SPLNOMOCNENEC VLÁDY SLOVENSKEJ REPUBLIKY PRE VÝSTAVBU A PREVÁDZKU SÚSTAVY VODNÝCH DIEL GABČÍKOVO - NAGYMAROS

PLENIPOTENTIARY OF THE SLOVAK REPUBLIC FOR CONSTRUCTION AND OPERATION OF GABČÍKOVO - NAGYMAROS HYDROPOWER SCHEME

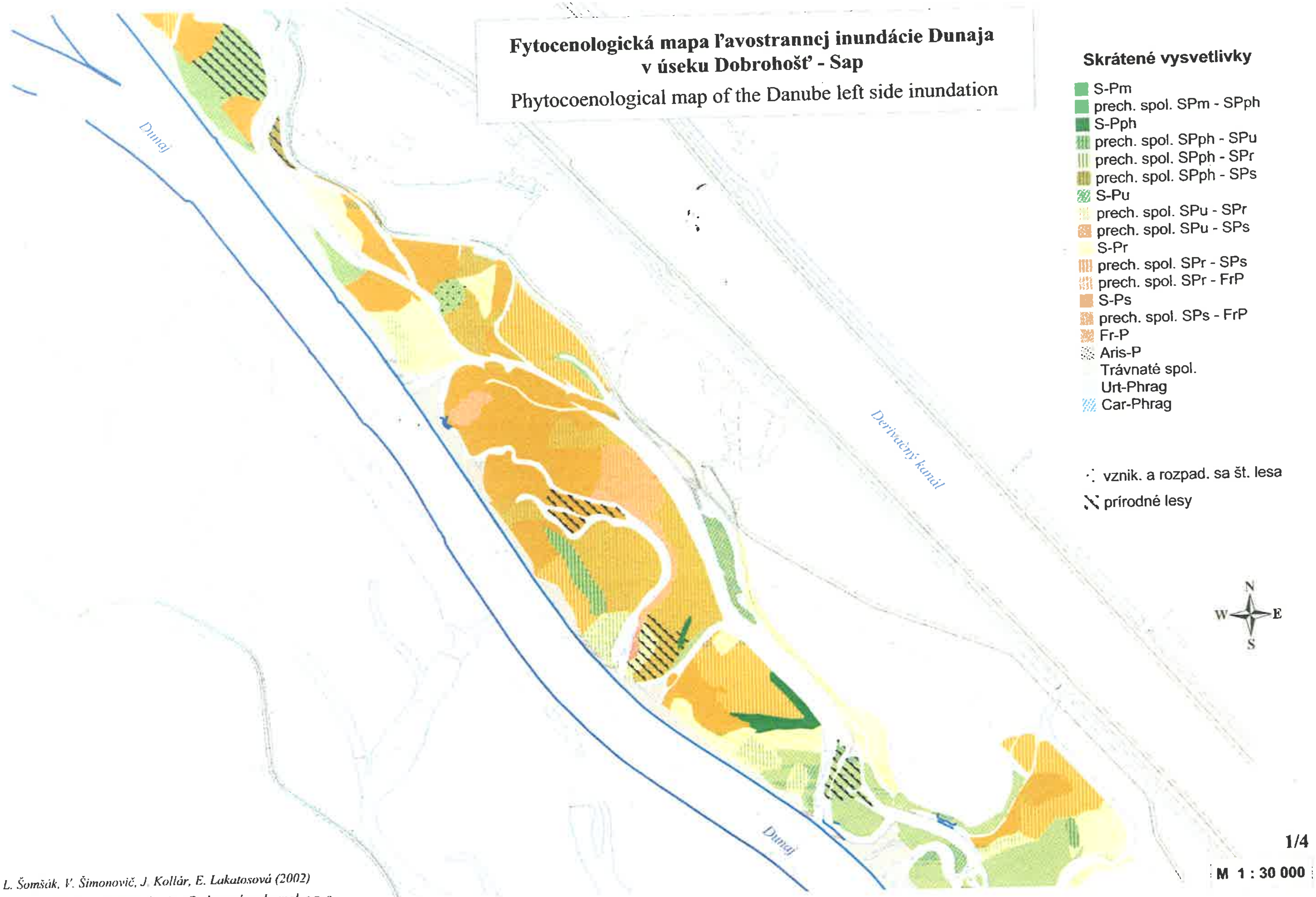
OPTIMALIZÁCIA VODNÉHO REŽIMU RAMENNEJ SÚSTAVY V ÚSEKU DUNAJA DOBROHOŠŤ - SAP Z HĽADISKA PRÍRODNÉHO PROSTREDIA

