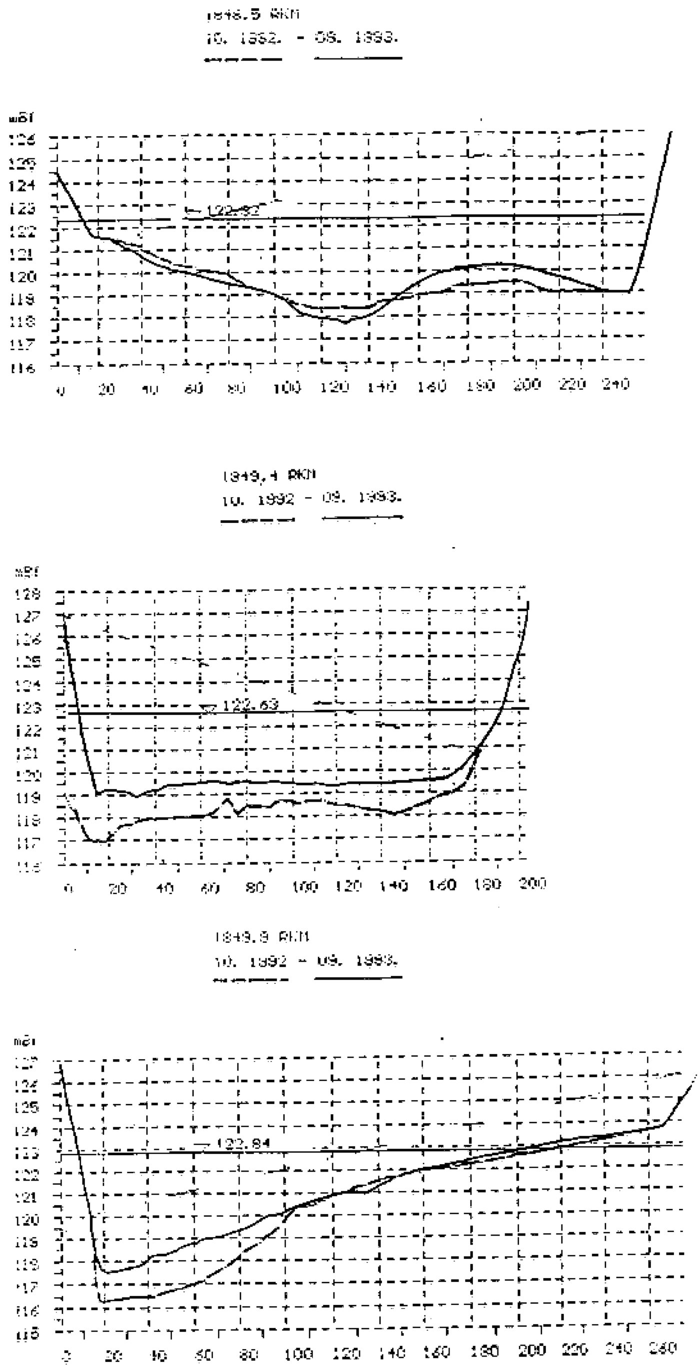

Fig. 2.3 *River cross-sections measured at three sites (Rkm 1848.5, Rkm 1849.4 and Rkm 1849.9) before and after the damming of the Danube*

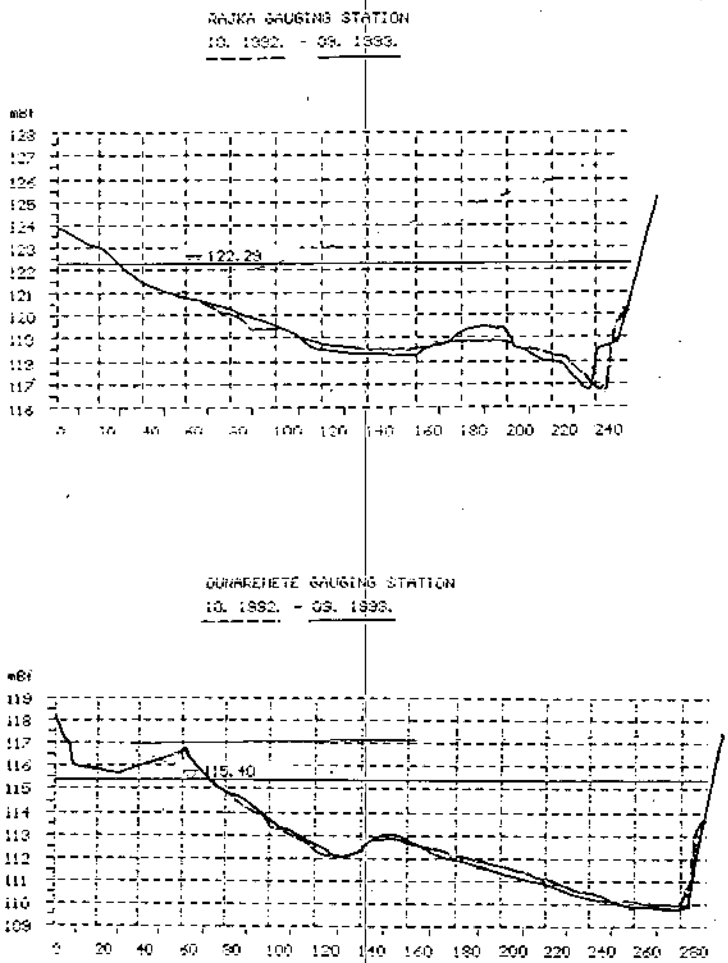

Fig. 2.4 *River cross-sections measured at the two gauging stations at Rajka and Dunaremete before and after the damming of the Danube*

For analysing the hydraulics of the main river a mathematical model, based on DHI's MIKE11 modelling system, has been set up under the PHARE project "Danubian Lowland - Ground Water Model", ref /4,5/. The data on river cross-sections used in the model corresponds to pre-dam conditions. For comparison with the measured data shown in Table 2.3 the results from model calculations for Rajka and Dunaremete are shown in Table 2.4.

Table 2.3 Water levels and cross-sectional average flow velocities at Rajka and Dunaremete for different discharges for the present and for pre-dam conditions.

Discharge (m^3/s)	Rajka 1993 Level (m asl)	Rajka 1993 Velocity (m/s)	Rajka Pre-dam condition Level (m asl)	Rajka Pre-dam condition Velocity (m/s)	Dunaremete 1993 Level (m asl)	Dunaremete 1993 Velocity (m/s)	Dunaremete pre-dam condition Level (m asl)	Dunaremete pre-dam condition Velocity (m/s)
200	120.3	1.04						
400	120.9	1.08			114.2	0.87		
600	121.3	1.13			114.7	1.03		
800	121.8	1.19	121.8	1.19	115.1	1.20	115.0	1.23
1000	122.3	1.29	122.4	1.31	115.4	1.28	115.3	1.29
2000	124.0	1.59	124.3	1.65	117.2	1.63	117.2	1.63
3500			126.3	2.08				

Table 2.4 Water levels and cross-sectional average flow velocities at Rajka and Dunaremete for different discharges calculated by the MIKE11 model for pre-dam conditions.

Discharge (m^3/s)	Rajka Water level (m asl)	Rajka Velocity (m/s)	Dunaremete Water level (m asl)	Dunaremete Velocity (m/s)
200	120.2	0.60	113.8	0.77
400	121.0	0.88	114.4	1.12
600	121.6	1.07	115.0	1.22
800	122.2	1.23	115.4	1.28
1000	122.7	1.35	115.9	1.34
2000	124.4	1.66	117.4	1.65
3500	126.1	2.04	119.1	2.00

By comparison of the figures in Table 2.3 and Table 2.4 it is noticed that the model simulated and the rating curve water levels show an average deviation of 20 cm. With respect to flow velocities the average deviation for discharges of 800 m^3/s or higher is 4 cm/s, while larger deviations occur for smaller discharges. Thus for small discharges the simulated velocities are smaller than the rating curve values at Rajka, while it is opposite for Dunaremete. No attempt has been made to analyze the exact reason for these deviations; instead it is noticed that the right order of magnitudes of flow velocities is simulated also for small discharges. More thorough validations of the model are provided in ref /5/. On this basis it can be stated that the model can represent water level and flow velocity conditions in the Old Danube to a level of accuracy sufficient for the present purpose.

Hence, estimates given later in this report on flow velocities in the Old Danube under different discharge conditions, both with and without underwater weirs, are based on model calculations.

In order to assess the impacts of different discharges on flow velocities at different locations in the Old Danube a number of model calculations have been made with constant discharges. Some key results are shown in Table 2.5. Furthermore the variation of flow velocities along the Old Danube is shown in Fig. 2.5 for a discharge of 600 m^3/s.

From Table 2.5 and Fig. 2.5 it is evident that the velocities vary considerably along the river. In the upstream part (Rkm 1825 - 1850) the variation is determined mainly by variations in local river cross-section. In the downstream part (Rkm 1810 - 1825) the backwater effect fromthe confluence with the outlet power canal is seen. In the model calculation the discharge in the outlet canal has been taken as 2000 m^3/s minus the discharge in the Old Danube. Due to backwater effects the water depths are higher in the downstream part and hence the resulting flow velocity is correspondingly lower.

Table 2.5 Average cross-sectional flow velocities calculated at different locations along the river for different discharges. The values have been calculated with the MIKE11 model using pre-dam river cross-sections.

Discharge (m^3/s)	Velocity RKM 1814.8[1)]	Velocity RKM 1822.1	Velocity RKM 1826.6	Velocity RKM 1834.8	Velocity RKM 1838.8	Velocity RKM 1845.6	Velocity RKM 1849.8
200	0.21	0.37	0.83	1.34	0.87	0.57	0.90
400	0.42	0.67	1.07	1.59	1.02	0.83	1.15
600	0.62	0.91	1.18	1.66	1.17	1.03	1.30
800	0.81	1.12	1.24	1.72	1.26	1.19	1.42
1000	1.00	1.29	1.29	1.77	1.35	1.32	1.51
2000	1.81	1.74	1.58	2.00	1.69	1.66	1.77

Note 1): RKM 1814.8 is just upstream the confluence with the outlet canal at Sap/Palkovicovo, which in the calculations has a discharge of 2000 m^3/s minus the discharge in the Old Danube. Hence this site is significantly influenced by backwater effects resulting in higher water levels and lower flow velocities.

It is noticed that the flow velocities given in Tables 2.3-2.5 and in Fig. 2.5 are average cross-sectional values. For estimation of maximum flow velocities in a given profile at e.g. 7 cm above the river bed as required by certain fish species (see Section 3.4 point (b)) the following two factors must be taken into account:

* Velocity variations at a given cross-section exist in the direction across the river, so that places with higher water depths have higher velocities and vice

versa. The velocity variation across the river depends mainly on the shape of the river cross-section. Simple calculations on the basis of the cross-sections at Rajka and Dunaremete indicate that the velocities in the deepest profile are respectively 35 % and 28 % higher than the cross-sectional average values for these two sections.

* Velocity varies vertically within a given cross-section with maximum velocity at (or close to) the surface water table and velocity close to zero at the river bed. Based on standard hydraulic assumptions (logarithmic velocity profile, Manning no = 33) and assuming typical water depths it can be estimated that the velocity 7 cm above the river bottom will be only about 50 % of the average velocity of a vertical profile.

Combining these two counteracting effects, it may be estimated that a multiplication factor of 1.3 * 0.5 = 0.65 has to be applied to convert a cross-sectional average velocity to the velocity 7 cm above the river bed in the vertical profile with the largest velocity.

In this report velocities refer to cross-sectional average flow velocities unless specifically stated otherwise.

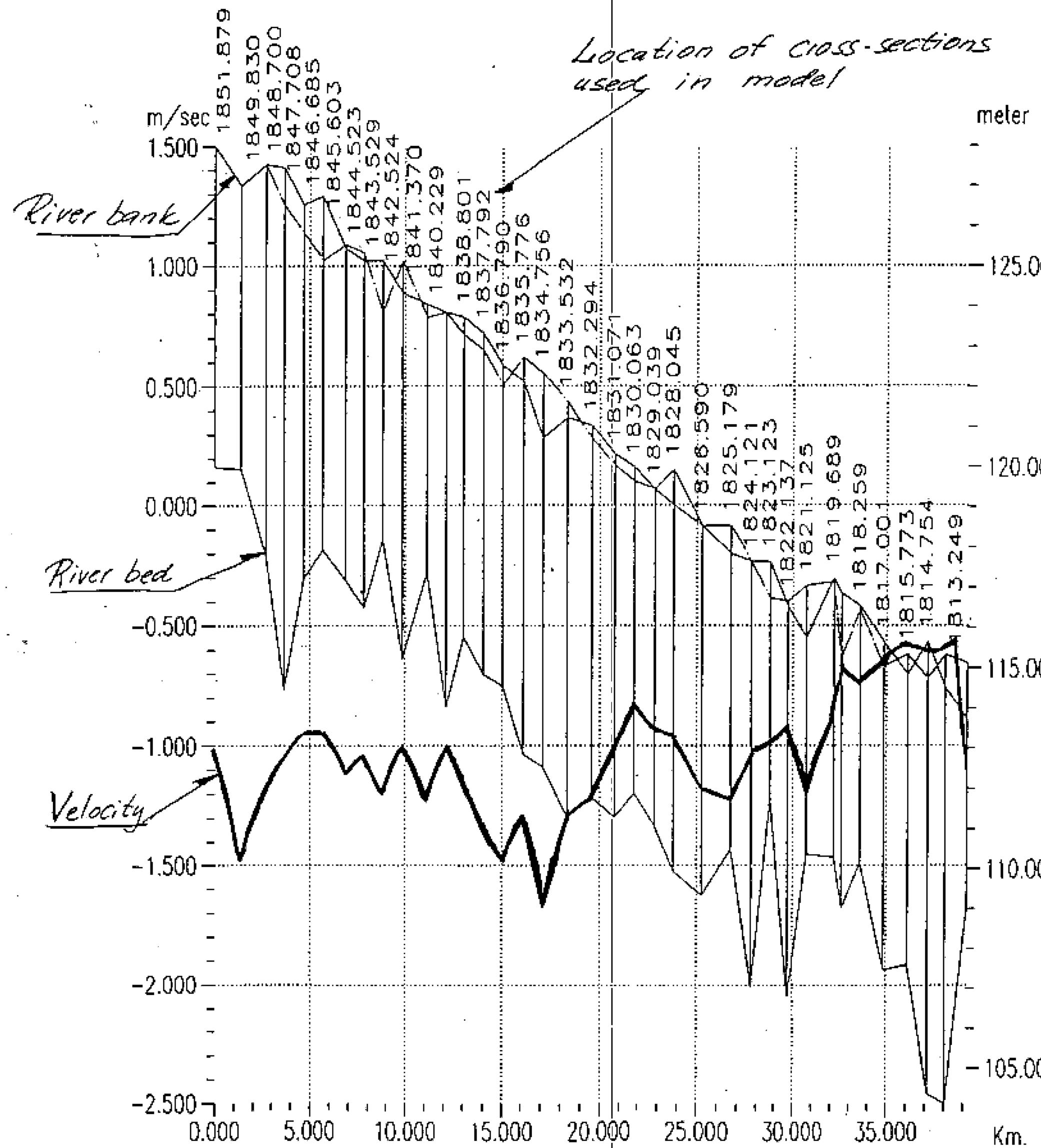

Fig. 2.5 *Velocity profile between Cunovo and Sap/Palkovicovo simulated with the MIKE11 model with a discharge of 600 m³/s*

2.3 Inundation Area on the left Side

The socalled inundation area or flood plain is the area between the main Danube and the flood dikes. On the left river side in Slovakia this flood plain covers the main part of the area between the main Danube and the power canal.

The inundation area is characterized by a large number of river branches of different sizes and interconnected in a complex way. A sketch of the area is given in Fig. 2.6, which also shows the location of the remedial measures implemented in the beginning of 1993.

Until about 30 years ago the side branches carried a substantial part of the total discharge. Measurements carried out in 1960 and 1961 showed that in the area near Gabcikovo the river branches carried about 20 % of the total discharge, also for low discharges. In the following years the connection between the river branches and the main river were closed in order to ensure high water depths for navigation. As described in ref /1/ this resulted in a pre-dam situation with total lack of connection about half the year and full connection only for about 20 days per year.

After damming of the Danube the water level in the upstream part of the Old Danube has been reduced so much that water now flows from the main river to the side branches only in flood situations a few days per year, while usually there is a water level difference of a couple of meters. In order to remedy this situation and the processes described in the para above Slovakia has implemented a project with the following key elements:

* Intake of water at an intake structure in the power canal at Dobrohost. Through a new canal this water is diverted into one of the river branches.

* Construction of a number of hydraulic structures in the side channels. As a result the flood plain is divided into seven compartments with almost constant water levels and separated by hydraulic structures.

* More efficient closing of the connections between the side channels and the main Danube in order to minimize loss of water.

Thus the water flows over a distance of about 20 km over seven cascades until it enters the Danube at RKM 1821. There is a loss of water of several m^3/s, due to infiltration to ground water, evaporation and flow to the Danube.

It is possible to regulate the intake of water from 0 to at present 140 m^3/s (234 m^3/s when the structure is completed). The system was taken into operation at the end of April 1993, and the discharges has since then varied between 10 m^3/s and 70 m^3/s. Monthly average values are

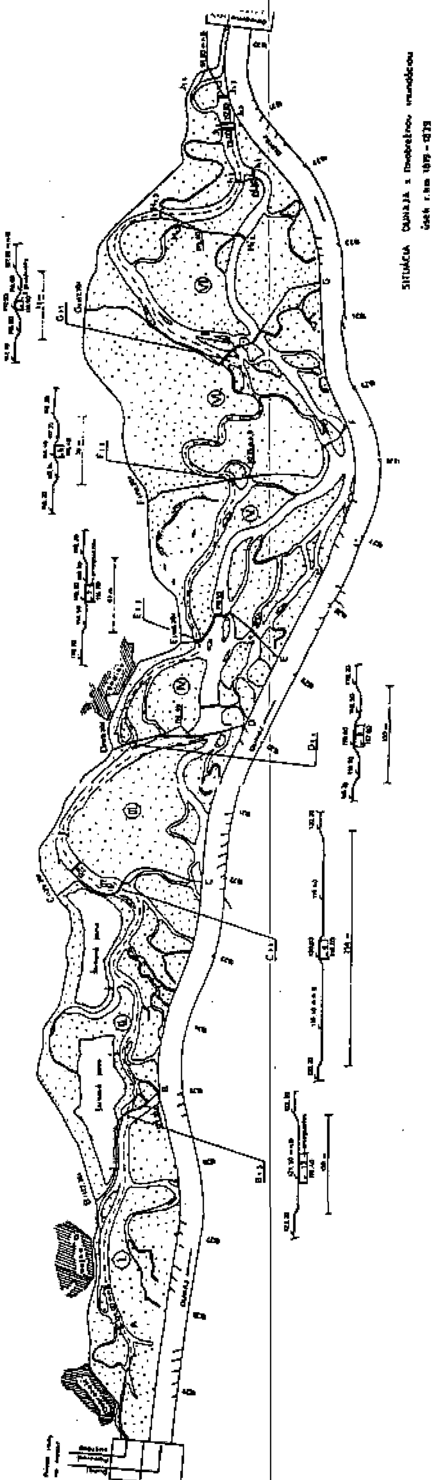

Fig. 2.6 Branch system on the Slovakian flood plain.

given in ref /2/.

More details on the remediation project is given in ref /6/.

The flow velocities vary very much in the area due to very large variations in cross-sections and bifurcations/junctions of flow paths. Simulation of the area with the MIKE 11 model, ref /5/, indicate that at a discharge of 40 m^3/s typical cross-sectional velocities are in the order of 0.05 - 0.25 m/s. These velocities have been confirmed by recent field measurements.

As a result of the discharges of up to 70 m^3/s the fine material/mud, which previously covered the bottom of the side channels, has been washed away at many locations. As described in ref /2/ it can be seen from ground water observations that a significant infiltration takes place now.

2.4 Inundation Area on the right Side

The inundation area on the right side forms part of the Szigetköz. The main part of the alluvial forest in Szigetköz is located in the inundation area. Like on the Slovakian side the area is characterized by a large number of river branches of different sizes and interconnected in a complex way. A sketch of the area is given in Fig 2.7.

As a result of river regulation during the past 30 years merely a limited number of side branches succeeded in preserving virtual connection with Danube. Thus the pre-dam situation was similar to the pre-dam situation on the Slovakian side.

After damming the Danube the connection between the Danube and the side channels virtually disappeared. In order to provide the branches with water Hungary has carried out considerable engineering efforts in 1993. They included the reduction of the elevation of closing dams and bypass weirs as well as cleaning some new channel sections. The most significant change related to the transformation of the branch system resulted from closing its previously open lower endings except for the ones in Asvanyi and Bagomeri. Branch systems have been connected by cut-offs creating thus the flood plain main channel stretching parallelly to Danube from Dunakiliti to the confluence of the Asvany branch system.

The water supply to the branch system presently comes from the outlet structure at Cunovo reservoir (22 m^3/s) and the right side seepage canal (3 m^3/s). This water is divided between the Mosoni Danube (10 m^3/s), a water supplying canal for protected area (5 m^3/s) and the flood plain main channel (10 m^3/s). This is illustrated in Fig 2.8. The water supply system to the Hungarian flood plain was put into operation in August 1993.

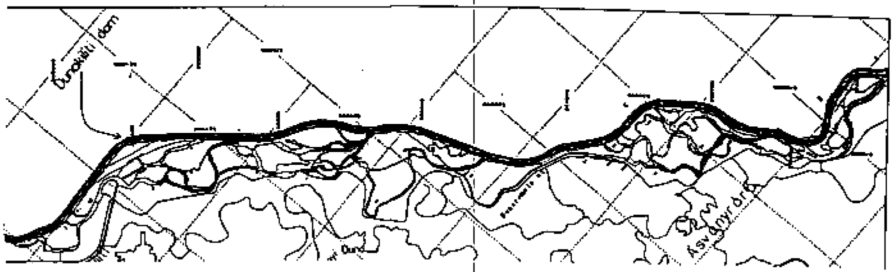

Fig. 2.7   Branch system on the Hungarian flood plain.

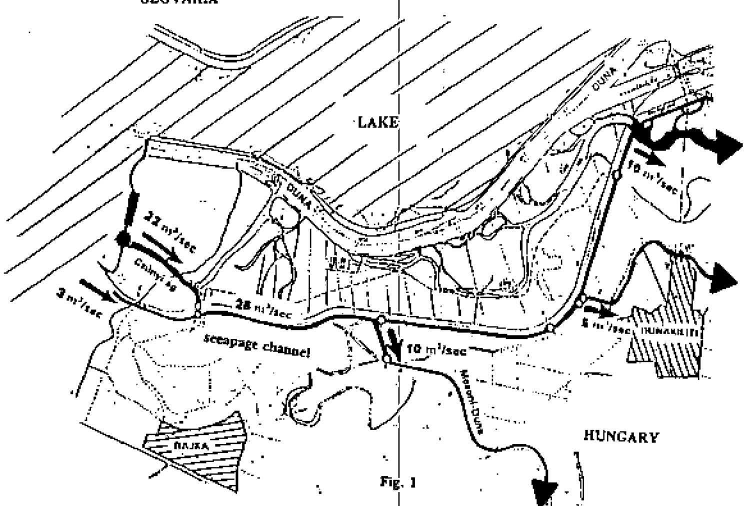

Fig. 2.8   Water supply system for the Hungarian flood plain.

The velocities vary very much in the area due to very large variations in cross-sectional area. The few existing point measurements indicate a velocity range from 0.02 m/s up to more than 1 m/s. However, calculations of cross-sectional average velocities for at three cross-sections in the flood plain main channel show velocities between 0.05 m/s and 0.09 m/s. Unlike on the Slovak side the velocities have not been high enough to remove the fine bed material so much that a significant infiltration to the ground water system has been initiated.

The capacities of the channel/canal system (see Fig. 2.8) are as follows:

* The seepage canal before the confluence with the outlet canal: 5 m^3/s.
* The outlet canal from the structure at Cunovo reservoir: 25 m^3/s.
* The canal betw... the confluence of the seepage canal and the outlet canal and the start of Mosoni Danube: 50 m^3/s.
* The canal between the start of the Mosoni Danube and the start of the flood plain main channel: 25 m^3/s.
* The flood plain main channel: 50 m^3/s.

In the original plans for the Gabcikovo-Nagymaros project the water supply to some part of the right side branches was suggested to be taken care of by pumping around Asvanyraro. In 1993 the Lipot morotva had the worst situation of water quantity and quality at the outside of the dikes, and therefore some water was pumped from Danube to a canal of oxbow lake. An operation of 18 hours per day (a single pumping engine) provided 0.5 - 0.7 m^3/s for 90 ... This resulted in a water level of 0.6 - 0.9 m. The cost of this operation was 0.04 mill ECU. Based on this experience the Nature Conservancy plans to extend this system to other protected areas too.

3. FORMULATION OF SCENARIOS

In this chapter five different scenarios for TWMR are briefly outlined. The scenarios are based on different characteristics with regard to discharges and water level regimesets as well as to remedial measures. It is emphasized that the members of the Working Group not necessarily agree to these characteristics. However the Working Group agrees to the subsequent descriptions of technical possibilities, environmental impacts etc. For each scenario the following aspects are described in details in the subsequent chapters 4-8:

* Characteristics of the scenario
* Technical and water management aspects
* Possible time schedule for implementation
* Impacts on discharges, water levels and flow velocities
* Impacts on erosion/sedimentation
* Impacts on surface water quality
* Impacts on ground water regime
* Impacts on ground water quality
* Impacts on flora and fauna
* Impacts on agriculture and forestry
* Impacts on electricity production
* Cost estimate for remedial measures

Unless specified otherwise, the impacts are described in comparison to the pre-dam conditions. Similarly the discharges and the technical remedial measures are, unless specified otherwise, described in relation to the November 1993 situation (Scenario 0). A summary of the quantitative impacts for the five scenarios is provided in tabular form in Appendix C.

3.1 Outline of the five Scenarios

Scenario 0: November 1993 Situation

The present situation is characterized by:

* In average 400 m^3/s into the Old Danube consisting of a base discharge of 250 - 300 m^3/s supplemented with more discharge during some flood events.

* 30-50 m^3/s into the side channels on the left side flood plain.

* 10 m^3/s into the side channels on the right side flood plain.

Scenario 1: Increased water supply to the Hungarian Side Branches

This situation can be characterized by the following discharge condition:

* In average 400 m^3/s into the Old Danube consisting of a base discharge of 250 - 300 m^3/s supplemented with more discharge during some flood events.

* 30-140 m^3/s into the side channels on the left side flood plain with an average value of 50 m^3/s.

* 30 - 70 m^3/s into the side channels on the right side flood plain with an average value of 50 m^3/s.

* 1-3 floods of more than 3500 m^3/s per year into the Old Danube (if hydrologically possible).

Scenario 2: Increased Discharge in Main River and in Hungarian Side Branches

This scenario can be characterized by the following discharge regime:

* Increase of discharge into the Old Danube to in average 600 m^3/s immediately and to somewhere between 600 m^3/s and 940 m^3/s after May 1994 with an average value of 800 m^3/s.

* 30-140 m^3/s into the side channels on the left side flood plain with an average value of 50 m^3/s.

* 30 - 70 m^3/s into the side channels on the right side flood plain with an average value of 50 m^3/s.

* 1-3 floods of more than 3500 m^3/s per year into the Old Danube (if hydrologically possible).

Scenario 3: Construction of some Underwater Weirs

This scenario consists in construction of some underwater weirs for increasing the water level in the Old Danube and for enabling interconnection between the main river and the branch system. The impacts of the underwater weirs on key parameters are demonstrated for different discharges ranging from 200 m^3/s to 2000 m^3/s. Construction of underwater weirs is possible along with any discharge regime. In Scenario 3 the impacts of constructing eight underwater weirs are elaborated in details for the discharge regime corresponding to Scenario 2.

Scenario 4: Full Capacity of Variant C Structures used for Water Supply of the Main River and the Branches.

In this scenario as much water as technically possible will be diverted into the Old Danube and the side channels. This scenario will have two different discharge regimes according to the status of the Variant C structures:

* Phase 1 structures.
* Phase 2 structures after 1996.

Scenario elaborated by the Slovak Expert:

In addition to the above five scenarios the Slovakian expert has prepared a separate scenario, which is included as Appendix D.

3.2 Approach in Assessment of Environmental Impacts

The assessment of environmental impacts follows the same procedure as already used in previous reports from the Working Group (ref /1,2/). The approach for the assessments of environmental impacts will be to separately consider the following impacts in respect of the:

(a) Reservoir.

(b) Navigation canal.

(c) Main river (Old Danube).

(d) Inundation area with the side branches on the left side (Slovakia).

(e) Inundation area with the side branches on the right side (Hungary).

(f) The connections in the total system.

3.3 Environmental Impacts common to all five Scenarios

Certain impacts caused by the new reservoir are identical for all five scenarios. Hence, they will not be described repeatedly for the individual scenarios in Chapters 4-7. These impacts are, as already described in ref /2/, the following:

* The discharges in the Little Danube and the Mosoni Danube have been increased by 10-20 m^3/s. This implies approximately a doubling of the discharge in the Little Danube. With regard to the Mosoni Danube, this means that it now carries discharge permanently.

* The surface water levels at Bratislava have during low flow periods been increased by 1-2 m as compared to pre-dam conditions, ie to a level corresponding to the situation 40 years ago. The amplitude of the water level fluctuations has been reduced.

* Sedimentation of the total bed load and a certain part of the suspended load will take place in the reservoir.

* The ground water levels in areas close to the reservoir have increased by up to 2½ m. This has occurred in the areas, which were most negatively affected by the long term trend of decreasing ground water levels of up to 2 m during the past 40 years. The fluctuations of the ground water levels have been reduced.

* Upstream the dam the river changed to an impounded lake for a length of 10 km with significantly smaller flow velocities. This causes a loss of many habitats for rheophile organisms.

* About 4,500 ha of floodplain forest on Slovakian and Hungarian territory have been removed under the construction phase. 570 ha of forest in Slovakia is now under afforestation.

* Fish migration along the Danube river is interrupted by the Variant C structures. At present only limited fish passage is possible through the spillway of the bypass weir.

In addition, the international navigation has been removed from the Old Danube to the navigation canal.

Furthermore, the Variant C structures have impacts on the flood management. As described in ref /1/ the discharge capacity of the power canal is required in all cases in order to have sufficient capacity to pass large floods.

3.4 Assumptions

In assessments of the impacts some assumptions have been made. They are described together with their justifications as follows:

Main river

(a) A discharge of 3500 m^3/s twice per year will be enough to clean the river bed sufficiently for fine material deposited during low discharge conditions and to spread this material in the whole inundation area.

3500 m^3/s is more than recorded maximum annual flows for some years. Hence, two such floods per year will not be possible every year. Realistically, two such floods per year routed through the Old Danube may be possible in average every second year, while at least one such flood per year may be possible in average four years out of five.

At 3500 m^3/s the flow velocities will be around 2 m/s in pre-dam conditions, see Section 3.2. Such flow velocities during a couple of days is more than sufficient to erode fine material from the river bed.

(b) To provide sufficient living conditions for typical fish species living in the Danube under pre-dam conditions a pattern of different flow velocities in the river bed is necessary. Flow velocities near the river bottom of at least 0.6 m/s must occur at several places all over the year.

Different fish species have different requirements to flow velocities. The species with low flow velocities will still be able to find such conditions, whereas the species requiring the largest flow velocities may have problems if the discharge and hence the flow velocities are too low. Therefore, the requirements of the fish species requiring the highest flow velocities are important. According to a study in the Austrian part of the Danube (ref /7/) flow velocities of 0.5 - 0.7 m/s are required for the fish species (*Zingel streber*) requiring highest flow velocities. This fish species is according to the Slovakian Data Report (ref /8/) also the fish species in this area, which require the highest flow velocity.

Streber should be seen as an indicator for species having requirements for large flow velocities.

It is noticed that the above required flow velocity refer to velocities 7 cm above the river bottom (ref /7/), where the fishes live. As described in Section 2.2 a multiplication factor of 0.65 can be applied to convert cross-sectional average velocities to specific point values 7 cm above the bottom. Thus in order to get 0.6 m/s for the fish *a cross-sectional average velocity of about 0.9 m/s* is required.

Inundation areas

(c) A variation of the water level within 2 m will be enough to ensure the dynamic character including the floodings according to the pattern in pre-dam conditions.

According to ref /1/ the difference in water level at Dunaremete for the following two flow conditions: "Flow in main channel and permanent branches (several times per year)" and "Complete inundation of flood plain (once per year)" is 1.9 m. Hence, a 2 m variation will be sufficient to ensure the dynamic conditions characterizing the pre-dam conditions.

(d) *If the river bed at some of the main side branches is free from mud the water can infiltrate sufficiently and the conditions for the biocenosis will be sufficient.*

According to the experience from supplying discharge to the Slovakian branches after May 1993, 70 m^3/s corresponding to a typical flow velocity in the main side channels of 0.1-0.3 m/s (cross-sectional average values) was apparently sufficient to clean the river bottom from mud at so many places that a very significant infiltration to the ground water system started (ref /2/). Correspondingly, such condition will be sufficient for the biocenosis.

(e) *To remove the mud from the bottom of the branches a flow velocity of 0.2 - 0.4 m/s is required.*

In the literature on sedimentation/erosion of cohesive sediments uncertainty exists on critical flow velocities. According to some references (Ref /9,10,11/) a flow velocity of 0.2 m/s will normally be sufficient to initiate erosion/resuspension of fine cohesive sediments like e.g. mud. According to other references (Ref /12,13,14/) flow velocities of at least 0.3 m/s are required for this purpose. This will in general depend on local conditions.

Field data from the Slovakian inundation area in 1993 show that a substantial part of the bottom of the Slovakian river branches were eroded under average cross-sectional flow velocities not much higher than 0.2 m/s.

(f) *To keep the bottom of the branches free from mud requires a minimum flow velocity of 0.1 - 0.3 m/s.*

According to some literature on sedimentation/erosion of cohesive sediments a flow velocity of 0.1 m/s will normally be sufficient to prevent sedimentation of fine cohesive sediments like e.g. mud. (Ref /9,10,11/). According to other literature sources (Ref /12,13,14/) flow velocities of at least 0.2 - 0.4 m/s will be required for this purpose.

Total system

(g) *To ensure ecological conditions which are as good as pre-dam conditions migration of wetland species between the main river and the side branches should be possible all over the year in both directions.*

Migration can be made possible either through fish passes or through direct flows between the main river and the side branches during some periods. Fish passes enable fish to migrate to some extent, while direct flow connections enable migration of all wetland species.

4. ELABORATION OF SCENARIO 0

Scenario 0 is a continuation of the present situation existing in November 1993 (ref /2/).

In addition to the impacts described in this chapter reference is made to Section 3.3, where environmental impacts common to all five scenarios are described.

4.1 Characterization of the Scenario

This scenario is characterized by the following discharge regime:

* In average 400 m^3/s into the Old Danube consisting of a base discharge of 250 - 300 m^3/s supplemented with more discharge during some flood events.

* 30-50 m^3/s into the side channels on the left side flood plain.

* 10 m^3/s into the side channels on the right side flood plain.

No remedial measures additional to the already existing will be implemented.

4.2 Technical and Water Management Aspects

Technically, this scenario is possible with the existing structures. It is assumed that the water management continues as experienced during the past months. This will result in the discharge pattern given in Table 4.1.

Table 4.1 Annual average discharge values in Scenario 0.

	Average annual discharge (m^3/s)
Danube, Bratislava	2.025
Inflow to Little Danube, Bratislava	30
Inflow to Mosoni Danube, Cunovo	25
Seepage canal, right side	2
Seepage canal, left side	5
Seepage from reservoir to Danube	20
Seepage to ground water	30
Intake to Slovakian river branches, Dobrohost	40
Bypass weir plus inundation weir, Cunovo	380
Ship locks, Gabcikovo	25
Turbines, Gabcikovo	1.468

4.3 Possible Time Schedule for Implementation

This scenario has already been in operation for several months by now.

4.4 Impacts on Discharges, Water Levels and Flow Velocities

The impacts on discharges and water levels, as already measured are described in ref /2/, and shown in Table 4.1. They can be characterized as follows:

* The discharges in the Old Danube will in average be about 20% as compared to pre-dam condition.

* The water levels in the upstream part of the Old Danube will be reduced by 2-4 m as compared to pre-dam conditions.

* The characteristic dynamics of water level and discharge fluctuations in the Old Danube will continue to be significantly reduced as compared to pre-dam conditions.

* The difference in water levels between the main river and the side branches will generally be so large that water flows from the main river to the side branches will only be possible under the flooding conditions expected to occur 1-2 times per year.

The split of the discharges can in a year with average discharge be described by the figures given in Table 4.1

The flow velocities have been estimated to be as described in Table 4.2. From the table it appears that the cross-sectional velocities at minimum discharge in the main river are 0.6 - 0.8 m/s corresponding to velocities near the bottom of 0.4 - 0.5 m/s.

4.5 Impacts on Erosion/Sedimentation

The impacts on erosion and sedimentation as already measured are described in ref /2/. Due to lack of specific measurements there is some uncertainty with regard to the development over the coming years. The best estimate is as follows:

* No major net erosion and sedimentation in the Old Danube. During some events sedimentation of fine material will take place. This fine material may be washed away during flood events.

* The river bed in the main branches on the Slovakian side will continue to be free from mud, so that good infiltration conditions exist.

* The river bed in the main branches on the Hungarian side will continue to be clogged with fine material/mud and prevent significant infiltration to the ground water system.

Table 4.2 Estimated discharge and flow velocity values in the main river and in the side branches under Scenario 0.

Location	Discharge characteristic	Discharge (m^3/s)	Cross-sectional average velocity (m/s)
Main river, Rajka	Minimum	200	0.60
	Average	400	0.88
	Typical annual maximum	3500	2.04
Main river, Dunaremete	Minimum	200	0.77
	Average	400	1.12
	Typical annual maximum	3500	2.00
Left side branch, main channel	Typical minimum	0	0
	Typical average	40	0.05 - 0.25
	Typical annual maximum	70	0.07 - 0.35
Right side branch, main channel	Typical minimum	0	0
	Typical average	10	0.05 - 0.09
	Typical annual maximum	15	0.06 - 0.10
Connection between main river and side branches	Flow from inundation area into main river	365 days/year	
	Flow from main river into a few river arms	5-10 days/year	
	Flow from main river into almost all river arms	< 5-10 days/year	

4.6 Impacts on Surface Water Quality

The impacts on the surface water quality are expected to be insignificant.

4.7 Impacts on Ground Water Regime

The impacts on ground water levels as already measured are described in ref /2/. This pattern is expected not to change, ie:

* Ground water levels on the Slovakian territory will be higher or equal to the pre-dam conditions.

* Ground water levels on the Hungarian territory will, as compared to pre-dam conditions, be higher close to

the reservoir (Rajka - Dunakiliti region), whereas the levels will be lower in the middle part of Szigetköz between Dunakiliti and Asvanyraro in areas up to a few km from the Old Danube.

* The ground water level fluctuations have decreased significantly as compared to pre-dam conditions. This could be influenced by implementation of improved operational rules for day-to-day water management.

4.8 Impacts on Ground Water Quality

The impacts on the ground water quality are in general expected to be insignificant. However, local changes are expected in areas close to the reservoir in certain parameters, such as total dissolved solids, nitrate, etc due to changes in flow pattern. These changes are not expected to lead to a worsening in the ground water quality.

4.9 Impacts on Flora and Fauna

The impacts on flora and fauna as already observed are described in ref /2/. However, if the present situation continues for some years an increased effect will result with regard to changes in alluvial ecosystems as follows:

* On the Hungarian inundation area (side branches plus forests) the decrease of the water level fluctuations makes the site conditions worse for floodplain biocenoses.

* On the Hungarian inundation area the reduction of deposition of fine material (nutrients!) by floods in the alluvial forests makes their growing conditions worse.

* On the Slovakian inundation area the decrease of water level changes due to flooding from the main river can be compensated for management of discharge intake from the navigation canal at Dobrohost. The net effect of this combination is not yet proven in pratise.

* On the Slovakian inundation area the reduction of deposition of fine material (nutrients!) by floods will be counteracted by deposition of smaller concentrations originating from artificial flooding by discharge from the navigation canal. The net effect of this combination is not yet certain.