OPTIMALIZATION OF THE WATER REGIME IN THE DANUBE RIVER BRANCH SYSTEM IN THE STRETCH DOBROHOŠŤ - SAP FROM THE VIEWPOINT OF NATURAL ENVIRONMENT

Bratislava, September 2003

Fytocenologická mapa ľavostrannej inundácie Dunaja v úseku Dobrohošť - Sap

Phytocoenological map of the Danube left side inundation



Zostavili: L. Šomšák, V. Šimonovič, J. Kollár, E. Lakatosová (2002)

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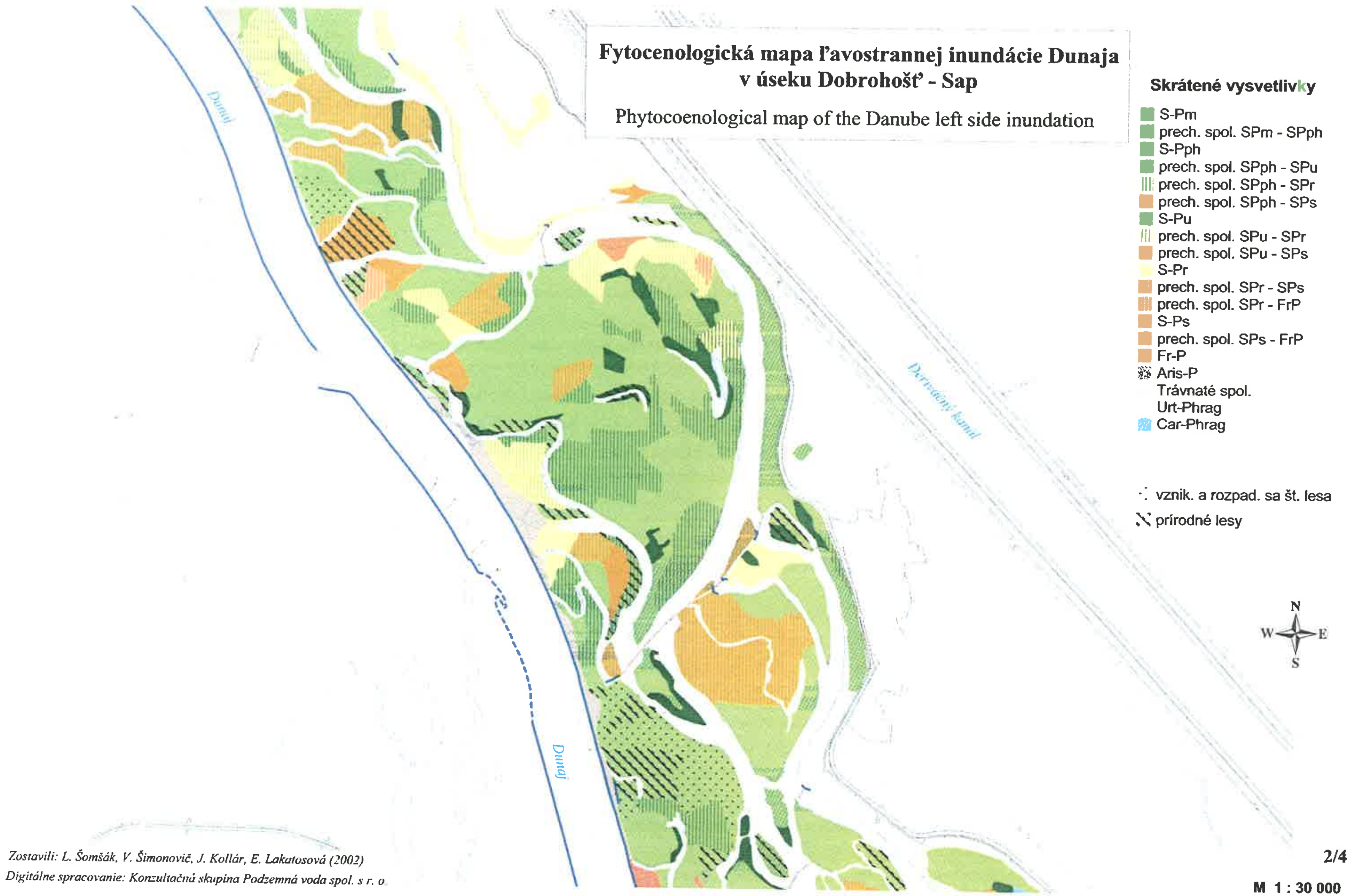
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Skrátené vysvetlivky
S-Pm
prech. spol. SPm - SPph
S-Pph
prech. spol. SPph - SPu
prech. spol. SPph - SPr
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S-Pu
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S-Pr
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Fr-P
Aris-P
Trávnaté spol.
Urt-Phrag
Car-Phrag
vznik. a rozpad. sa št. lesa
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N
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Dunaj
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Dunaj
2/4
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FACULTY OF NATURAL SCIENCES, COMENIUS UNIVERSITY, BRATISLAVA, SLOVAKIA
&
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Bratislava, September 2003