* Reduction of discharges in the Old Danube leads to reduction of the water body, the flow velocity and to sedimentation of fine material. This will cause the loss of species typical for streams, of rheophile

organisms, especially of fish species spawning on gravel ground.

* The flow velocities in the main river are not large enough to provide adequate living conditions for the species requiring higher flow velocity, for example fish species like Streber (0.6 m/s 7 cm above ground).

4.10 Impacts on Agriculture and Forestry

The impacts on agriculture and forestry as already observed are described in ref /2/, ie:

* Due to the increase of ground water tables on the Slovak territory an increase in the capillary water supply for the Slovakian agricultural areas has taken place. In Hungary, the impacts on agriculture are positive in areas with increase in ground water level and negative in areas with decrease in ground water level, see Section 4.7.

* As a result of the changes in ground water level the forestry is mainly positively effected in Slovakia and mainly negatively in Hungary.

As the ground water levels are not expected to change further, these impacts are not expected to be changed.

4.11 Impacts on Electricity Production

In a year with average discharges as outlined in Table 4.1 the electricity production can be estimated to about 2,000 GWh/year.

4.12 Cost Estimate for Remedial Measures

The remedial measures already implemented are the works on the Slovakian and Hungarian flood plains. The costs of these are approximately (excluding the intake structures at the power canal at Dobrohost and the outlet structure for Mosoni Danube at Cunovo):

* Slovakian flood plain: 12.0 mill ECU.

* Hungarian flood plain: 2.0 mill ECU.

5. ELABORATION OF SCENARIO 1

Scenario 1 has the same discharge regime in the Old Danube as presently existing but has improved water supply to the inundation area on the Hungarian side.

In addition to the impacts described in this chapter reference is made to Section 3.3, where environmental impacts common to all five scenarios are described.

5.1 Characterization of the Scenario

This scenario is characterized by the following discharge regime:

* In average 400 m^3/s into the Old Danube consisting of a base discharge of 250 - 300 m^3/s supplemented with more discharge during some flood events.
* 30-140 m^3/s into the side channels on the left side flood plain with an average value of 50 m^3/s.
* 30-70 m^3/s into the side channels on the right side flood plain with an average value of 50 m^3/s.
* 1-3 floods of more than 3500 m^3/s per year into the Old Danube (to the extent hydrologically possible).

Remedial measures (structures) will be implemented for the following purposes:

* Obtaining increased water supply into the side channels on the right side.
* Ensuring some migration of wetland species between the main river and the side branches.

All the remedial measures are technically reversible.

In addition improved operation rules for the day-to-day operation of the water management within the above given discharges will be implemented in order to obtain as good environmental conditions as possible.

5.2 Technical and Water Management Aspects

5.2.1 Additional remedial measures

The following technical measures are considered under this scenario:

Inundation area on the left side

* Construction of 7 fish passes connecting the main Danube to the side branches.
* Construction of fish passes within the inundation area.

These fish passes can be constructed in three months and is estimated to cost 0.54 mill ECU.

Inundation area on the right side

In order to achieve sufficient flow velocities in the channels on the Hungarian side it is estimated that the present 10 m^3/s have to be increased to the same level as the one presently existing on the Slovakian side, i.e. up to 70 m^3/s with average values in the order of 50 m^3/s. Such discharges will most likely result in sufficiently high flow velocities to ensure removal of mud from a substantial part of the river bottom.

The supply of these up to 70 m^3/s can be achieved by four technically alternative solutions:

(a) Construction of a supply canal from the inundation weir to the first side branch. This work can be completed within three months and is estimated to cost 2.4 mill ECU. In addition, the reconstruction work on the spillway of the bypass weir is neccecary and is expected to be completed in May 1994.

(b) Construction of an underwater weir between RKM 1843 and 1847. Previously such a project has already been designed. Implementation of a new project, including fullfilment of all legal procedures, is expected to be possible within a year and to cost 1.5 mill ECU.

(c) Using the supply canal and additional construction of syphons between the reservoir and the first side branch. The syphons, which need to have a total capacity of about 50 m^3/s, have to cross the river. Taking into account a length of 450 m and a 7 m difference in level, a water pipe of 1 m diameter enables transmission of 0.6 m^3/s. Hence about 80 syphons are required for transmitting 50 m^3/s. The best technical way of crossing the Danube is put the pipes in a trench below the river bottom. The cost of the syphon system is estimated to be in the order of 5 mill ECU.

(d) Increase of the capacity of the supply canal from 25 m^3/s to 70 m^3/s. This can be implemented within six months and is estimated to cost 5 mill ECU.

From a technical and economical point of view, the simplest alternative is the underwater weir (b). This solutions also provides the best water management possibilities and the minimum risk of damage during floods. From an implementation point of view alternatives (a) and (d) can with more certainty be implemented within six months.

In addition to the water supply fish passes between the main Danube and the side branches should be constructed. These works have not been designed but can according to designs on the Slovakian side be estimated to cost 0.5 mill ECU.

5.2.2 Water management regime

The water management regime will be characterized by the average annual discharge values shown in Table 5.1.

Table 5.1 Annual average discharge values in Scenario 1.

	Average annual discharge (m^3/s)
Danube, Bratislava	2.025
Inflow to Little Danube, Bratislava	30
Inflow to Mosoni Danube, Cunovo	25
Seepage canal, right side	2
Seepage canal, left side	5
Seepage from reservoir to Danube	20
Seepage to ground water	30
Intake to Slovakian river branches, Dobrohost	40
Intake to Hungarian river branches, Danube	50
Bypass weir plus inundation weir, Cunovo	380
Ship locks, Gabcikovo	25
Turbines, Gabcikovo	1.418

5.3 Possible Time Schedule for Implementation

This scenario can be implemented by May 1994, provided that fulfilment of possibly neccessary legal procedures does not take more than three months.

5.4 Impacts on Discharges, Water Levels and Flow Velocities

The impacts on discharges and water levels, as already measured are described in ref /2/, and shown in Table 5.1. They can be characterized as follows:

* The discharges in the Old Danube will in average be about 20% as compared to pre-dam condition.

* The water levels in the upstream part of the Old Danube will be reduced by 2-4 m as compared to pre-

dam conditions.

* The characteristic dynamics of water level and discharge fluctuations in the Old Danube will continue to be significantly reduced as compared to pre-dam conditions. This could be influenced by implementation of improved operational rules for day-to-day water management.

* Water level variations on the Slovakian inundation area will vary by 1.8 m at a difference in water supply from the intake canal at Dobrohost from 0 to 140 m^3/s.

* The difference in water levels between the main river and the side branches will generally be so large that water flows from the main river to the side branches will only be possible under the flooding conditions expected to occur 1-2 times per year.

The split of the discharges can in a year with average discharge be described by the figures given in Table 5.1

The flow velocities have been estimated to be as described in Table 5.2. From the table it appears that the cross-sectional velocities at minimum discharge in the main river are 0.6 - 0.8 m/s corresponding to velocities near the bottom of 0.4 - 0.5 m/s.

5.5 Impacts on Erosion/Sedimentation

The impacts on erosion and sedimentation as already measured are described in ref /2/. Due to lack of specific measurements there is some uncertainty with regard to the development over the coming years. The best estimate is as follows:

* No major net erosion and sedimentation in the Old Danube. During some events sedimentation of fine material will take place. This fine material may be washed away during flood events.

* The river bed in the main branches on the Slovakian side will continue to be sufficiently free from mud, so that good infiltration conditions exist.

* The river bed in the main branches on the Hungarian side will become sufficiently free from mud, so that good infiltration conditions will exist.

5.6 Impacts on Surface Water Quality

The impacts on the surface water quality are expected to be insignificant.

Table 5.2 Estimated discharge and flow velocity values in the main river and in the side branches under Scenario 1.

Location	Discharge characteristic	Discharge (m^3/s)	Cross-sectional average velocity (m/s)
Main river, Rajka	Minimum	200	0.60
	Average	400	0.88
	Typical annual maximum	3500	2.04
Main river, Dunaremete	Minimum	200	0.77
	Average	400	1.12
	Typical annual maximum	3500	2.00
Left side branch, main channel	Typical minimum	0	0
	Typical average	40	0.05 - 0.25
	Typical annual maximum	70	0.07 - 0.35
Right side branch, main channel	Typical minimum	0	0
	Typical average	10	0.05 - 0.09
	Typical annual maximum	15	0.06 - 0.10
Connection between main river and side branches	Flow from inundation area into main river	365 days/year	
	Flow from main river into a few river arms	5-10 days/year	
	Flow from main river into almost all river arms	< 5-10 days/year	

5.7 Impacts on Ground Water Regime

The estimated impacts on the ground water regime are:

* Ground water levels on the Slovakian territory will be higher than or equal to the pre-dam conditions.

* Ground water levels on the Hungarian territory are expected to be not lower than in the pre-dam conditions.

* Reestablishing the dynamics of ground water level fluctuations will to large extent be possible downstream the reservoir.

5.8 Impacts on Ground Water Quality

The impacts on the ground water quality are in general expected to be insignificant. However, some local changes are expected in areas close to the reservoir in certain parameters, such as total dissolved solids, nitrate, etc due to changes in flow pattern. These changes are not expected to lead to a worsening in the ground water quality.

5.9 Impacts on Flora and Fauna

The impacts on flora and fauna as already observed are described in ref /2/. However, if the present situation continues for some years an increased effect will result with regard to changes in alluvial ecosystems as follows:

* On the Hungarian inundation area the reduction of deposition of fine material (nutrients!) by floods in the alluvial forests makes their growing conditions worse.

* On the Slovakian inundation area the decrease of water level changes due to flooding from the main river can be compensated for management of discharge intake from the navigation canal at Dobrohost. The net effect of this combination is not yet proven in pratise.

* On the Slovakian inundation area the reduction of deposition of fine material (nutrients!) by floods will be counteracted by deposition of smaller concentrations originating from artificial flooding by discharge from the navigation canal. The net effect of this combination is not yet certain.

* Reduction of discharges in the Old Danube leads to reduction of the water body, the flow velocity and to sedimentation of fine material. This will cause the loss of species typical for streams, of rheophile organisms, especially of fish species spawning on gravel ground.

* The flow velocities in the main river are not large enough to provide adequate living conditions for the species requiring the higher flow velocity, for example fish species like Streber (0.6 m/s 7 cm above ground).

5.10 Impacts on Agriculture and Forestry

Due to the increase of ground water tables on both the Slovakian and Hungarian territory an increase in the capillary water supply for as well agricultural as forestry areas can be expected.

5.11 Impacts on Electricity Production

In a year with average discharges as outlined in Table 5.1 the electricity production can be estimated to about 1,930 GWh/year.

5.12 Cost Estimate for Remedial Measures

The remedial measures already implemented in addition to Scenario 0 are estimated to cost as follows:

* Fish passes on the Hungarian flood plain: 0.54 mill ECU

* Water supply plus fish passes on the Hungarian flood plain: 2.0 mill ECU.

6. ELABORATION OF SCENARIO 2

Scenario 2 represents an increase in discharge in the Old Danube and in the Hungarian side branches as compared to Scenario 0.

In addition to the impacts described in this chapter reference is made to Section 3.3, where environmental impacts common to all five scenarios are described.

6.1 Characterization of the Scenario

This scenario is characterized by the following discharge regime:

* Increase of discharge into the Old Danube to in average 600 m^3/s immediately and to somewhere between 600 m^3/s and 940 m^3/s after May 1994 with an average value of 800 m^3/s.

* 30-140 m^3/s into the side channels on the left side flood plain with an average value of 50 m^3/s.

* 30-70 m^3/s into the side channels on the right side flood plain with an average value of 50 m^3/s.

* 1-3 floods of more than 3500 m^3/s per year into the Old Danube (to the extent hydrologically possible).

Remedial measures (structures) will be implemented for the following purposes:

* Obtaining increased discharge to the Old Danube.

* Obtaining increased water supply into the side channels on the right side.

* Ensuring some migration of wetland species between the main river and the side branches.

All the remedial measures are technically reversible.

In addition improved operation rules for the day-to-day operation of the water management within the above given discharges will be implemented in order to obtain as good environmental conditions as possible.

6.2 Technical and Water Management Aspects

6.2.1 Additional remedial measures

The following technical measures are considered under this scenario:

Main River

* Improvement of the daily discharge capacity of the Variant C structures from the present 600 m^3/s to 940 m^3/s and 6240 m^3/s according to Subsection 2.1.3.

The time schedule and cost estimates are as follows:

* Discharge capacity: 940 m^3/s is possible from May 1994 and 6240 m^3/s is possible from summer 1996. The reconstruction of the spillway for the inundation weir enabling 340 m^3/s as a daily discharge can be implemented by May 1994 and is expected to cost 1 mill ECU/year in maintenance.

Inundation area on the left side

* Construction of 7 fish passes connecting the main Danube to the side branches.
* Construction of fish passes within the inundation area.

These fish passes can be constructed within three months and is estimated to cost 0.54 mill ECU.

Inundation area on the right side

In order to achieve sufficient flow velocities in the channels on the Hungarian side it is estimated that the present 10 m^3/s have to be increased to the same level as the one presently existing on the Slovakian side, i.e. up to 70 m^3/s with average values in the order of 50 m^3/s. Such discharges will most likely result in sufficiently high flow velocities to ensure removal of mud from a substantial part of the river bottom.

The supply of these up to 70 m^3/s can be achieved by five technically alternative solutions:

(a)-(d) See description in Subsection 5.2.1

(e) Dredging of a side branch at RKM 1845 - 1848. With discharges in the Old Danube of 800 m^3/s the water level will then be sufficiently high to enable diversion of 50 m^3/s to the right side branch system. This can be implemented in two months and is estimated to cost maximum 1 mill ECU.

From a technical and economical point of view, the simplest alternatives is the dredging (e).

In addition to the water supply fish passes between the main Danube and the side branches should be constructed. These works have not been designed but can according to designs on the Slovakia side be estimated to cost 0.5 mill ECU.

6.2.2 Water management regime

The water management regime will be characterized by the average annual discharge values shown in Table 6.1.

Table 6.1 Annual average discharge values in Scenario 2.

	Average annual discharge (m^3/s) Preliminary regime implemented now	Average annual discharge (m^3/s) Regime implemented May 1994
Danube, Bratislava	2.025	2.025
Inflow to Little Danube, Bratislava	30	30
Inflow to Mosoni Danube, Cunovo	25	25
Seepage canal, right side	2	2
Seepage canal, left side	5	5
Seepage from reservoir to Danube	20	20
Seepage to ground water	30	30
Intake to Slovakian river branches, Dobrohost	50	50
Intake to Hungarian river branches, Danube	40	40
Bypass weir plus inundation weir, Cunovo	580	780
Ship locks, Gabcikovo	25	25
Turbines, Gabcikovo	1.218	1.018

6.3 Possible Time Schedule for Implementation

The possible time schedule for implementation of the various elements are given in Section 6.2 above. In summary, it can be estimated that the scenario can be implemented in May 1994.

6.4 Impacts on Discharges, Water Levels and Flow Velocities

The split of the discharges can in a year with average discharge be described by the figures given in Table 6.1

The impacts on discharges and water levels, can be characterized as follows:

* The discharges in the Old Danube will in average be about 40% as compared to pre-dam condition.

* The water levels in the upstream part of the Old Danube will be reduced by 2 - 2.5 m as compared to pre-dam conditions.

* The characteristic dynamics of water level and discharge fluctuations in the Old Danube will be somewhat reduced as compared to pre-dam conditions.

* Water level variations on the Slovakian inundation area will vary by 1.8 m at a difference in water supply from the intake canal at Dobrohost from 0 to 140 m^3/s.

* The difference in water levels between the main river and the side branches will generally be so large that water flows from the main river to the side branches will only be possible under the flooding conditions expected to occur 1-2 times per year.

* The discharge through the downstream part of the reservoir will as compared to Scenario 0 be reduced from in average 1533 m^3/s to 1093 m^3/s resulting in a decrease in velocity of 29 % and an increase in retention time of 40 % respectively.

The flow velocities have been estimated to be as described in Table 6.2. From the table (and Table 2.5) it appears that the minimum flow velocities at minimum discharge are about 1 m/s corresponding to 0.6 -0.7 m/s as point velocity 7 cm above the river bottom (fish location). It is also noticed that the flow velocities on the Hungarian flood plain will be so large that erosion of the fine bed material can be expected.

6.5 Impacts on Erosion/Sedimentation

The development of the erosion and sedimentation over the coming years is somewhat uncertain due to shortage of specific measurements. The best estimate is as follows:

* No major net erosion and sedimentation in the Old Danube. During some events sedimentation of fine material will take place. This fine material will be washed away during flood events.

* Sedimentation in the downstream part of the reservoir of fine material will increase as compared to Scenario 0.

* The river bed in the main branches on the Slovakian side will continue to be sufficiently free from mud, so that good infiltration conditions exist.

* The river bed in the main branches on the Hungarian side will become sufficiently free from mud, so that good infiltration conditions will exist.

6.6 Impacts on Surface Water Quality

The impacts on the surface water quality are expected to be insignificant.

Table 6.2 Estimated discharge and flow velocity values in the main river and in the side branches under Scenario 2.

Location	Discharge characteristic	Discharge (m^3/s)	Cross-sectional average velocity (m/s)
Main river, Rajka	Minimum	400	0.88
	Average	800	1.23
	Typical annual maximum	3500	2.04
Main river, Dunaremete	Minimum	400	1.12
	Average	800	1.28
	Typical annual maximum	3500	2.00
Left side branch, main channel	Typical minimum	0	0
	Typical average	50	0.06 - 0.30
	Typical annual maximum	140	0.10 - 0.40
Right side branch, main channel	Typical minimum	0	0
	Typical average	50	0.06 - 0.30
	Typical annual maximum	70	0.07 - 0.35
Connection between main river and side branches	Flow from inundation area into main river		365 days/year
	Flow from main river into a few river arms		5-10 days/year
	Flow from main river into almost all river arms		< 5-10 days/year

6.7 Impacts on Ground Water Regime

The estimated impacts on the ground water regime are:

* Ground water levels on the Slovakian territory will be higher than or equal to the pre-dam conditions.

* Ground water levels on the Hungarian territory are expected to be not lower than in the pre-dam conditions.

* Reestablishing the dynamics of ground water level fluctuations will to large extent be possible downstream the reservoir.

6.8 Impacts on Ground Water Quality

The impacts on the ground water quality are in general expected to be insignificant. However, there is a risk that fine material may sediment at the downstream part of the reservoir and cause problems to ground water quality infiltrating from here.

6.9 Impacts on Flora and Fauna

Nature conservation values can by this scenario be preserved to a larger extent than under Scenario 1. However, if the scenario continues for some years an increased effect will result with regard to changes in alluvial ecosystems as follows:

* On the Hungarian inundation area the reduction of deposition of fine material (nutrients!) by floods in the alluvial forests makes their growing conditions worse.

* On the Slovakian inundation area the decrease of water level changes due to flooding from the main river can be compensated for management of discharge intake from the navigation canal at Dobrohost. The net effect of this combination is not yet proven in pratise.

* On the Slovakian inundation area the reduction of deposition of fine material (nutrients!) by floods will be counteracted by deposition of smaller concentrations originating from artificial flooding by discharge from the navigation canal. The net effect of this combination is not yet certain.

* Reduction of discharges in the Old Danube leads to reduction of the water body, the flow velocity and to sedimentation of fine material. This will cause the loss of species typical for streams, of rheophile organisms.

* The flow velocities in the main river could from May 1994 onwards in the major part of the Old Danube and of the year be large enough to provide adequate living conditions for the species requiring the higher flow velocity, for example fish species like Streber (0.6 m/s 7 cm above ground).

6.10 Impacts on Agriculture and Forestry

Due to the increase of ground water tables on both the Slovakian and Hungarian territory an increase in the capillary water supply for as well agricultural as forestry areas can be expected.

6.11 Impacts on Electricity Production

In a year with average discharge through the turbines of 1018 m^3/s as outlined in Table 6.1 the electricity production can be estimated to be about 1390 GWh.

6.12 Cost Estimate for Remedial Measures

The remedial measures to be implemented in addition to the ones in Scenario 0 and Scenario 1 is the reconstruction of the spillway for the inundation weir, which is estimated to cost 1 mill ECU/year in maintenance. Thus the total costs in addition to the ones already implemented in Scenario 0 are estimated as follows:

* Slovakian side: 0.54 mill ECU + 1 mill ECU/year.

* Hungarian side: 2.0 mill ECU.

7. ELABORATION OF SCENARIO 3

Scenario 3 as described below is basically identical to Scenario 2 except for construction of a number of underwater weirs. Hence, the discharge regime and many of the impacts are identical to those of Scenario 2.

In addition to the impacts described in this chapter reference is made to Section 3.3, where environmental impacts common to all five scenarios are described.

7.1 Characterization of the Scenario

This scenario consists in construction of some underwater weirs for increasing the water level in the Old Danube and for enabling interconnection between the main river and the branch system. Construction of underwater weirs is possible along with any discharge régime. The impact of the underwater weirs on key parameters are demonstrated for different discharges ranging from 200 m^3/s to 2000 m^3/s.

In Scenario 3 the impacts of constructing eight underwater weirs are elaborated in details for the discharge regime and the remedial measures corresponding to Scenario 2.

All the remedial measures are technically reversible.

In addition improved operation rules for the day-to-day operation of the water management within the above given discharges will be implemented in order to obtain as good environmental conditions as possible.

7.2 Technical and Water Management Aspects

7.2.1 Design of underwater weirs

Underwater weirs are technically visible and it is possible to remove them with heavy equipment. The effort required for removing underwater weirs is estimated to be the same or less as for the construction both with respect to time and costs. Hence, they can be considered as reversible technical measures.

As an example a specific design with 8 underwater weirs of about 4 m height is shown in Fig 7.1 and Table 7.1.

It should be emphasized that no attempt has been made in the Working Group to identify the optimal design for the specific discharges considered in this scenario. For instance the present design example may not be sufficient for local navigation. The particular design and the calculations made in the following aim at illustrating the effects of inundation weirs.

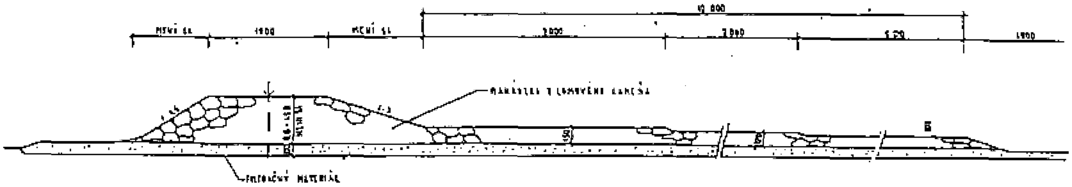

Fig. 7.1 Example of design of underwater weir constructed of large stones

The impacts of this particular design of underwater weirs on water levels and flow velocities have been assessed by calculations with the MIKE 11 mathematical model. The water level and velocity profiles for a discharge of 600 m^3/s is shown in Figs. 7.2a+b for the situation with underwater weirs. The velocity profile in Fig. 7.2a can be compared to the corresponding profile without underwater weirs shown in Fig. 2.5. Fig. 7.2b also shows the water level for the same discharge without under water weirs.

Table 7.1 Design parameters for a system of eight underwater weirs.

Location (RKM)	Crest (m.asl)	Bottom (m..asl)	Height (m)
1814.21	111.85	106.00	5.85
1818.60	113.10	110.00	3.10
1821.30	114.35	110.55	3.80
1824.43	115.50	110.55	4.95
1828.35	116.75	112.70	4.05
1831.70	117.65	113.70	3.95
1834.90	118.85	114.70	4.15
1843.00	121.25	117.20	4.05

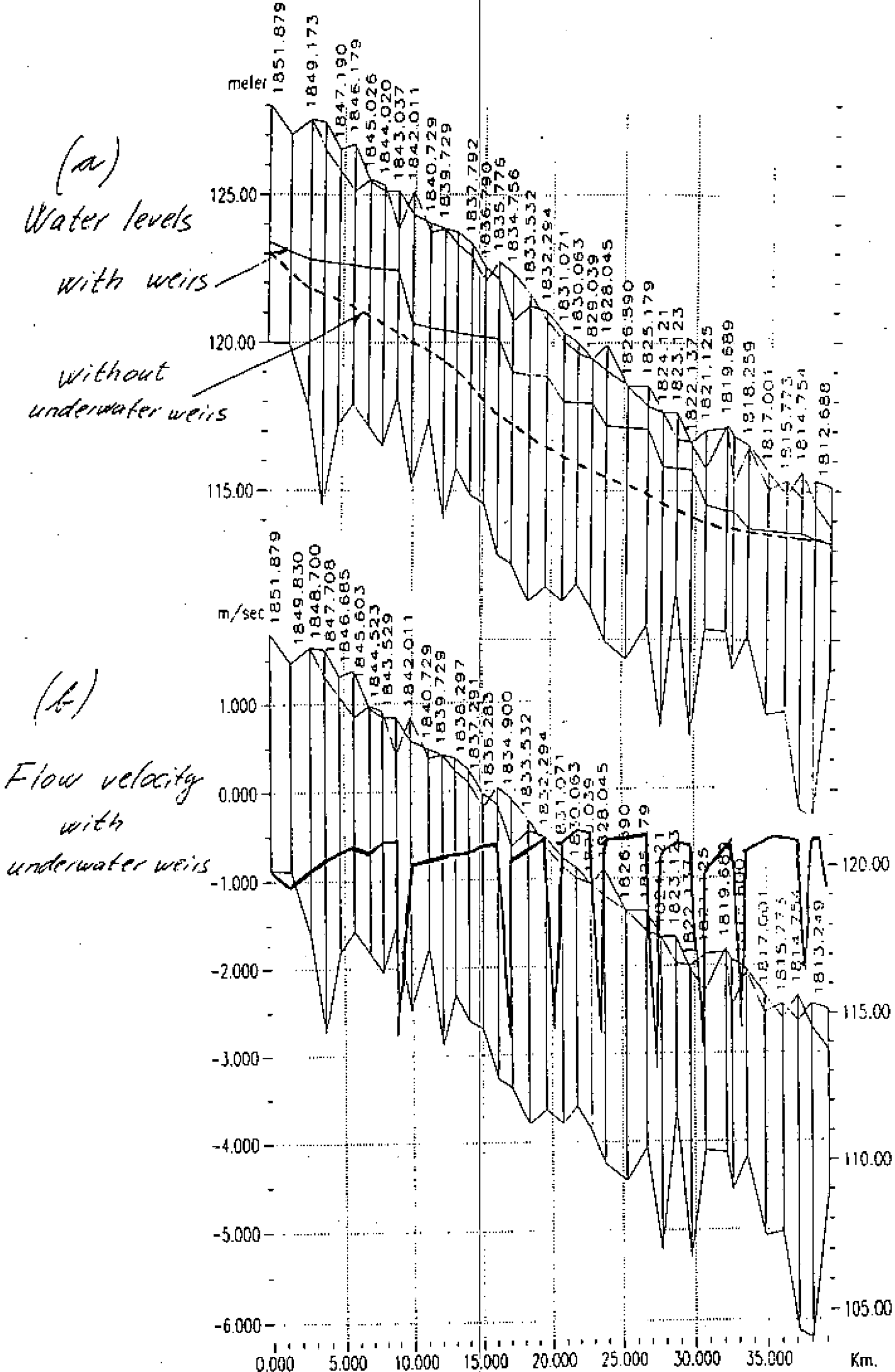

Fig. 7.2 *Model calculations of water level profile with and without underwater weirs (a) and of velocity profile with underwater weirs (b) between Cunovo and Sap/Palkovicovo.*

Table 7.2 Water depths and flow velocities at Dunaremete for different discharges for Scenario 3 compared with the situation without underwater weirs.

Discharge (m^3/s)	WITHOUT UNDERWATER WEIRS Water level (m asl)	Velocity (m/s)	WITH UNDERWATER WEIRS Water level (m asl)	Velocity (m/s)
200	113.8	0.77	116.2	0.25
400	114.4	1.12	116.8	0.40
600	115.0	1.22	117.1	0.55
800	115.4	1.28	117.5	0.66
1000	115.9	1.34	117.8	0.76
2000	117.4	1.65	119.0	1.15

For Dunaremete model results on water levels and flow velocities for different discharges are presented in Table 7.2 both without and with underwater weirs. From the figures and the tables it is evident that underwater weirs have major impacts. Thus the water levels are increased by 1.5 - 2.5 m, which in turn results in large decreases of flow velocities. At Dunaremete for example the water levels are increased by about 2.5 m, while the velocities for discharges less than 800 m^3/s are reduced to less than half. For other locations, such as e.g. Rajka, where the increase in water levels are less the impacts on velocities are also smaller.

7.2.2 Opening of connection to side branches

A few of the dikes presently closing the connection between the main river and the side branches will be opened to enable a small flow (few m^3/s) also under medium flow conditions in the main Danube.

7.2.3 Water management regime

The water management regime will be as described under Scenario 2, see Subsection 6.2.2.

7.3 Possible Time Schedule for Implementation

According to a similar, specific Slovakian design with nine underwater weirs one weir can be constructed in two months and all nine can under favourable conditions be constructed in five months. In addition to the time for construction some time will be required to fulfill the necessary legal procedures. The cost of the Slovakian project is estimated to 6.3 mill ECU.

7.4 Impacts on Discharges, Water Levels and Flow Velocities

The split of the discharges can in a year with average discharge be described by the figures given in Table 6.1

The impacts on discharges and water levels, can be characterized as follows:

* The discharges in the Old Danube will in average be about 40% as compared to pre-dam condition.

* The water levels in the Old Danube is expected to be kept similar to pre-dam conditions. If the underwater weirs have constant crest level across the river it will not be possible to reestablish the dynamics of the water level fluctuations.

* It will be possible to maintain or even improve the flow connections between the main river and the side branches on both sides as compared to pre-dam conditions.

* Water level variations on the Slovakian inundation area will vary by 1.8 m at a difference in water supply from the intake canal at Dobrohost from 0 to 140 m^3/s.

* The discharge through the downstream part of the reservoir will as compared to Scenario 0 be reduced from in average 1533 m^3/s to 1093 m^3/s resulting in a decrease in velocity of 29 % and an increase in retention time of 40 % respectively.

The flow velocities have been estimated to be as described in Table 7.3. From the table it appears that the flow velocities at minimum discharge of 400 m^3/s is about 0.5 m/s. For average flow conditions (800 m^3/s) the flow velocity is typically in the order of 0.8 m/s corresponding to about 0.5 m/s as point velocity 7 cm above the river bottom (fish location).

7.5 Impacts on Erosion/Sedimentation

The conditions with regard to erosion and sedimentation is expected to be as under Scenario 2, ie:

* No major net erosion and sedimentation in the Old Danube. During some events sedimentation of fine material will take place. This fine material is expected to be washed away during flood events.

* The river bed in the main branches on the Slovakian side will continue to be sufficiently free from mud, so that good infiltration conditions exist.

* The river bed in the main branches on the Hungarian side will become sufficiently free from mud, so that good infiltration conditions will exist.

Table 7.3 Estimated discharge and flow velocity values in the main river and in the side branches under Scenario 3.

Location	Discharge characteristic	Discharge (m^3/s)	Cross-sectional average velocity (m/s)
Main river, Rajka	Minimum	400	0.61
	Average	800	0.97
	Typical annual maximum	3500	
Main river, Dunaremete	Minimum	400	0.40
	Average	800	0.66
	Typical annual maximum	3500	
Left side branch, main channel	Typical minimum	0	0
	Typical average	50	0.06 - 0.30
	Typical annual maximum	140	0.10 - 0.40
Right side branch, main channel	Typical minimum	0	0
	Typical average	50	0.06 - 0.30
	Typical annual maximum	70	0.07 - 0.35
Connection between main river and side branches	Flow from inundation area into main river		365 days/year
	Flow from main river into a few river arms		>195 days/year
	Flow from main river into almost all river arms		> 21 days/year

7.6 Impacts on Surface Water Quality

The impacts on the surface water quality is expected to be insignificant.

7.7 Impacts on Ground Water Regime

The estimated impacts on the ground water regime are as under Scenario 2:

* Ground water levels on the Slovakian territory will be higher than or equal to the pre-dam conditions and also higher than or equal as compared to Scenario 0.

* Ground water levels on the Hungarian territory will be higher than or equal to the pre-dam conditions and also higher than or equal as compared to Scenario 0.

* If the underwater weirs have constant crest level across the river it will not be possible to reestablish the dynamics of the ground water level fluctuations.

7.8 Impacts on Ground Water Quality

The impacts on the ground water quality are, with the discharge regime as under Scenario 2, in general expected to be insignificant.

7.9 Impacts on Flora and Fauna

The impacts on flora and fauna as already observed are described in ref /2/. However, if the present situation continues for some years an increased effect will result with regard to changes in alluvial ecosystems as follows:

* Decrease of the water level fluctuations in the inundation area (side branches plus forests) makes the site conditions worse for floodplain biocenoses.

* Reduction of discharges in the Old Danube leads to reduction of the flow velocity and to sedimentation of fine material. This will cause the loss of species typical for streams, of rheophile organisms, especially of fish species spawning on gravel ground.

* Under minimum discharge conditions (400 m^3/s) the flow velocities in the main river are not large enough to provide adequate living conditions for the species requiring the higher velocities, for example fish species like Streber. In order to have adequate living conditions for this fish species the minimum discharge should be about 1000 m^3/s.

7.10 Impacts on Agriculture and Forestry

As under Scenario 2 the impacts on agriculture and forestry are expected to be an increase in the capillary water supply for as well agricultural as forestry areas both in Slovakia and in Hungary.

7.11 Impacts on Electricity Production

In a year with average discharges the electricity production can, with the discharge regime as under Scenario 2, be estimated to about 1390 GWh.

7.12 Cost Estimate for Remedial Measures

The costs of construction of a system of nine underwater weirs can be estimated to be between 6 and 12 mill ECU.

8. ELABORATION OF SCENARIO 4

Under Scenario 4 as much water as technically possible is diverted into the Old Danube and the side channels.

In addition to the impacts described in this chapter reference is made to Section 3.3, where environmental impacts common to all five scenarios are described.

8.1 Characterization of the Scenario

In Scenario 4 as much water as technically possibly will be diverted into the Old Danube and the side channels.

In this scenario the only new remedial measures to be implemented are finalisation of the parts of the Variant C structures, which enable diversion of water into the Old Danube and reconstruction of the spillway of the inundation weir enabling up to 1300 m^3/s to pass this structure in daily use. When these works are completed the navigation canal will be used for navigation only and no electricy will be produced.

All the remedial measures are technically reversible.

In addition improved operation rules for the day-to-day operation of the water management within the above given discharges will be implemented in order to obtain as good environmental conditions as possible.

8.2 Technical and Water Management Aspects

As part of the water management water will be provided to the ship locks at Gabcikovo, to Little Danube, Mosoni Danube and to the floodplains on both sides. The remaining water will, to the extent technically possible be diverted to the Old Danube.

This scenario will have four different discharge regimes according to the status of the Variant C structures (cf Table 2.2):

* From now until May 1994: max 600 m^3/s.
* Between May 1994 and December 1994: max 940 m^3/s.
* Between December 1994 and summer 1996: max 1900 m^3/s.
* After summer 1996: max 7200 m^3/s.

The above discharge figures represent the capacity for daily use. In addition it will be possible to pass more water in flood situations. Thus, in practise it will technically not be possible until the summer of 1996 to divert all water to the Old Danube.

The water management regime will be characterized by the average annual discharge values shown in Table 8.1. The impacts assessed in the following part of this chapter refer to the conditions after the full implementation of the scenario, i.e. after the summer of 1996.

8.3 Possible Time Schedule for Implementation

The time schedule is described in Section 8.2 above.

Table 8.1 Annual average discharge values in Scenario 4.

	Average annual discharge (m^3/s) Between December 1994 and Summer 96	Average annual discharge (m^3/s) After Summer 1996
Danube, Bratislava	2.025	2.025
Inflow to Little Danube, Bratislava	30	30
Inflow to Mosoni Danube, Cunovo	25	25
Seepage canal, right side	2	2
Seepage canal, left side	5	5
Seepage from reservoir to Danube	20	20
Seepage to ground water	30	30
Intake to Slovakian river branches, Dobrohost	50	50
Intake to Hungarian river branches, Cunovo	50	50
Bypass weir plus inundation weir, Cunovo	1451	1785
Ship locks, Gabcikovo	25	25
Turbines, Gabcikovo	337 1)	3 2)

Notes: 1) Discharge to the turbines in average about 130 days/year
2) Discharge to the turbines in average about one day/year

8.4 Impacts on Discharges, Water Levels and Flow Velocities

The split of the discharges can in a year with average discharge be described by the figures given in Table 8.1

After the summer of 1996 the impacts on discharges and water levels, can be characterized as follows:

* The discharges in the Old Danube will be 90 - 95% as compared to pre-dam condition.

* The water levels in the Old Danube will be 10 - 40 cm lower than in pre-dam conditions. The dynamics of the water level fluctuations will be maintained.

* Due to the small reduction in water levels, the flow

connections between the main river and the side branches will be slightly reduced as compared to pre-dam conditions.

* The discharge through the downstream part of the reservoir will as compared to Scenario 0 be reduced from in average 1533 m^3/s to 78 m^3/s resulting in a decrease in velocity and an increase in retention time by a factor of 20 respectively.

The flow velocities have been estimated to be as described in Table 8.2. From the tables it appears that the flow velocities have only been marginally changed as compared to pre-dam conditions.

Table 8.2 Estimated discharge and flow velocity values in the main river and in the side branches under Scenario 4.

Location	Discharge characteristic	Discharge (m^3/s)	Cross-sectional average velocity (m/s)
Main river, Rajka	Typical annual minimum	625	1.09
	Average	1800	1.58
	Typical annual maximum	5100	> 2.0
Main river, Dunaremete	Typical annual minimum	625	1.23
	Average	1800	1.57
	Typical annual maximum	5100	> 2.0
Left side branch, main channel	Typical minimum	0	0
	Typical average	50	0.06 - 0.30
	Typical annual maximum	140	0.10 - 0.40
Right side branch, main channel	Typical minimum	0	0
	Typical average	50	0.06 - 0.30
	Typical annual maximum	70	0.07 - 0.35
Connection between main river and side branches	Flow from inundation area into main river		365 days/year
	Flow from main river into a few river arms		<165 days/year
	Flow from main river into almost all river arms		< 19 days/year

8.5 Impacts on Erosion/Sedimentation

The conditions with regard to erosion and sedimentation is expected to be as follows:

* In the Old Danube increased erosion will take place, because the sediment concentrations in the water passing the structures will be significantly reduced and the velocities in the Danube will be almost the

same.

* The river bed in the main branches on the Slovakian side will continue to be sufficiently free from mud, so that good infiltration conditions exist.

* The river bed in the main branches on the Hungarian side will become sufficiently free from mud, so that good infiltration conditions will exist.

8.6 Impacts on Surface Water Quality

Directing in average 4% of the discharge through the downstream part of the reservoir, it can be expected that stagnant water with algae growth and sedimentation of organic material will occur in this water body. This may also have some negative impact on the surface water quality in the navigation canal and further downstream in the main Danube as well as in the Slovakian flood plains where the side branches now will be fed with eutrophe water from the navigation canal.

8.7 Impacts on Ground Water Regime

The estimated impacts on the ground water regime are as follows:

* Ground water levels on the Slovakian territory will be higher than or equal to the pre-dam conditions. However the ground water levels close to the downstream part of the reservoir will be lower than in Scenario 0.

* Ground water levels on the Hungarian territory will be higher than or equal to the pre-dam conditions.

* As compared to Scenario 0 it will be possible to reestablish a substantial part of the dynamics of ground water level fluctuations downstream Cunovo on the right side and downstream Dobrohost on the left side of the Danube.

8.8 Impacts on Ground Water Quality

The impacts on the ground water quality will in most of the area continue to be insignificant. Due to eutrophication in the downstream part of the reservoir the groundwater quality is likely to be threatened at the Samorin Water Works, which produces about 40 % of the water supply for Bratislava. This threat is associated to sedimentation of organic material due to stagnant water and algae growth in the downstream part of the reservoir. A layer of organic material at the reservoir bottom, from where the infiltration to the aquifer takes place, may result in anoxic groundwater conditions.

8.9 Impacts on Flora and Fauna

The impacts on flora and fauna are expected in most respects to be small compared to pre-dam conditions.

8.10 Impacts on Agriculture and Forestry

As under Scenario 2 and 3 the impacts on agriculture and forestry are expected to be an increase in the capillary water supply for as well agricultural as forestry areas both in Slovakia and in Hungary.