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Práca sa cituje ako celok nasledovne (prípadne v anglickom jazyku):

Lisický M., J., Mucha I., 2003: Optimalizácia vodného režimu ramennej sústavy v úseku Dunaja Dobrohošť – Sap z hľadiska prírodného prostredia, Prírodovedecká fakulta Univerzity Komenského v Bratislave. Monografia.

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Bohuš, M., 2001: Expertízne vyjadrenie k optimalizácii vodného režimu v inundácii. In Lisický M., J., Mucha I., (eds) 2003: Optimalizácia vodného režimu ramennej sústavy v úseku Dunaja Dobrohošť – Sap z hľadiska prírodného prostredia, Prírodovedecká fakulta Univerzity Komenského v Bratislave, Monografia.

PREDSLOV

Diskusia o vplyve sústavy vodných diel Gabčíkovo Nagymaros na prírodné prostredie začala dávno pred podpisom medzinárodnej Zmluvy v roku 1977. Príkladom môže byť „Beseda za okrúhlym stolom o Dunajských vodných dielach", ktorá bola v redakcii časopisu Životné prostredie a bola uverejnená v tomto časopise v čísle 4 v roku 1968 (Maňák, 1968). Už v tomto materiále sa hovorí o „bioprojektoch". Dr. Ružička (Ústav biológie krajiny, SAV) napríklad požaduje, začať súbežne s projektovaním vodných diel aj práce na bioprojektoch. Ing. Obložinský (Riaditeľstvo vodných tokov) za investorskú organizáciu potvrdzuje, že súčasťou sústavy vodných diel bude aj „Bioprojekt" (pozri URBION 1976). Prof. Matula (Prírodovedecká fakulta Univerzity Komenského) zdôrazňuje, že do popredia budú vystupovať hydrobiologické problémy a preto je treba zvoliť takú adaptáciu variantov, aby v súvislosti s režimom vodného diela bol najpriaznivejší režim podzemných vôd. Hovorilo sa aj o kvalite vôd v budúcej zdrži, ktorá bude závisieť aj od toho, či budú efektívne čistené odpadové vody z Viedne, Moravy a Bratislavy, vrátane Slovnaftu.

Návrh „Biologického projektu" (URBION 1976) obsahuje časti: Lesné hospodárstvo, Poľnohospodárstvo, Rybné hospodárstvo, Poľovníctvo, Hygienické pomery, Ochrana prírody, Návrh na využitie územia pre rekreáciu a cestovný ruch, Štruktúra a estetika krajiny, Priemysel. Bioprojekt bol doplnený a ukončený v roku 1986.

Koncom roku 1989 podpredseda vlády národného porozumenia SR V. Ondruš a minister lesného a vodného hospodárstva I. Veselý iniciovali širokú diskusiu o problematike prírodného prostredia na úrovni odborných vodohospodárskych a environmentálnych skupín. V tomto štádiu začali konštruktívne rozhovory a boli realizované mnohé návrhy na ochranu prírody. V roku 1992 začal projekt PHARE „Podunajská nížina – model podzemných vôd" (PHARE 1995), ktorého výsledky tiež prispeli k riešeniu mnohých otázok. V roku 1995 bola podpísaná Dohoda medzi vládou SR a vládou MR o niektorých dočasných technických opatreniach a prietokoch do Dunaja a Mošonského ramena Dunaja (AGREEMENT 1995), podľa ktorej sa realizuje aj spoločný slovensko-maďarský monitoring vplyvu prevádzky Vodného diela Gabčíkovo na prírodné prostredie po vybudovaní prelievanej prehrádzky pri Dunakiliti v rkm 1843 starého koryta Dunaja.