8.11 Impacts on Electricity Production

After Summer 1996 no electricity will be produced at Gabcikovo.

8.12 Cost Estimate for Remedial Measures

The cost for reconstruction of the spillway of the inundation weir is estimated to 3.3 mill ECU. The maintenance costs are estimated to 5 mill ECU/year. These maintenance costs will be significantly reduced if the downstream water level is higher than 124.0 m asl.

9. CONCLUSIONS AND RECOMMENDATIONS REGARDING TEMPORARY WATER MANAGEMENT REGIME

9.1 Summary of the five Scenarios and their most important Impacts

In the present report the existing water system has been described and various possibilities for implementing remedial measures have been outlined. On this basis five scenarios with different characteristics have been elaborated and the impacts expected to occur within the time horizon of the Temporary Water Management Regime (3 - 5 years) have been described.

The five scenarios and their most important impacts that exceed the common environmental impacts, as described in Section 3.3, can be summarized as follows:

Scenario 0: November 1993 Situation

The November 1993 situation is characterized by the following average discharges:

* Old Danube: 400 m^3/s
* Slovakian side branches: 40 m^3/s
* Hungarian side branches: 10 m^3/s

The impacts result in the following key figures:

* The difference in the water levels between the main river and the side branches will generally be so large that water flows from the main river to the side branches will only be possible under flooding conditions expected to occur 1-2 times per year.
* The ground water levels on the Hungarian territory will, as compared to pre-dam conditions, be higher close to the reservoir (Rajka-Dunakiliti region), whereas the levels will be lower in the middle part of Szigetköz between Dunakiliti and Asvanyraro in areas close to the Old Danube.
* The flow velocities in the main river are not large enough to provide adequate living conditions for species requiring higher flow velocity, for example representative fish species like Streber.
* The electricity production at Gabcikovo can be estimated to about 2,000 GWh/year.

Scenario 1: Increased water supply to the Hungarian Side Branches

The Scenario is characterized by the following average discharges:

* Old Danube: 400 m^3/s
* Slovakian side branches: 50 m^3/s
* Hungarian side branches: 50 m^3/s

1-3 floods of more than 3500 m^3/s are expected to occur each year in the Old Danube.

The impacts result in the following key figures:

* The ground water levels on the Hungarian flood plains are expected to be not lower than in pre-dam conditions.
* The flow velocities in the Old Danube are not sufficient for the typical biocenosis.
* The connection between the Old Danube and the side channels is not sufficient to allow migration of wetland species.
* The electricity production at Gabcikovo is estimated to about 1,930 GWh/year.

Scenario 2: Increased Discharge in Main River and in Hungarian Side Branches

Scenario 2 is characterized by the following average discharges:

* Old Danube: 800 m^3/s
* Slovakian side branches: 50 m^3/s
* Hungarian side branches: 50 m^3/s

1-3 floods of more than 3500 m^3/s are expected to occur every year in the Old Danube.

The impacts result in the following key figures:

* The connection between the Old Danube and the side channels is not sufficient to allow migration of wetland species.
* The electricity production at Gabcikovo is estimated to about 1390 GWh/year.

Thus, Scenario 2 represents significant improvements of the environmental situation of November 1993.

Scenario 3: Construction of some Underwater Weirs

Scenario 3 is basically identical to Scenario 2 except for construction of a number of underwater weirs. Hence, the discharge regime and many of the impacts are identical to those of Scenario 2.

The impacts result in the following key figures:

* The connections between the main channel and the side branches on both sides are maintained or even improved as compared to pre-dam conditions.

* The flow velocities in the Old Danube are (up to 1000 m^3/s minimum discharge) not sufficient for maintaining the typical biocenosis

* The electricity production at Gabcikovo is estimated to about 1390 GWh/year (with the same discharge regime as under Scenario 2).

Thus, as compared to Scenario 2 one key problem has been substituted by another one if the minimum discharge does not exceed 1000 m3/s.

Scenario 4: Full Capacity of Variant C Structures used for Water Supply of the Main River and the Branches

In Scenario 4 as much water as technically possible will be diverted into the Old Danube and the side channels. Thus, after summer 1996 the discharge in the Old Danube will be 90 - 95 % of the pre-dam conditions.

The impacts result in the following key figures:

* The water quality in the downstream part of the reservoir will be affected by stagnant water and hence significant algae growth and sedimentation of organic matter will occur in this water body.

* The ground water quality is likely to be threatened at the Samorin Water Works due to sedimentation of organic matter in the downstream part of the reservoir.

* The connection between the Old Danube and the side channels is reduced as compared to pre-dam conditions.

Thus, although most of the key problems occurring under the other three scenarios do not exist in Scenario 4, other key problems are created.

9.2 Conclusions

As appearing from Section 9.1 above none of the selected scenarios are free from key environmental problems. Furthermore, different scenarios result in different environmental problems, which are not directly comparable. Scenario 2 and Scenario 3 show that some environmental problems can be reduced by increasing discharge and remedial measures.

In addition to the environmental aspect also economical aspects should be considered. In this respect it may be noticed that the value of the present electricity production of 2000 GWh/year is in the order of 50 - 100 million ECU/year. It is noticed that the costs for implementation of the remedial measures range between 2 and 12 million ECU depending on the scenario.

9.3 Recommendations by the EC Members of the Working Group

None of the described scenarios can be recommended without modifications. Therefore the three EC members of the Working Group will recommend a combination of elements from different Scenarios.

Objectives

Considering that the Temporary Water Management Regime shall be valid only for a short period until the conclusions from the judgement of the International Court of Justice can be implemented it is obvious to choose the overall objective for the regime as minimization of any irreversible developments.

The primary specific objectives are assumed to be as follows:

* The water level and velocity regime in the inundation area should at least approach the pre-dam conditions.
* The ground water regime on both sides of the river should be at least as good as in pre-dam conditions.
* The water quality in the reservoir and the main river should be as good as possible.
* The flow velocity in the main river should be sufficient to provide living conditions for species (especially fish) typical for pre-dam conditions.
* Migration of wetland species between the main river and the side branches should be possible in both directions at least some places.
* No irreversible technical measures should be implemented.

The secondary objective is assumed to be maximum electricity production within the discharge constraints imposed by the primary objectives.

Discharge regime

* Minimum discharge in Old Danube of 400 m^3/s.
* Average discharge in Old Danube of 800 m^3/s.
* 1-3 floods of more than 3500 m^3/s per year into the Old Danube (to the extent hydrologically possible).
* 30 - 140 m^3/s into the side branches on the Slovakian side.
* 30 - 70 m^3/s into the side branches on the Hungarian side.

Remedial measures

* Improvement of the daily discharge capacity of Variant C structures from the present 600 m^3/s to 940 m^3/s by May 1994.
* Construction of an underwater weir at RKM 1835 enabling direct contact between the main river and the Slovakian side branches at one upstream point of the Slovakian floodplain and to improve the water supply to the Hungarian floodplain at rkm 1845.5. This underwater weir mainly serves an environmental purpose.
* Construction of an underwater weir at RHM 1845.5 for improving the operational reliability of water supply from the inundation weir (less maintenance of the spillway). This underwater weir is sufficient without other measures to ensure the water supply to the Hungarian floodplain.
* Deposition of gravel between the inundation weir and the underwater weirs in the main channel.
* Construction of fish passes at Cunovo.

Day-to-day Operation

Improved operation rules for the day-to-day operation of the water management within the above given discharges has be implemented in order to obtain as good environmental conditions as possible.

Environmental Impacts

The recommended Temporary Water Management Regime is seen to be a combination of Scenario 2 and Scenario 3, each of which had one key problem.

By only constructing one "environmental" underwater weir at RKM 1835 the velocities in the main part of the Old Danube will be high enough to provide living conditions for the typical flora and fauna.

Similarly, by constructing this underwater weir a direct connection between the main river and the side branches is established for both sides. This is essential for enabling migration of wetland species in the total system.

Hence the recommended Temporary Water Management Regime is believed to ensure that minimum irreversible environmental developments take place during the few years the temporary regime is supposed to last.

It is furthermore recommended to maintain a detailed environmental monitoring including taking the steps to strengthening the present monitoring system as recommended in the Data Report, ref /2/.

Reliability

Construction of a second underwater weir at RKM 1845.5 significantly improves the reliability of the day-to-day water supply through the inundation weir. Without this there is a large risk that the inundation weir spillway will be under repair most of the time.

The spillway of the inundation weir is a key issue in terms of discharge possibilities, reliability, time schedule and costs. As no comprehensive design exists for its daily use a design review is recommended to be carried out by an independent, specialized institute.

10. SUGGESTION FOR OPERATION MANUAL FOR TEMPORARY WATER MANAGEMENT REGIME

Two key elements of a Temporary Water Management System are a Water Management and Monitoring Committee and an Operation Manual

10.1 Possible Roles and Functions of Temporary Water Management and Monitoring Committee

Composition, Mode of operation, Organisation

* To be considered.

Scope of work

* Monitor the day to day operation and report to the two governments on a monthly basis.

* Plan, coordinate and review joint activities on monitoring, modelling and studies related to the water management and its impacts on environment, navigation and hydropower.

* Review studies on and decide on optimal design of remedial measures (e.g. underwater weirs, opening of a few connections to side arms, arrangements in flood plains) by March 1994.

* Prepare recommendations for adjustments to the water management and the Operation Manual whenever required on the basis of the operational experiences and the results from the activities on monitoring, studies and modelling. Justifications for proposed adjustments should be based on the degree of fulfilment of the set of environmental criteria described in the Operation Manual. In November 1994 an analysis of the results from the water management until then should be carried out and recommendations prepared accordingly.

* Prepare recommendation for urgent measures to be taken in case of emergency situations.

10.2 Operation Manual

The aims of the Operation Manual are to describe how the day-to-day operation should be carried out and how the operation should be monitored and controlled.

10.2.1 Monitoring System

The monitoring to be reviewed by the Committee will include measured variables on the following aspects:

* Discharges
* Surface Water Levels
* Surface Water Quality
* Ground Water Levels
* Ground Water Quality
* Flora and Fauna

Discharge

(a) The following discharges shall be measured daily and form the basis for the water management control:

(1) At Devin, Q_{Devin}
(2) At Rajka, Q_{Rajka}
(3) At Dunaremete, $Q_{Dunaremete}$
(4) At Medvedov, $Q_{Medvedov}$
(5) At Komarom, $Q_{Komarom}$
(6) At the by-pass weir, $Q_{bypass\ weir}$
(7) At the inundation weir, $Q_{inundation\ weir}$
(8) At the shiplocks, $Q_{shiplocks}$
(9) At the turbines, $Q_{turbines}$
(10) Intake to Little Danube, $Q_{Little\ Danube}$
(11) Intake to Mosoni Danube, $Q_{Mosoni\ Danube,\ intake}$
(12) At Mosoni Danube, Rajka, $Q_{Mosoni\ Danube,\ Rajka}$
(13) Seepage from reservoir to seepage canals, $Q_{Seepage}$
(14) Intake to Slovakian river branches, $Q_{Dobrohost}$

The "discharge" measurements can follow today's routine, i.e. as water level measurements and subsequent conversion to discharge values by use of "rating curves", which are updated regularly on the basis of real discharge measurements.

The discharge measurements at the above 14 sites are the responsibility the respective countries, i.e. Slovakia for 1, 4, 6, 7, 8, 9, 10, 11, 13, 14 and Hungary for 2, 3, 5, 12. However, Hungarian and Slovakian specialists have free access to check and participate in the measurements and the subsequent data processing for the above discharge measurement points in the other country.

(b) Discharge values shall be exchanged daily as preliminary values. Final values shall be presented and approved at the regular meetings of the Joint Committee.

(c) Check the consistency of the measurements, i.e.

$Q_{a1} = Q_{a2} = Q_{a3} = Q_{a4}$

where

$Q_{a1} = Q_{Bratislava} - Q_{Little\ Danube}$

$Q_{a2} = Q_{Turbines} + Q_{Shiplocks} + Q_{Dobrohost} + Q_{Seepage} + Q_{Mosoni\ Danube,\ intake} + Q_{Rajka}$

$Q_{a3} = Q_{Medvedov} - Q_{Mosoni\ Danube,\ intake}$

$Q_{a4} = Q_{Komarom}$

and

$Q_{b1} =< Q_{b2} =< Q_{b3}$

where

$Q_{b1} = Q_{Bypass\ Weir}$

$Q_{b2} = Q_{Rajka}$

$Q_{b3} = Q_{Dunaremete}$

The equation $Q_{a1} = Q_{a2} = Q_{a3} = Q_{a4}$ should be fulfilled within +/- 10% on a daily basis and within +/- 5% on a weekly basis. The inequality $Q_{b1} =< Q_{b2} =< Q_{b3}$ should always be valid. If the accuracy is not satisfactory the Joint Committee can decide to carry out special studies by use of independent experts in order to achieve technical consensus.

Surface Water Levels

The three EC experts and the Slovakian expert recommend that data on surface water levels from the national monitoring networks should be exchanged.

The Hungarian expert in theory agrees to exchange all relevant environmental data. Further agreement is necessary, however, on the detailed elaboration of this after the political decision has been made on which TWMR should be implemented.

Surface Water Quality

The three EC experts and the Slovakian expert recommend that data on surface water quality from the national monitoring networks should be exchanged.

The Hungarian expert in theory agrees to exchange all relevant environmental data. Further agreement is necessary, however, on the detailed elaboration of this after the political decision has been made on which TWMR should be implemented.

Ground Water Levels

The three EC experts and the Slovakian expert recommend that data on ground water levels from the national monitoring networks should be exchanged.

The Hungarian expert in theory agrees to exchange all relevant environmental data. Further agreement is necessary, however, on the detailed elaboration of this after the political decision has been made on which TWMR should be implemente.

Ground Water Quality

The three EC experts and the Slovakian expert recommend that data on ground water quality from the national monitoring networks should be exchanged.

The Hungarian expert in theory agrees to exchange all relevant environmental data. Further agreement is necessary, however, on the detailed elaboration of this after the political decision has been made on which TWMR should be implemented.

Flora and Fauna

The three EC experts and the Slovakian expert recommend that data on flora and fauna from the national monitoring networks should be exchanged.

The Hungarian expert in theory agrees to exchange all relevant environmental data. Further agreement is necessary, however, on the detailed elaboration of this after the political decision has been made on which TWMR should be implemented.

10.2.2 Description of day-to-day operation

The day-to-day operation will depend on which scenario is implemented. This decision is taken at a political level. Hence, it is not possible at this stage to prescribe this operation in details. Therefore only some general comments will be given here.

The water management regimes described in the scenarios should be seen as frameworks setting overall goals for the distribution of water and implementation of remedial measures. Within these frames there is possibilities to optimize the daily operation with regard to environmental conditions.

A very essential element in such optimization of the daily operation is to ensure that the dynamics of the regime become as close to the pre-dam conditions as possible with regard to temporal fluctuations of surface and ground water levels, inundation of flood plains, interaction between the main river and the side channels. For some aspects it may also be possible to achieve conditions which represent improvements as compared to pre-dam conditions.

With the already existing hydraulic structures and the additional technical measures proposed in the various scenarios there are very large management possibilities and identifying the "optimum" way of operating these is not trivial. There are two fundamentally different approaches in defining operation rules:

(a) Detailed operation rules can be prescribed. For example by relating the regulated discharges such as $Q_{Bypass\ Weir}$, $Q_{inundation\ Weir}$, $Q_{Dobrohost}$, $Q_{Turbines}$, etc on a given day to the incoming discharge recorded at Devin. The operation rules in the Slovakian Scenario (Appendix D) are based on this approach.

(b) A mathematical model can be used to forecast the next few days-ahead conditions, as they would have been under pre-dam conditions e.g. with regard to water level regime and utilize the management possibilities to establish the same conditions as far as possible.

It is recommended that a detailed Operation Manual be prepared after the political decision has been made on which TWMR should be implemented.

Bratislava, 1. December 1993

For the entire report including the recommendations:

Johann Schreiner   Jan M. van Geest   Jens Christian Refsgaard

For the report excluding the recommendations in Section 9.3:

Igor Mucha   Gabor Vida

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APPENDIX A: Terms of References for the Working Group

COMMISSION OF THE EUROPEAN COMMUNITIES
DIRECTORATE-GENERAL
EXTERNAL ECONOMIC RELATIONS

Brussels, 26 August 1993
Service/L-3/hcs

Establishment of a Group of Monitoring and Water Management Experts for the Gabciovo system of locks

I. Introduction

In order to provide reliable and undisputed data on the most important effects of the current water discharge and the remedial measures already undertaken as well as to make recommendations for appropriate measures the Republic of Hungary and the Republic of Slovakia will establish a Group of Monitoring and Water Management Experts (Group of Experts).

The Group of Experts shall consist of one expert appointed by Hungary and one expert appointed by Slovakia. Three independent experts appointed by the Commission of the European Communities will participate in the Group. The meetings will be chaired by one of the EC experts. The EC experts will have expertise in hydrology, including monitoring of hydrological data, ecological issues and water based constructions. The Slovak andd Hungarian experts can be supported by associate experts if necessary.

The monitoring will cover the whole area surrounding the Gabcikovo system of locks, and monitoring and measuring systems will be established both at Slovak and Hungarian territory.

No recommendations or activities arising from the establishment of the Group of Experts or its operation will effect, or reflect upon, any of the issues of legal liability which, in accordance with the Special Agreement, must be determinated by the International Court of Justice.

The Group of Experts will submit reports and recommendations based on consensus between the experts. In cases of disputes in the Group of Experts the Slovak and Hungarian experts as well as the EC experts can submit separate reports and recommendations.

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2. Objectives

The Group of Experts will:

I. Collect and assess data on all relevant aspects and effects of the current water discharge including the effects of the various remedial measures already put in place. The data to be collected will be defined by the Group of Experts within three days after its formal establishment. The methodology to be applied in the subsequent data analysis will be defined by the Group of Experts in connection with its first report 17 days after its formal establishment. The data to be collected will at least include:

* water discharge at all relevant places;

* surface water level and quality including sedimentation at all relevant places.

* ground water level and quality;

* impact on flora and fauna in the region;

* impact on agriculture and forestry;

* electricity production

* other possible essential aspects.

The data collection will be based on the existing data currently at the disposal of both sides as a result of regular measuring made jointly or separately by each side. Further the Group of Experts will decide on new or harmonised monitoring procedures and identify possible need for additional monitoring to be carried out in the future.

II. On the basis of the data collection (I) prepare recommendations for submission to the two Governments on the following aspects, with a view to safeguard the environment and the ecological conditions in the region:

A. A Temporary Water Management Regime including a detailed manual with specifications for the day-to-day operation and different water discharge situations:

B. The necessary water discharge and water level in the old riverbed and in the adjacent area and remedial measures to be taken.

c. The establishment of a Water Management and Monitoring Committee for the operation of the Temporary Water Management Regime. The main task of the Water Management and Monitoring Committee would be to:

- propose modifications in the Temporary Water Management Regime or new remedial measures to be taken on the basis of the operational experience and continued monitoring,

- initiate and supervise additional studies, measurements and research required; and

- prepare recommendations for urgent measures to be taken in case of emergency situations.

3. Activity and time schedule

The Group of Experts will work in accordance with the annexed time and activity schedule.

4. Mode and place of operation

A detailed activity and meeting plan will be prepred at the first meeting in the Group of Experts. Place of meetings will alternate between Slovakia and Hungary and secretarial support will be provided by the host country.

5. General

All proceedings, data collected by and recommendations from the Group of Experts will be confidential until the two Governments and the Commission decide otherwise. The Experts will make no public statements on the work of the Group.

DATE	ACTIVITY
September 8, 1993	First meeting to develop a detailed action and meeting plan.
September 13,1993	Report by the EC Experts on the need for clarification or adjustments in the Working Document
September 30,1993	Report on the assessment of existing data, the preliminary findings from analysing the data and the recommendations regarding modifications to the present monitoring practice. The report will be submitted to the two Governments and the Commission.
November 19, 1993	Final report, including recommendations for: 1. Temporary Water Management Regime, including a detailed manual with specifications for the day-to-day operations and different water discharge situations; 2. The necessary water discharge and water level in the old river bed and in the adjacent area and remedial measures to be taken; 3. The establishment of a Water Management and Monitoring Committee re. item 2.II.C.

APPENDIX B: Members of the Working Group and the Associate Experts

Members of the Working Group

Johann Schreiner, EC (primus inter pares)
Jan M. van Geest, EC
Jens Christian Refsgaard, EC
Gabor Vida, Hungary
Igor Mucha, Slovakia

Associate experts from Hungary

Károly Baross, North Transdanubian District Water Authority, Györ

Adrienne Hajosy, Ministry for Environmental and Regional Policy, Budapest

Lajos Horvath, North Transdanubian District Environmental Authority, Györ

Ferenc Meszaros, Hungarian Natural History Museum, Budapest

Zoltán Nagy, North Transdanubian District Environmental Authority, Györ

János Szekeres, Water Resources Research Center, Budapest

György Toth, Hungarian Geological Survey, Budapest

Associate experts from Slovakia

Vaclav Mikulka, Law Expert, VUB, Prague

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Ing. Ferdinand Kubicek, Institute of Ecobiology, Slovak Academy of Sciences, Bratislava

Miroslav Liska, Vodohospodarska Vystavba, Bratislava

Ivan Uhlar, Hydroconsult, Bratislava

APPENDIX C: **Summary of quantitative impacts for different scenarios**

Temporary Water Management Regime

Summary of quantitative impacts for different scenarios

Characteristic	Pre-dam condition (historical data)	Scenario 0	Scenario 1	Scenario 2	Scenario 3	Scenario 4
Date for possible start of specified water management operation		Ongoing	May 1994	May 1994	Second half of 1994	Summer 1996
Discharges as average annual values (m^3/s)						
Danube, Bratislava	2025	2025	2025	2025	2025	2025
Old Danube	1965	400	400	800	800	1800
Side branches, left side	?	40	40	50	50	50
Side branches, right side	?	10	10	50	50	50
Turbines	0	1468	1468	1008	1008	0
Water levels for typical discharge situations at Dunaremete (m asl)						
At minimum discharge	115.4	113.8	113.8	114.4	116.8	115.0
At average discharge	117.2	114.4	114.4	115.4	117.5	117.1
Flow velocities for typical discharge situations (m/s)						
Danube, Dunaremete At minimum discharge At average discharge	 1.3 1.6	 0.8 1.1	 0.8 1.1	 1.1 1.3	 0.4 0.7	 1.2 1.6
Side branch, left side Typical average	< 0.1	0.05-0.25	0.05-0.25	0.06-0.30	0.06-0.30	0.06-0.30
Side branch, right side Typical average	< 0.1	0.05-0.09	0.05-0.09	0.06-0.30	0.06-0.30	0.06-0.30
Flow connections between main river and branches (days/year)						
Flow from inundation area into main river	195	All	All	All	All	All
Flow from main river into a few river arms[1)]	195	5 - 10	5 - 10	5 - 10	> 195	165
Flow from main river into almost all river arms[2)]	21	5 - 10	5 - 10	5 - 10	> 21	19
Electricity production at Gabcikovo (Gwh/year)	0	2000	1930	1390	1390	0
Cost of remedial measures (Mill ECU)[3)]	0	SK: 12.0 H : 2.0	SK: 0.5 H : 2.0	SK: 0.5 + 1 per year H : 2.0	SK+H: 6 - 12	SK: 3.3 + 5 per year

Notes:
1) The definition corresponds to the flow situation "flow in a few river arms" which according to ref /1/ in the pre-dam condition occurred at a discharge around 1800 m^3/s.
2) The definition corresponds to the flow situation "flow in almost all river arms" which according to ref /1/ in the pre-dam condition occurred at a discharge around 3500 m^3/s.
3) The costs of Scenario 1-4 are in addition to the costs already spend on Scenario 0.

APPENDIX D: Scenario submitted by the Slovak Expert

See seperate Volume

APPENDIX E: Statement by Ing. I. Uhlar, Ing. J. Frankovsky and Ing. J. Cabel: "Possibility of everyday discharge through inundation weir Cunovo into the old Danube"

Appendix E

Possibility of everyday discharge through inundation weir Čunovo into the old Danube

1. The inundation weir was designed and constructed for temporary use (discharge of floods), until the definitive weir (with the sill in the level of the river-bottom) is constructed in the second phase (by the end of 1996). Under these presumptions, also the fortification of the spillway was designed and partially already realised. It was supposed that after each use (flood) necessery reparation of the fortification will be realised.

2. The first four fields of the weir could be used from May 1994, for everyday discharge at these conditions :
- the completion by May 1994 of the relevant part of the fortification works (the whole fortification is scheduled to be completed in December 1994);
- the discharge of 340 cumecs will not be exceeded (hydraulic stability of the water-jump in the stilling basin is assured only up to this limit);
- inspection and reparation of the outlet canal downstream of the spillway and of its fortification must be ensured (there will be damages after certain time of use, presumably each week), even with the discharge mentioned above (the costs of reparation at such periodical use - one week of use and one week of reconstruction - are estimated to 3 mill.Sk/month).
It should be noted, that the everyday use of four fields will complicate the rest of remaining works.

3. For daily use of the weir with higher discharges, an additional heavy fortification of the spillway would be necessary, similarly as downstream of the bypass weir.

The additional costs of such fortification are estimated to 120 mill.Sk. As there is not enough experience with such a construction, the risk of damage remains high. If such a decision is taken by the end of 1993, the fortification for the daily use of the inundation weir could be completed by the end of 1994.

The maximum discharge capacity in this case is 1300 cumecs and all openings have to be used, to avoid uneven distribution of flow. The estimated maintenance costs are 15 mill.Sk/month.

4. A higher water level downstream of the spillway, reduces the risk of damages caused by the everyday use of the inundation weir. The relationship between the possible safe discharge and the downstream water level could be established only by means of hydraulic research on a model.

Bratislava, November 30, 1993.

Estimated by Ing.I.Uhlár, Ing.J.Frankovský, Ing.J.Cábel

APPENDIX F: Seperate Statement by the Hungarian Expert

APPENDIX F

SEPARATE STATEMENT OF HUNGARY

More than a year has been spent with futile negotatioations on water distribution due to the unilateral diversion of the Danube at Cunovo. The dispute is rooted in the fact that the water discharge of the frontier river, which formerly was shared equally by the two countries, now exhibit a 80%+1/2*20% = 90% Slovak and 10% Hungarian proportion. Consequently, most of the positive effects are on the Slovak side, while all the negative ones occur in our country.

During the last 13 months there has been no Slovak indication of willingness to reach a compromise. Instead, there are some signs which give us reason to deny the credibility of the Slovak or Czechoslovak party (see London Agreed Minutes signed by Czechoslovakia on 28 October, 1992). On the contrary, Hungary was ready to accept the very unfavourable minimum ecological conditions of directing roughly two third of the total discharge into the shared Slovak-Hungarian main riverbed (and the operation of Gabcikovo Hydropower plant) as a temporary water management regime.

Each time in the long series of negotiations Hungary was prepared to accept smaller proportion of discharge, while the Slovak side recommended correspondingly lower and lower values. The last Slovak offer is already a further reduction of the present discharge into the shared main river (cf. Appendix about Slovak Proposal).

During the present Working Group sessions started on 8 September 1993. It has been stated at the onset of our WG that recommandations of Temporary Water regime will be based on the technical realities. One day before the end of the working group meeting new statement was given to us by the Slovak party on the state of the C variant structures. This made almost impossible to formulate realistic recommendation. It was finally declared by the Slovak party that at present they cannot satisfy the request of providing water continuously through the variant C structures more than 600

m^3/sec, but they perhaps will be able to give 940 m^3/sec (less than 1/2 of the total discharge) after May 1994 under some conditions. The daily operation of the floodweirs which were promised to be finalized by 1 January 1993 (!) (see ref. Working Group Report, November 23, 1992, page 7-8) are now in a distant future. This unexpected announcement upset many time schedules worked out under the scenarios in the present report.

It cannot be excluded therefore, that the signing of another temporary water distribution agreement much worse than before can only be regarded as an accepted humiliation without any improvement of the present environmental situation in Hungary. It has become also clear, that the approach of collecting and evaluating environmental impacts of the unilateral action with the present method is insufficient. Obviously major negative effects can be differenciated into "insignificant" changes in several single factors, especially considering relatively slow gradual processes. Many such damages are practically very difficult or impossible to measure. It is undisputable from analogous situations, that we cannot avoid the followings (unless rapid return towards the original conditions is provided):

- decreasing the biodiversity;
- loss of natural habitats and beauty;
- loss of the ability of self-maintenance of the flood plain ecosystems;
- loss of long-term evolutionary-ecological experience so far stored in genetic informations of the natural communities;
- loss of genetic diversity within the diminishing populations.

In addition, the risk of contamination of our unique, large drinking water reservoir cannot be excluded for the following reasons.

After damming the pattern of groundwater recharge (infiltration) and discharge-zones, and this way the total three dimensional flow system has changed basically. Infiltration rate its dynamics and the infiltrated raw water are also different, then they were at pre-dam conditions.

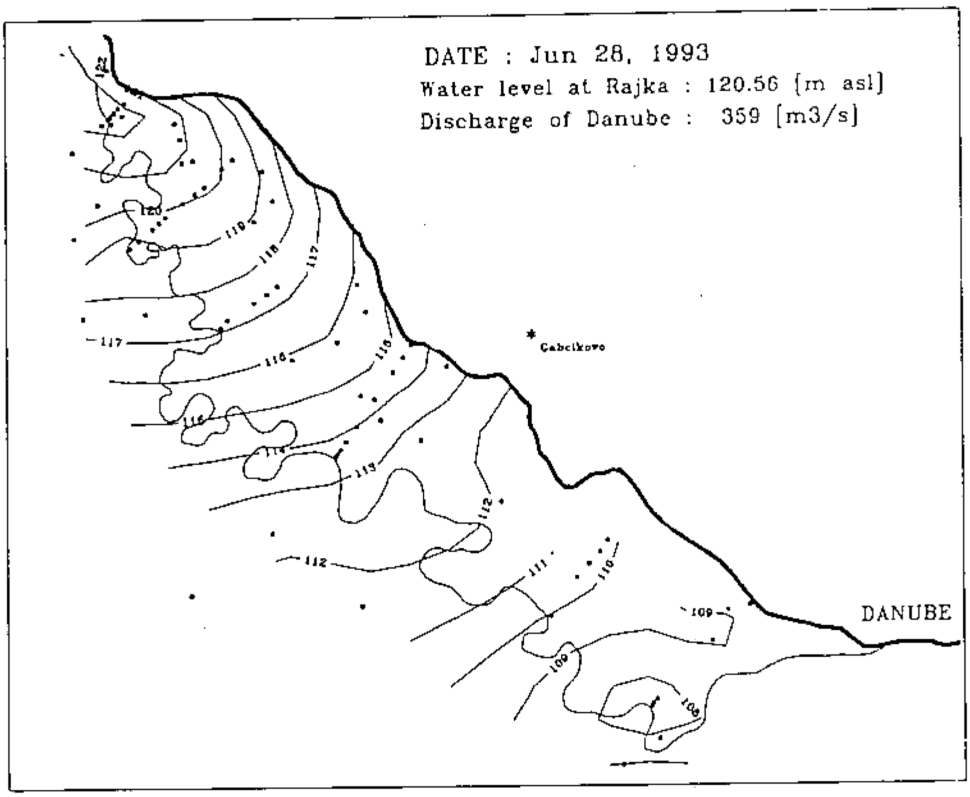
This changed situation is shown in the figure, where the groundwater levels indicate that after the damming, the

Danube became a major discharge zone between Rajka and Ásványráró, while Mosoni-Danube and water supply channel on the flood protected aera are now major recharge zones. The groundwater movement now directed to the Danube.

This change could have been important inconnection with vulnerability of the drinking water reserve.

The present proposal cannot guarantee even the average 40% discharge into the shared reach of the main Danube. It actua aims to improve variant C structures, known to be unaccepta to Hungary.

Fig to Appendix F



Bratislava, December 1, 1993

G. Vida
[Gabor Vida]

Annex 20

A NEW SOLUTION FOR THE DANUBE

WWF Statement

on the EC Mission Reports of the
"Working Group of Monitoring
and Management Experts"
and on the Overall Situation
of the Gabcikovo Hydrodam Project

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PHOTOS AND MAPS OMITTED

WWF®

Vienna/Rastatt, December 13, 1993

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Executive Summary

On request of WWF, a group of independent scientists reviewed basic documents and the two Reports of the EC Working Group, produced in fall 1993. It states that contrary to popular belief, the cause of the severe lowering of the Danube river bed in the border region was the overexploitation of gravel resources in the Danube mainly near Bratislava. This erosion is used by Slovak engineers to justify the "needed" damming of the Danube by the Gabcikovo scheme.

The overall importance and economic value of the self-purification work of the intact floodplain was largely ingored in the EC Reports.

After Gabcikovo was operating for six months without the needed legal permissions, certain legal prerequisites in Slovakia (e.g. on the use of Danube water) are still not fulfilled until today.

The WWF scientists emphasize that, based on their international experience, the danube diversion and the operation of Gabcikovo will inevitably result in detrimental alterations of the wetland and adjacent areas.

The EC Reports largely underestimate and even ignore the warning signs of the environment that indicate the increasing degradation even after one year. The political interests of both states prevented an unbiased, comprehensive scientific review and interpretation of the ecological impacts of Gabcikovo in the region.

The positive conclusions of the EC Reports on groundwater quality are actually not supported by the provided data or by independent expert knowledge. The provision of more data and an independent water analysis is demanded.

The monitoring of Slovak floodplain biocenoses is done from a forestry perspective ignoring crucial ecological prerequisitesfor floodplains and existing data bases. The Hungarian data are insufficient.

The EC expert recommendations for a Temporary Water Regime are limited by the new schedule for the reparation and completion of the inundation weir at Cunovo. It is not clear why the EC Reports did not examine the ecologically more acceptable interim solution of a 65-75% discharge into the Old Danube. Most of the recommended "remedial measures" (underwater weirs, artificial water inputs into the side branches) and the suggested average discharge of 800 m3/sec into the Old Danube is decidedly too little to prevent further damages. New French studies by the university of Lyon reveal that the degradation of the Slovak floodplain due to the dissecting lateral dikes and to untypical water levels worsened in 1993.

For local people, a tunnel or a bridge crossing the canal near Vojka would be a better recompensation for the loss of life quality than a road to Bratislava, especially with respect to the technocratically oriented economic and social transformation of their region. The wetland must urgently be protected from the already started degradation into a recreation facility.

The technical problems with the fragile design and state especially of the Cunovo inundation weir are likely to bring more time delays, before a higher discharge into the Old Danube will be possible. It is urgently suggested that an independent water engineering study be conducted for the future using possibilities of this scheme and for the reconstruction of the storage lake into a navigation route.

Based on the priority objectives to reestablish the hydrological and morphological dynamics, WWF recommends, as a short term solution, the accumulation of sediment bodies in the old river bed in the form of islands and gravel banks. These will lift the water level and preserve the original river continuum. Lateral dikes in the floodplain and side-arm closures at the Danube should be reopened.

As a long-term solution, an extended lifting and constricting of the river bed is recommended including the filling in of a large layer of gravel and boulders. This idea is based on a guaranteed discharge of 65-75% in the Old Danube orienting on the Slovak legal conditions from 1991 and on the EC compromise proposal from 1993. Secondly, the Cunovo reservoir should be constricted to a navigation route with the restoration of adjacent areas: This will reduce the undesired sedimentation processes threatening the groundwater. It is believed by WWF scientists that these "gentle measures" can not only limit the alterations but partly even reverse them saving and preserving the Danube floodplains and its groundwater reservoir. This contributes to the re-establishment of the ecological-economic balance of the affected border region.

Introduction

WWF (World Wide Fund for Nature) has been actively engaged in the Gabcikovo case since 1986. Several experts reported on the most important aspects of Gabcikovo(references 1,2,3). In January 1993, WWF submitted a joint NGO paper to the EC recommending much needed studies necessary to get a comprehensive overview of the benefits and negative impacts of the hydroengineering project on ecology, the economy, national/international law and on the social situation of the people affected.

Thanks to the ongoing efforts of the European Commission to mediate the continuing conflict between Hungary and Slovakia (until 1992 as CSFR), a new experts mission was agreed upon in July 1993. This follows the three other expert missions which took place in November 1992 (8) and May 1993 (9).

As a follow-up to the "Special Agreement for Submission to the International Court of Justice of the differences between the Republic of Hungary and the Slovak Republic concerning the Gabcikovo-Nagymaros-Project" a group of experts from Hungary, Slovakia and the Commission of the European Communities was established

> *"in order to provide reliable and undisputed data on the most important effects of the current water discharge and the remedial measures undertaken as well as to make recommendations for appropriate measures"* for a Temporary Water Management Regime for the Danube river and for a Water Management and Monitoring Committee.

The mission lasted from 8 September 1993 to 1 December 1993 and produced two "Data Reports" (2 November 1993 (Ref. 4)) and a final "Report on Temporary Water Management Regime" (1 December 1993 (Ref. 5)).

The goal of this WWF paper is

* to give an independent, scientifically based review on the present situation in the Danube region affected by Gabcikovo,
* to critically comment on the Reports of the EC Mission and
* to give recommendations for the future management of the river.

This paper cannot discuss all the questions, issues and data which were discussed and concluded upon in the EC Reports. It concentrates on a few critical points and necessary activities that are to be discussed and decided upon on the political level.

WWF herewith wants to stress his appreciation of the great work done by the EC Working Group. Any critique has to respect the fact that this phase is only the beginning of a big monitoring program and that the political interests of both Hungary and Slovakia made every delivery of relevant data to the "other side" a delicate step in the bilateral conflict.

Also, the huge amount of monitoring data and the relatively small personal capacities of the EC experts resulted in a task which was practically impossible to be accomplished in a satisfying way. Nevertheless, the two Reports are of great importance for the evaluation of the Gabcikovo project and will have an impact on upcoming political decisions.

WWF having high competence on the Danube and in the Gabcikovo issue considers it as his responsibility to produce this independent Statement.

Today, circa 8.000 hectares of interconnected, mostly very valuable floodplain biotopes and the second largest drinking water reservoir in Europe for up to 5 million people can still be saved. This makes this river stretch between Bratislava and Györ unique at Central and West European scale and an eclogical priority area.
It is the objective of our recommendations to prevent the continued, total destruction of this wetland and to develop a long-term, ecologically sound solution for the Danube.

Brief Review of the recent Gabcikovo "history"

On 24 October 1992, the Danube was diverted at the new diversion weir near Cunovo, Slovakia, into the Gabcikovo reservoir and canal (see attached maps).

Following WWF's international law study(3), presented in Bratislava on 20 October 1992, this "Variant C" is illegal because it violates the international principles of good neighourliness and of equitable utilization of shared resources. Also, Variant C violates several boundary agreements and does not constitute a legitimate response of CSFR or Slovakia to an alleged violation of the 1977 Treaty on Gabcikovo-Nagymaros by Hungary.

Since then, various political efforts of the European Community and its Commission resulted in the signature of the London Protocol (28 October 1992) - whose duties were totally ignored by Slovakia - and in numerous political negotiations which succeeded only in a joint agreement to address the dispute to the International Court of Justice (April 1993).

Furthermore, the EC organised three expert missions (November 1992, May 1993, Sept.-Dec. 1993) which brought about important progress in the knowledge of the overall technical and ecological situation around Gabcikovo. **However, all political efforts did not affect the growing detrimental impacts on the Danubian landscape downstream of Bratislava.**

After its diversion, the "Old" river bed received only 10-20% (200-400 m3/sec) of its water, while the "rest" was continuously diverted into the turbines of the Gabcikovo power plant. The debateable, one-sided benefit comes in the form of electricity production. Though, it involves numerous negative impacts on the hydrology and ecology of floodplains as well as on the social situation of local people.

In winter 1993, the Slovak investor company VVsp (Vodohospodarska Vystavba s.p.) started to build an artificial water-input system for the remaining parts of the valuable floodplain system which was about to totally dry up. Since May 1993, an input structure in the power canal near the village of Dobrohost leads ca. 30 m3/sec of Gabcikovo reservoir water into a large, sealed canal. This provides a constant filling of the interconnected side-arms which are dissected by newly errected or enlarged lateral dikes (creating 7 "cassettes").

Due to the ongoing river diversion and the drying up of its entire side-arm system, Hungary started at the end of July 1993 a similar input of water (10 m3/sec coming from the Cunovo weir) into its side-arm system.