Existencia záplavového územia Dunaja s ramennou sústavou, dunajská inundácia, je založená na dynamike režimu prúdenia povrchových a podzemných vôd, na prietoku vody ramennou sústavou, na existencii všetkých typov ramien, od prietočných po neprietočné, až občas vysýchajúce terénne depresie, zazemnené staré ramená, mokrade a relikty mokradí. Pre Dunaj a jeho záplavové (inundačné) územie sú v prirodzených podmienkach typické viac menej pravidelne sa vyskytujúce vyššie prietoky v letných mesiacoch, občasne spojené so záplavami terénu, prínosom živín a sedimentov počas záplav, ohraničenie záplavového územia protipovodňovými hrádzami, ktoré zároveň oddeľujú toto záplavové územie od poľnohospodárskeho a obývaného územia. Vegetácii prospievajú aj vhodné klimatické podmienky s vysokým počtom slnečných dní, vysokou teplotou a zároveň, práve na jar a v lete, s vysokými hladinami v Dunaji a v podzemných vodách. Systém biotopov tohoto územia vznikol postupne v symbióze človeka s prírodným prostredím, po ohrádzovaní inundácie protipovodňovými hrádzami chrániacimi obývané a poľnohospodárske územie pred povodňami a po sústredení prietokov do jedného napriameného dunajského ramena, dnes známeho ako Dunaj. Tým vzniklo územie medzi ochrannými protipovodňovými hrádzami a Dunajom, ktorého hydrologický režim sa postupne zmenil na režim s podstatne vyššími rýchlosťami prúdenia vody, podstatne vyšším kolísaním hladín, s podstatne vyššími a častejšími záplavami medzihrádzového záplavového územia a trvalými prietokmi v ramenách aj pri nízkych prietokoch. Toto územie využívalo hlavne lesné hospodárstvo. Prísun štrkov z úseku Dunaja nad žulovým prahom pri Bratislave bol v minulosti vyšší, štrk a piesok sa ukladal pod Bratislavou v náplavovom kuželi, dno sa zvyšovalo a tiež hladiny vôd i podzemných vôd stúpali. Protipovodňové hrádze sa postupne zvyšovali. To bol stav od 19. storočia do 60-tych rokov 20. storočia, kedy začalo postupné uzatváranie ramien a oddeľovanie ramennej sústavy od hlavného koryta Dunaja. V skutočnosti sa hlavne kvôli plavbe voda sústredila do jedného koryta, koryto sa napriamilo, brehy opevnili, erózia dna sa zvýšila a tvoriace sa brody boli pravidelne vybagrované, a to aj nad Bratislavou. Prísun štrkov cez žulový prah (Devínsku bránu) sa postupne, vplyvom bagrovania plavebnej dráhy i vodných diel nad Bratislavou, zmenšoval. Koryto Dunaja pod žulovým prahom sa začalo prehlbovať. Dunaj stále viac strácal kontakt s ramennou sústavou a hladiny podzemnej vody rapídne klesali. Do takéhoto stavu, spôsobeného antropickou činnosťou a pod priamymi skúsenosťami s dvoma katastrofálnymi povodňami v roku 1954 a 1965 bola vyprojektovaná Sústava vodných diel Gabčíkovo-Nagymaros. Časť Gabčíkovo bola uvedená do prevádzky pomocou stupňa Čunovo v októbri 1992.