In April 1993, WWF published excerpts from the first Slovak groundwater monitoring data (26 October to 31 December 1992) indicating some organic pollution in several groundwater observation wells near the storage lake(7). While this first monitoring is premature to give a sound information of possible changes in the aquifer, WWF's concerned, scientific interpretation contradicted the official, very positive interpretation by Slovak authorities. After this, no more comprehensive information on groundwater monitoring was published or available, even not extend needed for the EC experts (see chapter "Comments A").

Finally in fall 1993, the new EC Mission collected numerous data reports on hydrology, ecology, sedimentation/erosion, agriculture/forestry, electricity production and on engineering aspects which are presented in the Reports (4) and (5).

New Important Facts

Over the last months, WWF gained access to various pieces of information which we consider as crucial to a comprehensive, correct interpretation and evaluation of the Gabcikovo issue.

In addition, we want to stress these points because they were either not included or were largely underestimated in the EC Reports.

River bed erosion

Slovak sources often state that over the last two to three decades the growing river bed erosion had resulted in decreasing levels of surface and groundwater downstream of Bratislava, causing a serious detrioration of the wetlands and of the drinking water supply. However, the various origins of these effects were never reallyquantified. A Slovak study from June 1991 reveals that the reason for this impact was neither the river regulation measures for navigation (excavating 3,5 mio. m3 of gravel over 40 years) nor the catching of river sediments by the Austrian and Bavarian hydrodams located upstream (the regular bedload is 3-400.000 m3/year). The really outstanding interference was the huge gravel excavation near Bratislava: in the period of 1976 to 1989, ca. 50 mio. m3 were exploited from the river bed. Following a WWF estimation, this caused ca. two thirds of the deformation and erosion processes monitored both up- and downstream. This can be observed up to Hainburg (Austria) and in the floodplains near Gabcikovo. It also threatened the stability of the bridges in Bratislava and lowered the groundwater table reducing the productivity of several important drinking water wells near Bratislava.

This leads to the conclusion that the recent overexploitation of the gravel resources near Bratislava supported the "urgent need", as claimed by Slovak river engineers, to finish the Gabcikovo project. The excavated gravel was used for large-scale industrial constructions in Bratislava and for the building of the Gabcikovo scheme. Without this activity, the river bed erosion would be a small problem today.

Drinking Water Supply

Numerous informed sources confirmed that, since summer 1993, the water works (drinking water wells) of Samorin and Kalinkovo reduced their production to two third resp. stopped it. Official sources explain this by claiming a surplus of drinking water production in other wells upstream, being positively affected by the lifted groundwater due to the Gabcikovo storage lake. However, other water experts expected before the filling of the lake that these wells would be the first to be potentially affected by a changed groundwater quality due to infiltration of more polluted Danube water or by enhanced leakage of old waste deposits in the area (including the refinery Slovnaft). Similar to the recommendations made in chapter "Comments A" it is therefore recommended that the original data be analysed and interpreted in this concern by an independant institution in order to check if the original monitoring data really indicate no harm for the drinking water reservoir.

Economic benefits of self-purification processes

The Finance Institute of the Technical University in Vienna recently concluded a cost-benefit analysis comparing a Danube national park with several variants of hydropower plants downstream of Vienna. The extraordinarily better economic benefits of the national park alternative are based, among others, on the work of water organisms which in an intact floodplain significantly contribute to the cleaning of organic water pollution and thus, to the improvement of water quality on the surface and in the aquifer. Under the alternative of hydrodams, i.e. also in the case of the Gabcikovo scheme, this work has to be done by sewage treatment plants and water purification schemes for drinking water supply, both being very expensive installations. The Austrian Finance Institute calculated that in Austria investments of ca. ATS 640 million and operational costs of ca. ATS 60 million per year would be needed as a substitute to the "free work" of floodplain organisms.

This significant economic value has been largely ignored in the evaluation of the EC Working Group Reports (especially in their Scenarios) when comparing the former river situation with the present one where the water is derivated from the floodplain into the storage lake with its many negative attributes (sedimentation, colmation, infiltration of less purified or even more polluted water into the aquifer and towards the near-by drinking water wells).

A discussion paper of the Slovak parliament from January 1992 states: "*Following the joint Gabcikovo-Nagymaros Treaty from 1977 sewage treatment plants are to be built with complete mechanical-chemical-biological purification along the entire Czecho-Slovak section of the Danube. The water quality of the Morava river* (remark: a heavily polluted tributary upstream of Bratislava) *is to be raised to the quality class II up to the start of operation of the Gabcikovo power plant*".

At the end of 1993, some of the largest polluters of the Danube still do not have the required purification treatment: the chemical company ISTROCHEM has no biological treatment and the city of Bratislava can clean only 65% of its sewage. The new sewage treatment plant in the big suburb Petrzalka has no biological treatment, while its mechanical treatment has severe technical problems until today.

Several villages along the Danube were promised by the investor company (as a recompensation for the direct and indirect drawbacks for the construction of Gabcikovo) to get their own sewage treatment plants before Gabcikovo will operate. Several months ago, it was stated in Slovakia upon request that the fulfillment of the investor's promises is postponed up to the time when Gabcikovo will make profit.
Therefore, it can be stated that **the loss of self-purification capacity due to the diversion of the Danube together with the lack of sufficient sewage treatment schemes has led to a decrease of Danube water quality downstream of Bratislava and to the increased need for respective, expensive investments.**

Legal situation in Slovakia

In February 1993, WWF published an internal document from the Slovak environment ministry stating that the needed permissions for the completion of the Gabcikovo storage lake dikes, for the use of Danube water, for the diversion of the Danube and for the operation of the Gabcikovo scheme could not be granted by the responsible Slovak authorities to the operator VVsp.

Following WWF's present information, these permissions were granted by the responsible district authority Bratislava Vidiek only on 17 May 1993, i.e. **for more than 6 months the Danube was diverted and the Gabcikovo scheme was operating without the respective, needed Slovak permissions.** On 19 August 1993, this was confirmed by the Slovak state attorney in Bratislava. Also, VVsp was symbolicly fined for having done this.

The reason for the delayed permission process is the fact that, already on 25 June 1991, the **Slovak environment commission (= ministry) SKZP being the central authority for water economy prescribed a specific, binding "Statement"** (called the "19 Conditions" under § 14 of the Slovak Water Act no. 138/1973 Zb) **as a prerequisite to permit the use of water and to operate Gabcikovo.** This statement says that the suggested technical solution for Gabcikovo (i.e. the "Variant C") is only possible by the fulfillment of these specifically determined Conditions. The investor has the duty to fulfill this on top of the required permissions (it does not substitute them) and cannot appeal against it.

Especially, **the conditions no. 11** (demanding the inundation of the Slovak floodplains under natural conditions from the old river bed) **and no. 18** (demanding 1.300-1.500 m3/sec of water during the vegetation period in the Old Danube) **are not fulfilled by the investor company.**

On 17 April 1993, a specific permission for the manipulation of Danube water was granted, apparently replacing the Condition no. 18 for an interim period because the technical situation at the Cunovo weir did not allow a higher discharge at this time. The Slovak state attorney wrote in a letter on 19 August 1993 that, "*on 17 May 1993, the investor received the permissions for accumulation and damming of surface waters at the Danube on 17 May 1993. With this decision, the 'Preliminary Manipulation Order for the operation of the Gabcikovo powerplant by the preliminary solution on the territory of the Slovak Republic' was approved.*"

However, as the investor was unable to technically provide more water for the Old Danube, this specific order was granted by the authority under the conditions that a **minimum flow of 600 m3/sec be guaranteed in the Old Danube**, that a proposal for a new water manipulation order be presented by the investor by 1 October 1993 and that this order to expire on 15 November 1993. In fact, the monitoring data in the EC Reports show that only 300-400 m3/sec were flowing in the Danube throughout the year, i.e. **the order was not fulfilled. Today, this interim manipulation order has again expired and has not yet been renewed.**

Comments to the Results of the EC Mission September - December 1993

It is not useful to consider this paper as a critical comment on all details of the two EC Reports. Again, it must be emphasized that a lot of valuable and important information was collected which will give a better base for the upcoming political discussions and negotiations. **It is evident that the scientists of the Working Group were not given all available data and knowledge. The political interests of both Hungary and Slovakia strongly affected the selected volume and data of the submitted reports. This led to the exclusion of available data/studies and of competent scientists to which the EC experts should have been given access to.**

The Hungarian side especially supplied far too few documents, data and detailed information that were needed for a sound evaluation of all issues. The Slovak side supplied much more data which, however, often supported the suspicion that selected details and samples were used to lead to a positive impression and conclusion.

The first result of the review reveals that the largely missing or one-sided information does actually not justify the many general conclusions of the two EC reports. Therefore, the continuation and extension of the monitoring (as suggested in the EC Reports), together with a more independent evaluation, is crucially needed over the next years - independently, what technical or ecological measures will then be happening in the affected area.

Based on the year's experience gained from this section of the Danube, other rivers and similar engineering projects, it must be stated that the river diversion and the operation of Gabcikovo inevitably will result in detrimental alterations for the hydrology/biogeochemistry (ground- and surface waters), for the geomorphological processes (sedimentation/erosion) and for the floodplain ecology (diversity of biocenoses and especially adapted species) during the next years in the wetland and adjacent areas. Even though many impacts are not yet visible to the public, they can already be monitored by experts.

The monitoring data, as used for and presented in the EC Reports, only partly refer to the most sensible indicators. The experts' conclusions largely underestimate the importance of monitored impacts. By consequence, the experts' recommendations are based on insufficient knowledge, and miss basic facts and ecological needs crucial for the existence of the floodplain ecosystem and the preservation of the groundwater.

The future monitoring has to respect these problems. In addition, it is strongly suggested that **any further "independent" scientific study or analysis should involve the local, competent but independent experts.** However, these must not be selected by the government, its authorities or the institution to be analysed or having personel interests in the examination. The names of such experts and of relevant studies can be found, e.g by help of other scientists or of NGOs. Otherwise, the political pressure on science (which can be observed especially in Slovakia) will never allow a really objective result. It is very much in the interest of scientists that their work be separated from political interests and interpretation.

A. Evaluation of the Monitoring

Surface and groundwater quality/quantity

It is regrettable that Hungarian groundwater data apparently were not provided. Even though qualitative changes mainly affected the Slovakian side, the possibility of detrimental changes on the Hungarian side is given.

The following findings are based on the two EC Mission Reports (4,5), the Slovak data reports on "Surface and Groundwater Quality" (6) as well as on the first monitoring report on water quality during the filling of the Gabcikovo dam (26 Oct. - 31 Dec. 1992) (7) which WWF could receive in its complete form; thus, this first report(7) can serve as a important reference for comparison with the other data provided.

It has to be stated that the presented data in the reports (6) are not sufficient to scientifically justify the conclusions in the EC Reports. The Report on a Temporary Regime(5) concerning surface and groundwater quality says that for the Scenarios I, II and III "*the impact on the surface water quality will continue to be insignificant*" and that "*the impact on the groundwater quality will in general be insignificant. However, there will be some local changes in areas close to the reservoir in certain parameters, such as total dissolved solids, nitrate etc. due to changes in flow pattern. These changes are not expected to lead to a worsening in the groundwater quality*".

For Scenario IV it is written: "*Directing less than 5% of the discharge through the downstream part of the reservoir, it can be expected that stagnant water with algae growth and sedimentation of organic material will occur in this water body. This may also have some negative impact on the surface water quality in the navigation canal and further downstream in the main Danube. The impact on the groundwater quality will, as in other scenarios, in most areas continue to be insignificant. However, ... the groundwater quality is likely to be threatened at the Samorin Water Works, which produces about 40% of the water supply for Bratislava.*"

The given Slovak information(6) looses credibility in interpreting the changes in the aquifer. The analysis is a general torso of results which is non-representative of the changes in the groundwater.

Examples:

* Table 2 indicates observation points ("10" and "RU") on the right banks of the river which are not identical to the selected observation wells for the reservoir's impacts, given in Table 4 (Rusovce-Ostrovne lucky "D1-D6");

* The data shown in the graphical analysis do not correspond to the data structure and frequency of the monitoring in the indicated period and in the respective tables (e.g. while the sampling frequency is once every 2 weeks, the attached respective graphs show much less data).

* The only given example (well S4 Kalinkovo) does not fulfill the demand of a solid documentation of the changes in chemistry and of the element concentration in the observed aquifer on both sides of the Danube. Looking at the monitoring of groundwater quality changes in the first stage of the reservoir filling (Oct. to Dec. 1992), this object was non-representative from the standpoint of specific organic elements. The presented Table 3 does not show the non-polar extractable matter which is part of every chemical analysis and which could indicate with high evidence the degree of organic pollution of the entire area and of all objects.

Table 10 shows the given technical parameters of observation objects having several horizontal levels. It is questionable why the object S4 Kalinkovo was given as model because S4 has only one, very large horizon (depth of 40-80 m), while most other wells have small horizons of only a few meters depth, being much more precise for the indication of changes.

Data on hazardous organic pollutants and heavy metals are not presented in the supplied documents in spite of their analysis. According to the first monitoring report (7), elevated concentrations of dichlorethen, dichlorbenzen, pentachlorfenol, benzopyren, hexachlorbenzen and lindan were recorded in the surface and groundwater.

Data on selected sampling points and selected water quality parameters are presented in ref. 6. It is not explained why these points and these parameters have been chosen and why only one example of statistical evaluation is presented. The important criterion for the impact assessment are the selected sampling points, for those are the most sensitive to the changes in water quality. The selected parameters also have the largest temporal variations and the most significant impacts on environmental health. **This has to be documented before the conclusions about insignificant impact on water quality are made.**

According to drinking water standards (in Slovakia CSN 75 7111 approved: 1989, CSFR) important physical and chemical indicators such as heavy metals (Cd, Pb, Hg, Cu, Zn), other trace inorganic elements (Ba, Be, Cr, Ni, Se, Ag, V) and many organic indicators (dichlorbenzen, dichlorethen, pentachlorfenol, hexachlorbenzen, lindan, PCB etc.) are important. Such pollutants can be dangerous even at very low concentrations, especially if they act in combination. Their effect on health is still not fully understood. Some of them tend to accumulate in sediments and later, under changing conditions of the water regime and the water quality, they can be released and migrate to groundwater reservoirs. This phenomenon is called an environmental time bomb" because of its retardation and accumulation effect.

Unfortunately, any data and any discussion which would enable the evaluation of this environmental hazard could not be found in the documents. The data in (7), and previous data known about organic pollution of bottom sediments, indicate that a potential danger is real. However, data are not complete enough to make any definitive conclusions. From the biogeochemical point of view, the data on pollution of heavy metals, other trace inorganic elements and organic pollutants of bottom sediments, alluvium sediments, surface water and groundwater **have to be presented in full before any scientific conclusion can be made as regards the impacts of Gabcikovo dam on water quality.**

The properties of sediments can vary considerably. It would be very helpful to know distribution coefficients of organic compounds between water and the sediments as well as experimental data on the ability of the sediments to yield the pollutants to groundwater.

* It is not evident why the data are not available for independent evaluation. If it is proved by inter-laboratory validity tests that the data are correct, it should be possible for a small team of independent hydrochemical, hygiene and medical experts to evaluate the impact of the Gabcikovo dam on water quality and on consumers of the water.

* It is therefore in conformity with the EC Report (4) that a continuous program of monitoring is needed, however it should be specified what parameters will be monitored. **A review of the originally monitored data together with a control sampling and analysis should be made by an independent expert team and not by parties involved in this difficult dispute.**

* Unless the Working Group which produced this report had other data available, we do not think that the data are adequate to justify their conclusions. Especially the Summary of Impact Assessments for Scenarios is not supported by relevant scientifically varified data in the rows dealing with surface and groundwater quality. On the contrary, the data in (7) indicate pollution of surface and groundwater by mutagenic organic pollutants.

Flora and Fauna (incl. Forestry)

The Report sections and conclusions dealing with this topic reflect the poor data base which was provided by Slovakia and Hungary for evaluation. Even though a more profound scientific data base exists, the best available knowledge, data and experts were not involved in the evaluation.

The Hungarian report is insufficient to give any sound statement or conclusion. Large losses in fish biomass and the visible, critical state of the floodplain forests are a remarkable indication of the changed situation. However, these and other indicators are not properly documented and interpreted.

The following comment refers only with the Slovak **document**. It's authors prove to be mostly forest experts who omit many basic factors of floodplain ecology and subsequent demands for the affected area. The final phrase of the report about "positive consequences" of Gabcikovo reveals that the authors (were asked to?) consider the Gabcikovo dam construction as a benefit and needed for "the stabilization(!!) of these ecosystems". This phrase is in contradiction to the very dynamic character and the varying environment conditions of this ecosystem, and to all scientific knowledge about impacts of dams on floodplains and forests.

The Slovak report and the reference list do not contain the very important Slovak monitoring studies or species databases which were produced in the Slovak floodplains over the last years (especially by the Institute for Ecosozoology at the Slovak Academy of Sciences). However, certain details in this report are obviously taken from this monitoring.

The authors overestimate the detrimental impacts of the decreased water levels in the last decades ("disappearing of the whole nature biocenoses") and are far too optimistic regarding ecological benefits for the forests through the simulation of floods.

The study lacks a more thorough, critical evaluation of the newly constructed lateral dikes (cf. chapter B) in Slovak floodplains and of several important indicator groups other than forests (e.g. birds, beetles, mammals and molluscs).

WWF learned that a special ichthyological prognose study on the impacts of Gabcikovo was ordered and submitted in the summer of 1993 by relevant Slovak authorities. However, it did not becamc part of the Slovak or the EC reports.

The Slovak report is incorrect in stating that the decrease of surface and groundwater levels were only caused by river bed regulation and the construction of upstream hydrodams. The huge impacts originating from Slovak and Hungarian gravel excavation are ignored.

There is no comparison with other intact floodplain ecosystems (e.g. the Danube upstream of Bratislava) or with floodplains damaged in the past by other hydroschemes (the Danube upstream of Vienna, thet Rhine downstream of Basel, the Rhone etc.) from which the state of the floodplain ecosystem prior and after the Danube diversion could be better compared and estimated (cf. page 65: Hügin 1981). Then it would have been possible to give a better prognosis than the authors did.

It is not clear how *"a considerable part of biotopes"* will *"gradually turn by successive way to 'original state'"* (at the end of the fifties), if only some forest plantations, an increased water level and a watering of the side-arm system will be provided for the floodplain area.

The many problems of the Danube river bed itself are not discussed nor were respective conclusions made. The crucial importance of the open connection with the floodplain side-arm system is largely ignored. There are no comments on the changed nutrient input and exchange when discussing the artificial water input from the canal in comparison to the natural situationat the end of the '50s.

The estimation, that the needed floods can be simulated from the Dobrohost intake structure of the Gabcikovo canal and that this can recreate the hydropedological situation of this territory at the end of the fifties, ignores all available data and experience about such artificial measures from the Rhine and Upper Danube; it is far too optimistic (cf. chapter B).

The given example used to "prove" the restoration of soil moisture due to the Gabcikovo scheme, while comparing the mean losses of leaves in August 1992 and 1993, is actually unfair:

* August 1992 was a very dry period, as it is even stressed
* In other locations (rather than the quoted Cunovo/Rusovce area) especially along the Danube up- and downstream of Dobrohost, the groundwater level was not raised, but lowered by *up to 2 meters due to the river diversion*: there, not positive but damaging effects in the floodplain forests can be found in 1993, as compared to 1992.

Another example is the strange comparison of Aranea species diversity of the very wet, morphologically dynamic Danube inland delta with the xerothermal, stable Jur peat-bog: spiders are no indicators for floodplains because they prefer constant habitat conditions; second, the peat-bog (Carici elongatae - Alnetum) is not a floodplain ecosystem.

The same applies for the example of butterflies. For floodplain biotopes, such a comparison would be much more appropriate by taking beetles (Carabidae, Staphylinidae).

The report does not treat the problems of the important Istragov side-arm area (upstream of Palkovicovo) which is yet *not supplied by artifical water input* (a new canal is planned from Gabcikovo power plant!) and therefore drying out, since the Danube was diverted in fall 1992.

The whole report concentrates too much on the forest productivity (plantations). For instance, there are no recommendations to reconnect the side-arms with the main river even though this is partly recognized as absolutely crucial for the survival of the biocenoses, especially the regeneration and migration of the fishfauna.

Even though it is true that a one-year-period is too short to produce a sound scientific evaluation of potentially caused changes in fauna and flora, the monitoring data could have given many more results than the EC Report has referred to. It is not clear why the summary assessment of impacts ignores the visible damages in fish fauna, forests and habitats. The early general conclusion that the forestry has been positively influenced in Slovakia must at least be doubted, especially when looking at the slow reaction of forests to changed environmental conditions.

The suggested monitoring program will help to provide a clearer picture if it will be financed and really executed. This, however, is anything but certain in both countries.

B. Comments to the Recommendations for a Temporary Water Management Regime

The EC Report recommendations are restricted to the technical limits, especially of the Cunovo weirs, indicated to the EC group by the Slovak side (see also chapter C). Secondly, the discussed scenarios look only at the range between 20% and 40% and at the 95% alternative. **The ecologically more acceptable range between 40% and 95% of water for the Old Danube as an interim solution, which in fact is realistic from the technical point of view, was not discussed at all.**

This includes that the EC experts did not notice the original Slovak legal prerequisites for the operation of Gabcikovo (the "19 Conditions" demanding 65-75% of water in the Old Danube) as well as [illegible] compromise solution which was suggested in February 1993 by EC Commission and accepted by the Hungarian side. **Such a scenario would certainly** reduce the ecological problems and would still leave a large amount of water for Slovak energy production.

On the other side, the package of measures, the EC experts recommended (an average 800 m3/sec discharge plus 1-3 floods of more than 3.500 m3/sec per year, the installation of two underwater weirs in the Old Danube and the higher discharge of the artificial input of water into the floodplain) is **decidedly too little to prevent further damages and obviously accepts the technical limits of the Cunovo** weirs. Detailed comments are:

The suggested minimum discharge of 400 m3/sec is well below the historical minimum of the river in this region. This will promote the extraordinary drainage effect of the river, affecting the floodplains and the adjacent lands. A minimum discharge of 600 m3/sec is close to the historic minima and technically feasible at the Cunovo bypass weir..

Underwater weirs

As one "remedial measure", the new construction of two underwater weirs is recommended. The Slovak engineers plan to built the same kind of such weirs as on the Southern Upper Rhine (e.g. near Strasbourg). **From the many years of experience about these weirs on the Upper Rhine and the many scientific data produced on its impacts it can be stated that this measure will be inappropriate, inefficient and ecologically detrimental for the Danube and it will rather worsen the situation:** it will dissect the river continuum into a chain of ponds and result in higher erosion downstream of each weir (cascade effect); upstream of the weirs it will create standing water, higher eutrophication and sedimentation processes (colmation) reducing the river water quality, i.e. a complete change of the former bedload regime. The design of the planned underwater weirs creates such great velocities that fish will not migrate; artificial fish ladders proved to be useless investments.

On top of this, **underwater weirs proved to have no decisive, positive impact on the groundwater.** The water levels will be adjusting only to the water level of the downstream level of each weir. Even with a narrow sequence of many weirs, these drawbacks could only partly be reduced. In addition, the important exchange between surface and groundwater will be reduced after some time due to upstream colmation. On the Upper Rhine e.g. in the Weisweil weir section, less than 20% of the "inundated" area maintained ecological conditions similar to floodplains, but over 80% of the former, typical ecosystem is lost today.

Lateral dikes in the floodplain

Even though the EC experts did not expressively recommend the construction of lateral dikes in the floodplain area as a "remedial measure", their operation is included in their recommendations. They were constructed on the Slovak side dissecting the wetland into 7 "cassettes". **Even though in 1991 the Slovak environment ministry expressively(!) critisized such measures to be very detrimental and demanded a solution ensuring a water input in the side-arms from the Danube and a removal of the disclosures between the river and the side-arms (no. 11 of the "19 Conditions" from 25 June 1991), the Gabcikovo engineers started to build this scheme in winter 1992/93 destroying parts of the side-arm system, re-enforcing the disclosures with the Danube and starting a permanent inundation of the wetland in May 1993.** Condition no. 11 stated already in 1991 that *"the construction of lateral dikes in the inundation area and the creation of cassettes will damage the thru-flowing of the side-arms and result in an unnatural water regime of surface and groundwater, which with their oxygen regime and nutrient contents will not correspond to the needs of floodplain forests. It would provoque a non-desired long-term inundation of the forests causing its complete or significant change."*

This view is strongly supported by the WWF scientists: these dikes will transform the previous continuum of the floodplain into a chain of practically independent ponds which **perhaps give the impression of an intact wetland at first sight and in**

very short term. It even may be true that the new water levels following the new artificial water input from the Dobrohost intake structure lifted the water level to a higher level than under recent predam conditions. However, the single-point inflow of water, its stable, significantly reduced volume and its changed water quality (the water comes from the storage lake having lost most of its suspended matter including nutrients crucial for the floodplain ecosystem) in fact result in detrimental effects.

The water level just upstream of each lateral dike is lifted too high and remains stable over many months. This is damaging for natural floodplain biocenoses. Further upstream of each lateral dike, the water damming has no more impact: the dammed water remains horizontal, while the floodplain morphology is inclined.

This measure induces a real threat to the affected floodplain forests. Opposite to the propaganda of the Slovak investor company in 1993, the artificial water input has not "saved the Danube inland delta". Even more, the negative scientific prognosis is already reality, as it was revealed during recent studies by French scientists from the Lyon University who investigated the lower part of this Slovak floodplain section in 1992 and 1993: they found clear signs of physiological problems for willows which in large numbers soon will die or died already (especially large trees).

In addition, the lateral dikes proved to impede the migration of fish and other water organisms because they created high barriers which no Danube fish can cross. In 1992, there were four small lateral dikes in the side-arms near the village Baka; in fall 1993, the number of even larger barriers increased to ten. The French studies documented a drastic loss of fish biomass as compared to the 1992 situation: apparently almost all large fish have gone, only a few species dominate (e.g. bleaks = Alburnus a.) while the original diverse fish cenoses are largely altered today. The detailed analysis will be available in January 1994.

Finally, the construction of these new lateral dikes together with the permanent, controlled filling of the channels provided unlimited access for many more visitors (recreation!) and for the often illegal construction of weekend houses all over the floodplain: the wetland, which until recently hosted many threatened, but sensible species is today dramatically endangered to turn into a big recreation area for thousands of people.

It can be concluded that after thes weirs and dikes were largely tested on the Upper Rhine in the 1960s and 1970s, they will have no satisfying effect on ecology, groundwater or forestry at the Danube.

Unfortunately, the most important recommendation of the EC Report suggesting a "deposition of gravel" downstream of the Cunovo weir is not discussed any further. However, WWF thinks that this actually could become a very positive route changing of the present situation (see WWF Recommendation B.).

C. Technical Limits of the Present and Future Discharge into the Old Danube

The technical possibilities to restore the hydrodynamics of the Danube region and to establish an ecologically acceptable Temporary Water Management are largely dependent on the technical situation of the Gabcikovo scheme, especially the Cunovo diversion weir with its various openings (see attached map). A major problem arose from the fact that the diversion of the Danube in October 1992 happened at a stage when the whole scheme, but especially the Cunovo weir, was still under construction. Its completion was scheduled for the end of 1992. However, the interest of the Gabcikovo investor to deviate the Danube at the earliest moment possible resulted in a high risk of technical problems and damages.

A relatively small problem arose with the **ferry** service in the Gabcikovo canal providing a second connection to the three isolated villages. It turned out that the ferry is operating in a very unreliable way, causing a lot of frustration and anger among those who need it (see chapter D).

A second problem was the left lock chamber of the **Gabcikovo power plant** which, subsequent to an accident, had to be repaired and could be opened for navigation only in May 1993, i.e. not, as the EC Report is stating, in November 1992. Also, navigation was closed several times, especially on 29 days between 20 October and 30 November 1992.

The Cunovo bypass weir was originally designed for auxiliary purposes with a hydraulic capacity of 1.460 m3/sec (4 gates). However, after a few hours of operation, it proved to have a faulty design for the strong erosion activities at its downstream parts (9). Therefore, the weir's discharge is limited in all cases to 600 m3/sec, otherwise it could be destroyed by erosion.

Similarly, the original design of the adjacent Cunovo **inundation weir** (20 gates with 4.600 m3/sec discharge capacity) allowed only a few days use per year (during large floods). In fall 1992, it was still under construction and protected by a small earth dike. An "unexpected flood" on 25 November 1992 washed away the protection dike searching its way through the construction site back into the old river bed. Downstream of the weir, the flood caused major destruction of the unfinished bottom protection. Scour holes of 11 m developed locally and caves were formed underneath some downstream parts of the weir. Between 2 and 3 million m3 of soil, sand and gravel were eroded from the former floodplain(5). Two tainter gates (each 24 m long and 25 t heavy) were washed 2 km downstream onto Hungarian territory.

Until today, the repairing works and the redesigning of the weir for continuous use has made little progress; only four gates can be used at present. The reconstruction of the spillways of the 16 remaining openings is now planned by Slovak engineers to start only in May 1994. Other protection measures are scheduled to be completed in May 1994. Following the EC Report(5), the technical circumstances allow only a very limited discharge of, all together, 940 m3/sec through the bypass and inundation weirs. Following the Slovak engineer plans, only in the summer of 1996, the discharge capacity of the weir can be extended to 5.900 m3/sec. This is also (by chance?) the scheduled completion for the construction of new ship locks and a small power plant at Cunovo; for this "Phase II", financing is apparently very insecure.

In addition, the EC Reports (5) phrase "*the time schedule will depend on weather conditions*" reveals that new damages caused by, technically undesired, floods or ice going through this weir will probably not only delay the whole construction/repairing works, but could actually threaten the entire weir ("*it is necessary to inspect the fortifications each week and make frequent repair work*").

This explains why one of the remedial measures of the EC Working Group recommends the "*construction of an underwater weir at RKM 1845.5 for improving the operational reliability of water supply from the inundation weir (less maintenance of the spillway). ... Without this there is a large risk that the inundation weir spillway will be under repair most of the time.*"

The obvious inability of the Slovak side to quickly and satisfactorily bring this weir to an operational state over the last 11 months should be compared to the hasty construction of the entire "Variant C" scheme (new storage lake with dikes, new large diversion weir etc.) which has been achieved between November 1991 and October 1992 (= 11 months).

The EC Report's technical discussion of the possibilities to quickly enlarge the discharge capacities of this weir is very limited. The Report's recommendation that "*a design review be carried out by an independent, specialized institute*" **for river engineering is strongly emphasized by the WWF scientists and should be realized as soon as possible.**

This technical study should investigate whether the technical situation of the weirs allow more than the indicated volumes e.g through other, not discussed technical measures which can help to soon increase the discharge into the old river bed.

The sedimentation processes in the Cunovo storage lake were always stressed by Slovak side to be an important limit for a higher discharge of water into the Old Danube because a reduced discharge in the storage lake will enhance the undesired settling of sus*pended load. The new EC Report(4) confirms that "all bed load and 60% of the suspended bed load have settled in the reservoir"* and that the damming at Cunovo has high significantly disturbed the sedimentation/erosion balance in the Danube. It must be stated:

1. **The Slovak side now admits for the first time that this problem in the storage lake already exists.** Even the building of artificial islands in the storage lake cannot stop this process. Most-likely, detrimental biogeochemical processes inducing a threat for the groundwater quality have started and thus will probably threaten the drinking water wells near-by.

2. Beside finer bed sediments, there will be a clear deficite of transportable matter compared to the river's transport capacity in the Danube downstream of the reservoir. This will inevitably result in erosion processes downstream of both the Cunovo and the Gabcikovo weirs, similarly to such effects on other dams elsewhere.

This leads to the conclusion that still something has to happen in order to reduce or balance these negative processes, induced by the Gabcikovo scheme.

Modern river engineering knows only two alternatives:

* the construction of further dams downstream, i.e. especially the Nagymaros project which itself will result in the need to continue the building of more dams downstream, or

* measures to balance the transport capacity, like the continuous input of gravel (example: downstream the Iffezheim dam on the Upper Rhine) or the fortification of the river bed with large-sized gravel (example: downstream the Vienna-Freudenau dam in the Danube where this method is now being tested).

If politicians don't want to dam up the entire Danube they have to vote for the second option. This is where WWF's recommendations are aiming at (see chapter WWF Recommendations, esp. C,D).

D. Comments to the Social Situation of Local People

The question of local people suffering from the Gabcikovo scheme was discussed in the EC Reports only from the point of view of the Gabcikovo investor. It may be that the new road presently under construction between Dobrohost and Cunovo will soon open a new communication route with Bratislava.

However, the local people of the three villages use to mainly commute with their relatives and neighbors living in adjacent villages, now located on the other side of the canal. In addition, it is the near-by city of Samorin which serves them as a center for shopping, medical and administrative attention. The unreliable ferry service (it runs just once an hour due to limited fuel; its limited capacity often leads to long waiting times; it has to stop during fog, wind or ice) caused unacceptable travel times. Several workers even lost their job.

As a result, this new road will mainly serve those who (now develop an interest to) spend their week-end or recreation time in this area. Together with the new, permanent access to the entire wetland over the lateral dikes, the permanently filled-in water-ways, the hundreds of often illegally built week-end houses along the side-arms and the newly planned recreation areas at the gravel pits, **a total transformation/ alienation of the wetland character and of the traditional villages with their social structure is now being implemented from the outside:**This process is technocratically oriented ignoring local interests and ecological sensibilities. It must urgently be stopped.

To balance this, not only a much more limited access into the wetland, an active involvement of local people into the economic development of their region but also an investigation on how to improve their damaged life quality is needed. It is suggested to seriously consider the substitution of the ferry crossing the canal by a tunnel or a bridge near Vojka which could, at least partly, allow the native people to regain their former communication network.

Recommendations by WWF and Independent Scientists

A. Recommendations with Respect to the EC Reports

As stated above, WWF suggests to produce as soon as possible

* **a water quality study including**
  - *control sampling and analysis on the changes in* surface and groundwater quality,
  - changes of the underground currents and
  - potential impacts on the drinking water reservoir;

* **a river engineering study** investigating
  - the present state of the Cunovo scheme,
  - the technical possibilities and costs for the improvement of the discharge into the Old Danube and
  - the new variant to reduce the undesired sedimendation processes in the storage lake up- and downstream of the Cunovo weir through the construction of a small navigation route (see WWF recommendation C).

Each study should be worked out by an independent expert team also involving local, competent experts, providing that they can work independantly from the government and Gabcikovo operator.

B. Alternative Recommendations for the Future Water Regimes

WWF is aware of the fact that due to the present technical state of the Cunovo weirs, to the very short time up to the next vegetation period (March 1994) and to the difficult political situation it is hard to achieve significant improvements.

However, it is clearly a question of the European political interest how quickly the needed political negotiations will produce results and how much time will be allowed to pass by for the realisation of the urgently needed and hopefully agreed steps.

WWF tried to keep this "time problem" in mind when discussing and formulating the following recommendations. The scientists involved are convinced that this "gentle solution" can be achieved faster, cheaper and politically easier, than the "technical solution" the EC Mission's Working Group was able to agree on.

Priority objectives

Every new solution has to respect the following priority objectives:

1. **The reestablishment of the hydrological dynamics both**
   in the old river bed,
   in the side-arm system and
   in the floodplains.

   This means that the water level fluctuations in their amplitude (height-depth), number and duration, in the channels and in the floodplain, have to run in such a way as they were at least under pre-dam conditions, and at best before the serious gravel excavations started (i.e. 1960s). This automatically *entails the needed input of nutrients into the flood*plain.

   The water supply for the Old Danube is closely dependend of the upstream Danube discharge fluctuations, as measured at the Devin gauge.

2. **The restoration of the groundwater table dynamics**

   This is possible only under a non-restricted connection between the surface water and the aquifer.

3. **The reestablishment of a direct and non-inhibited connection between the river and the floodplain including the side-arms.**

   This will allow the migration of organisms and diaspores.

4. **The enhancement of the morphodynamics**

   Erosion and sedimentation are prerequisites for the habitat and biological dynamics of floodplains. They should be promoted to the largest extent possible.

5. **The restoration of self-purification processes**

   They have to be supported to the maximum extent in the entire floodplain and river area.

C. Short-term Solution

Based on the technically possible

* discharge minimum of 600 m^3/sec and
* maximum of at least 940 m^3/sec (more up to 1.500 m^3/sec depending on the technical possibilities of the Cunovo weirs and with respect to the Slovak legal order stated in the "19 Conditions" from June 1991),

WWF suggests as an urgent measure for the next two years, which are needed for the preparation of the long-term solution, instead of underwater weirs

the accumulation of sediment bodies in the old river bed in the form of gravel banks and islands.

The goal of this measure is to reduce the discharge area, which provokes a lifting of the water level and thus will even permit an inflow of Danube water into some of the side arms (whose closures have to be reopened again).

Even though this interim solution cannot balance the drawbacks of underwater weirs concerning the groundwater levels,

* it largely prevents upstream colmation and
* eutrophication,
* it preserves the river continuum and
* allows free migration of fish and other organisms in the river bed.
* In addition, it is no alien construction (like an artificial underwater weir) in the river bed, and uses authochtonous material from the river bed itself and from the banks. This measure does not disturb or change the typical environment for the river biocenoses.
* These sediment bodies allow an easy transition towards the needed long-term solution which is suggested in D.

These sediment bodies can easily be built up within a short-term of a few weeks **using the existing local gravel and sand deposits in the old river bed.**

Even moderate changes of these sediment bodies by erosion will not reduce their expected purpose and positive effects.

The design and planning preparation of the suggested measure can be accomplished within a few months.

Subsequently to this measure in the river bed, the lateral dikes especially in the Slovak floodplain and the bilateral closures between the side-arms and the Old Danube should be reopened (lowered) to the maximum extent which is ecologically supportive.

D. Long-term Solution

Starting from the above-mentioned facts

* that the previous, natural water level dynamics with all its positive effects for the floodplains and the groundwater have to be restored,

* that the discharge in the Old Danube realistically will remain below the former discharge,

* that at least the Slovak legal standards (as stated in the "19 Conditions" from June 1991 following § 14 of the Slovak Water Law) be fulfilled, but in their meaning of a dynamic discharge (cf. description in B) of 65 to 75 % of water

* that an acceptable compromise be found, orienting on the EC proposal from February 1993 (average discharge of 66%) which was already accepted by Hungary,

the compensation of the discharge deficite (25-35%) can only be achieved by

lifting and constricting the present river bed

which is entailed by a reduction of the existing discharge area.

The lifting and constricting of the river bed can be achieved by the deposition of gravel and small sized boulders in the old river bed. Similarly to the short-term solution, this measure includes the forming of islands and gravel banks. It is expected that a stretch of ca. 20-30 km downstream of Cunovo has to be filled up with a volume of one to two meters. For this purpose, an amount of ca. 5-10 million m3 gravel and boulders will be needed.

The origine of such material, its environmentally sound exploitation and transport still has to be investigated. In comparison to the amount excavated from the Danube alone on Slovak side (e.g. 50 million m^3 within 14 years) it becomes evident that the volume needed is realistic and technically feasible. The cover layer of this "new river bed" should be provided by gravel with locally typical size that can be acquired from the vicinity.

As a second WWF recommendation it is suggested that

the storage lake up- and downstream of Cunovo be reduced by new dikes to a navigation route.

The objective is to reduce the sedimentation and undesired biogeochemical processes in surface and groundwater of this artifical lake (which has no efficient sealing to the underground like the the power canal) to the minimum extent. This will reduce the potential water pollution threatening the near-by and downstream drinking water wells. The area in-between the new dikes parallel to the navigation route and the present lake dikes should be turned into restoration areas. If done in the appropriate way, these man-made biotopes can develop over the years into secondary wetland biotopes.

It is evident that the entire planning and realisation of this solution has to be examined thoroughly and in detail by an independent, international water engineering institute together with an ecological institute experienced in river management.

However, the preparation of this solution has to be started as soon as possible because it will require several years for its completion.

Opposite to other proposals this "gentle" solution offers a comprehensive approach to the river area. It wil help to limit and partly even reverse the detrimental changes induced by the Gabcikovo scheme. It will not only bring a long-term preservation of this floodplain ecosystem of European importance but it guarantees an improvement of the presently critical groundwater situation. It is a solution for the Danube and the base for an ecologically-oriented, economic development of the border region which is to serve the livelihood of poeple living on both sides of the river.

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