V súčasnosti, po desaťročných skúsenostiach a poznatkoch z prevádzky VDG a osemročnom spoločnom slovensko-maďarskom monitorovaní vplyvov na prírodné prostredie je vhodná doba nahradiť nerealizované zámery Bioprojektu i nerealizované zámery splnomocnencov vlád a Spoločného zmluvného projektu novým pohľadom a návrhmi na ochranu a zveľaďovanie prírodného prostredia vychádzajúcich z dnešného skutkového stavu. Cieľom bolo bez emócií, v konštruktívnom duchu, s využitím dostupných podkladov a skúseností, akceptovaním rôznorodých stanovísk, vlastníckych, národných, nadnárodných záujmov, načrtnúť optimalizáciu vodohospodárskeho, environmentálneho a komerčného usporiadania a ochrany vzácneho ekosystému zachovanej Dunajskej záplavovej oblasti – inundácie Dunaja. Dovoľujem si vysloviť presvedčenie, a to aj na základe štúdie „Prognóza stavu hladín povrchových a podzemných vôd v podmienkach bez vybudovania vodného diela Gabčíkovo (MUCHA I., BANSKÝ Ľ., et al., 2001), že bez existencie dnešného stavu s funkčným vodným dielom Gabčíkovo by sme nemohli hľadať optimálne riešenie vodného režimu pre inundáciu, ale starali by sme sa o protipovodňovú ochranu Žitného ostrova, o zabezpečenie plavby od Bratislavy po Sap, a bezmocne by sme sa dívali na vyschnuté dunajské ramená, premeny lužného i komerčného lesa a hlboko zaklesnuté hladiny podzemných vôd na hornej časti Žitného ostrova a Szigetközu so všetkými dôsledkami na poľnohospodársku výrobu. Možno to dokumentovať na vývoji hladín podzemných vôd v oblasti Rusovce – Čunovo, kde bola 8. novembra 2002 vyhlásená prírodná rezervácia Dunajské ostrovy (Všeobecne záväzná vyhláška Krajského úradu v Bratislave č. 7/2002 z 8. novembra 2002). Ako odôvodnenie je napísané: "zabezpečenie ochrany biotopu lužného lesa a biotopu mokradí ako typického rázu lužnej krajiny". Z **obrázkov 0.1** a **0.2** je možné vidieť, že keby sa boli bývali od novembra 2000 opakovali tie prietoky, ktoré reálne nasledovali po novembri 1978, potom v roku 2012 (dvadsať rokov po prehradení) by priemerná hladina vody v Dunaji v Bratislave bola o 2.82 m nižšie ako bude so vzdutím. V Rusovciach by to bolo o 6.07 m menej. Z **obrázku 0.3** je možné vidieť, že bez vodného diela v roku 2012 by pokles hladín podzemnej vody v oblasti Rusoviec bol 4.41 a 3.83 m, teda približne o 4 m. Tieto výsledky sú vypočítané na základe zmien, ktoré nastali za obdobie 20 rokov pred uvedením vodného diela Gabčíkovo do prevádzky a za predpokladu, že intenzita týchto zmien by pokračovala nezmenená, keby vodné dielo nebolo bývalo uvedené do prevádzky. Na základe týchto skutočností a predpokladov si dovolím poznamenať, že bez uvedenia vodného diela do prevádzky nebola by bývala vznikla ani prírodná rezervácia Dunajské ostrovy, ako "rezervácia na zabezpečenie ochrany biotopu lužného lesa a biotopu mokradí ako typického rázu lužnej krajiny".

V rámci prípravných prác pre túto publikáciu bola v roku 2001 vypracovaná podkladová štúdia nazvaná „Optimalizácia vodného režimu ramennej sústavy z hľadiska prírodného prostredia", ktorá sa skladá z dvoch častí. Prvú časť tvoria hlavne podklady o povrchovej a podzemnej vode pre prírodovedných a ekologických expertov. Túto časť vypracovali: I. Mucha, Ľ. Banský, Z. Hlavatý, D. Rodák.

Druhú časť tvoria názory a stanoviská nasledujúcich ekologických expertov:

- **Bohuš M.**: Expertízne vyjadrenie k optimalizácii vodného režimu v inundácii
- **Bulánková E.**: Epifauna v oblasti VD Gabčíkovo. Vážky (Insecta: Odonata)
- **Cambel B.**: Expertízne vyjadrenie k optimalizácii vodného režimu v inundácii. Téma: Optimalizácia vlhkostného režimu pôdy v inundácii Dunaja.
- **Čejka T.**: Gabčíkovo waterwork and changes in the land snail fauna on the Middle Danube, Slovakia.
- **Halgoš J.**: Vplyv umelých záplav na štruktúru komárov (Culicidae) a muškovitých (Simuliidae) v oblasti DVD.
- **Holčík J.**: Ryby slovenského úseku Dunaja.
- **Holecová M.**: Fytofágne chrobáky (Coleoptera, Curculionoidea) vegetačného lemu dunajských ramien na území ovplyvnenom VD Gabčíkovo.
- **Illyová M.**: Expertízne vyjadrenie k optimalizácii vodného režimu v inundácii. Zooplankton litorálu v Dunaji a jeho ramenách.
- **Izsák G.**: Expertné vyjadrenie k optimalizácii prírodného prostredia v inundácii Dunaja od Čunova po Sap.
- **Košel V.**: Optimalizácia prietokových pomerov v Dunaji z ramenách so zreteľom na permanentný zoobentos.
- **Kovačovský P.**: Expertízne vyjadrenie (vodné a dravé vtáky).
- **Krno I.**: Expertízne vyjadrenie k optimalizácii vodného režimu v inundácii Temporálna epifauna (Ephemeroptera, Plecoptera, Trichoptera).
- **Kubalová S.**: Močiarna vegetácia stojatých a tečúcich vôd. (Expertízne vyjadrenie k optimalizácii vodného režimu v inundácii Dunaja).
- **Lisický M., J.**: Expertné vyjadrenie k optimalizácii vodného režimu ramennej sústavy z hľadiska prírodného prostredia.
- **Matis D.**: Ekologické dopady výstavby Dunajského vodného diela.
- **Neštický Š., Varga L.**: Optimalizácia vodného režimu ramennej sústavy z hľadiska lesného hospodárstva. Expertízne vyjadrenie k optimalizácii vodného režimu v inundácii.
- **Oťahelová H.**: Expertízne vyjadrenie k optimalizácii vodného režimu v inundácii. Makrofytná vegetácia stojatých a tečúcich vôd.
- **Pachinger K.**: Zmeny v spoločenstve mikromamálií na území ovplyvnenom výstavbou vodného diela Gabčíkovo – doklady, úvahy, perspektívy.
- **Rác.P.**: Zmeny ornitocenóz počas výstavby a po uvedení VD Gabčíkovo do prevádzky.
- **Šomšák L.**: Optimalizácia vodného režimu ramennej sústavy z hľadiska prírodného prostredia – expertízne vyjadrenie.
- **Šporka F.**: Expertízne vyjadrenie k optimalizácii vodného režimu v inundácii. Polychaeta, Oligochaeta, Amphipoda a Isopoda v inundácii
- **Štepanovičová O.**: Vplyv výstavby VD Gabčíkovo na štruktúru taxocenóz bzdôch (Heteroptera) v epigeóne lužného lesa.
- **Šustek Z.**: Potenciálny stav spoločenstiev bystruškovitých a možnosti zlepšenia ich súčasného stavu v oblasti dotknutej VD Gabčíkovo.
- **Uherčíková E.**: Expertízne vyjadrenie k optimalizácii vodného režimu v inundácii Dunaja. Časť: Lesné fytocenózy v inundácii.

- **Vilinovič K.**: Vodný režim inundácie Dunaja z hľadiska trvalo udržateľného rozvoja.
- **Vranovský M.**: Expertízne vyjadrenie k optimalizácii vodného režimu ramenných sústav Dunaja medzi Dobrohošťou a Sapom s ohľadom na rozvoj mediálneho zooplanktónu.

Títo experti a ich príspevky sú zahrnuté a publikované v tejto štúdii v nasledujúcej forme: (Autor, rok, a v literatúre označené poznámkou: in Optimalizácia 2001).

Na základe týchto podkladov a ďalších prispievateľov editori a ko-editori: **M. J. Lisický, I. Mucha a M. Bohuš, L. Jedlička, M. Kozová, I. Krno, I. Országh, L. Šomšák, F. Šporka**, zostavili túto publikáciu. Názory jednotlivých prírodovedných a ekologických expertov k optimalizácii vodného režimu v inundácii vychádzali z ich osobných skúseností a poznatkov, z ich vedeckej práce a často dlhodobého monitorovania predmetného prírodného prostredia. Ich názory sú ovplyvnené špecifickým predmetom monitorovania a výskumu. Názory sú preto rozdielne, odrážajú aj rozdielne osobné stanoviská. Na druhej strane názory všetkých expertov sa snažia o vyjadrenie spoločných priorít a konvergujú a prispievajú k spoločnému stanovisku: **v prostredí inundácie treba vytvoriť a udržať čo najprírodnejšie podmienky v súlade so základnými funkciami hydrologicky funkčnej inundácie.**

Na tomto mieste si dovoľujem poďakovať všetkým autorom, prispievateľom i zostavovateľom a editorom za nesmierne úsilie, ktorého výsledkom je táto štúdia. Štúdia si kládla za cieľ vysvetliť základné princípy najlepšieho spôsobu optimalizovania záplavového územia, hlavne z hľadiska vodného režimu, tak, aby bola podkladom pre návrhy na konečné usporiadanie tohoto úseku Dunaja pri ďalších rokovaniach s maďarskou stranou a pri navrhovaní ďalších riešení, v snahe o čo najlepšie poňatie ochrany prírodného prostredia zo všetkých možných hľadísk, ale hlavne z hľadiska vodného hospodárstva a ochrany typických biotopov záplavového územia.

Táto štúdia otvára priestor na rozpracovanie alternatívnych návrhov riešení a orientáciu samosprávnych orgánov pri usmerňovaní prevádzkovateľov Vodného diela Gabčíkovo pri manipulovaní s vodami a pri rozhodovaní o vodohospodárskych, hospodárskych, turistických a iných ľudských aktivitách v medzihrádzovom záplavovom území. Štúdia zároveň aj vysvetľuje a argumentuje ako ďalej ekologicky rozmýšľať a postupovať pri navrhovaní vodohospodárskych zámerov. V neposlednej miere tento spoločný príspevok má prispieť k vytvoreniu čo najlepšieho integrovaného manažmentu vo funkčnej inundácii a následne k integrovanému manažmentu krajiny pri Dunaji.

Ing. Dominik Kocinger
Splnomocnenec vlády SR

1 ÚLOHA A CIEĽ TEJTO ŠTÚDIE

Úlohou tejto štúdie je **definovať stav, ktorý sa z ekologického a ekosozologického hľadiska môže považovať** pre systém rieka a jej záplavové územie (inundačné územie) **za optimálny** (rešpektujúc limity, ktoré predstavujú najmä požiadavky protipovodňovej ochrany a existencia Vodného diela Gabčíkovo) a odporúčať spôsob ako takýto stav dosiahnuť. Úlohou je tiež navrhnúť zásady spôsobu regulácie takéhoto stavu, hlavne vodohospodárskymi metódami (vodný režim a regulačné zariadenia). V tejto úlohe je konečným cieľom pripraviť z ekologického hľadiska čo možno najlepšie návrhy zlepšenia vodného režimu pre ekosystém tohoto inundačného územia, a to hlavne pomocou optimalizácie vodného režimu jeho priblížením k prírodnému. Ide aj o definovanie kritérií, ktorými sa na základe monitorovania prírodného prostredia zistí, nakoľko sa výsledky uskutočňovaných opatrení približujú predstavám o optimálnom stave. Pri zostavovaní štúdie boli využité aj rokovania so zainteresovanými subjektami a aj s maďarskou stranou.

Zadanie úlohy bolo stanovené v podstate v dvoch úrovniach. Prvou je definovať stav, ktorý sa z ekologického hľadiska a z hľadiska prírodnosti biotopov môže považovať pre inundáciu za optimálny, a to bez ohľadu na spôsob ochrany a realizácie optimalizácie (dlhodobý cieľ). Druhá úroveň je kvalita ekotopu a biotopu, ktorú si z ekologického hľadiska želáme dosiahnuť a je reálne dosiahnuteľná predovšetkým riadením režimu vodnej zložky prírodného prostredia. O tejto druhej úrovni sa viedli a budú sa viesť aj medzinárodné rokovania v zmysle rozsudku Medzinárodného súdneho dvora, pričom musia byť rešpektované špecifické štátne záujmy oboch strán.

Pri definovaní postupu prác treba vedieť nielen aký stav prostredia je možné z ekologického hľadiska považovať za optimálny, ale aj poznať kritériá, ktoré takýto stav charakterizujú a poznať etapové možnosti ako sa k takémuto stavu dopracovať. Druhá úroveň si kladie za úlohu definovať stav prírodného prostredia (a kritériá jeho dosiahnutia), ktorý je možné dosiahnuť vedomým usmerňovaním a v prípade potreby aj riadením vodného režimu. Zároveň je potrebné definovať monitorovateľné kritériá, ktoré hodnotia plnenie dosiahnutia takto normovaného stavu. Pritom sme si vedomí faktu, že napriek dôležitej úlohe vodného režimu, existuje celý rad ďalších antropogénnych vplyvov, ktoré v území inundácie nie je možné zanedbať, a ktoré môžu byť v rozpore so záujmami ochrany prírodného prostredia. Za také môžeme považovať lesné hospodárstvo, rybné hospodárstvo, poľnohospodárstvo, rekreáciu, vlastnícke vzťahy, hospodárske záujmy obcí a jednotlivých vlastníkov pozemkov a pod. Štúdia sa diskusiám o stretoch záujmov nevyhýba. Z toho vyplýva potreba odsúhlasenia priorít pri riešení stretov záujmov. Okrem toho je potrebné hľadať účinné opatrenia na elimináciu nežiadúcich negatívnych javov, akými sú napr. pytliactvo, vytváranie nelegálnych skládok, divoká rekreácia a turistika a iné formy narušovania a znečisťovania prírodného prostredia, čo však nie je predmetom tejto štúdie.

Pre prirodzené dunajské inundačné územie je charakteristický veľmi špecifický, dynamicky sa meniaci systém akvatických, semiakvatických až terestrických ekotopov predstavujúcich biotop pre rozmanité špecializované druhy, ako aj paletu patričných biocenóz. Počínajúc nosným typom, ktorý predstavuje eupotamál v hlavnom toku a prietočných ramenách, cez parapotamál a plesiopotamál, zaplavované a nezaplavované terestrické ekosystémy (od mokradí cez lúky, mäkké luhy, až po tvrdé luhy a miestami aj lesostep). **Určujúcim a riadiacim mechanizmom takýchto ekosystémov v priestore a čase je predovšetkým režim vodnej zložky prostredia**, ktorý chceme vedome, v priestore a čase, upraviť podľa dnešných najlepších vedomostí. Pritom **všeobecným cieľom má byť stav blízky prírodnému.**

Cieľom úprav vodného režimu celého systému, starého koryta Dunaja, simulovaných záplav v ramennej sústave a ďalších úprav v inundácii je predovšetkým na základe doterajších poznatkov, monitorovania a ekologickej syntézy:

- podporiť prírodné procesy typické pre prírodné záplavové územie pri rešpektovaní protipovodňových funkcií, ktoré v skutočnosti inundáciu formujú, t.j. zabezpečiť aj bezpečné prevedenie povodňových prietokov a prevedenie ľadov medzi stupňom Čunovo a obcou Sap,
- vodným režimom podporiť stav biologickej diverzity blízky prírodnému, t.j. odpovedajúci veľkej stredoeurópskej rieke a jej záplavovému územiu s prietočnou ramennou sústavou a všetkými typmi vodných útvarov,
- podporiť priestorovo a časovo premenlivú rozmanitosť ekosystémov zodpovedajúcu prírodným pravdepodobnostným vzťahom prírodných fenoménov typických pre záplavové územie s prietočnou ramennou sústavou,
- podporiť podmienky pre sukcesiu spoločenstiev typických pre občasne zaplavované územie, a tým aj podporiť zabezpečenie patričnej biodiverzity nielen ako funkcie priestoru, ale aj ako funkcie času, teda podporiť čo najväčšiu dynamickú rovnováhu ekosystémov vychádzajúcu z plôškovej dynamiky v čase a priestore,
- podporiť zachovanie prirodzenosti a obnovu prírodnosti inundačnej oblasti, ktorá je založená na vodnom režime a vlhkostných pomeroch a na ich časovo priestorových sledoch,
- podporiť taký stav, ktorý odpovedá konektivite rieky pred oddelením ramennej sústavy,
- zabezpečiť, aby voda v hlavných ramenách nestagnovala, aby jej kvalita bola dobrá, lepšia ako pred prehradením Dunaja, zabezpečiť, aby v priestoroch vhodných na využívanie podzemnej vody nebola ohrozená kvalita podzemnej vody stojatou vodou v ramenách,
- simulované záplavy robiť vtedy, keď je vo vode dostatočné množstvo plavenín a ak sa prirodzene vyskytne jarná záplava, manipulačným poriadkom prispieť k čo najvyššiemu obsahu živín vo vode (po postupnom dosiahnutí

prirodzeného stavu simulovanie záplav sa bude zmenšovať a stanú sa skôr výnimočné v zvláštnych prípadoch, prípadne podporou prirodzených záplav),

- zabezpečiť, aby sa vodný režim v inundácii čo najviac podobal vo vlhkostných pomeroch a tiež v slede vodných stavov a záplav prírodným podmienkam odpovedajúcim dunajským prietokom, ale nekolidoval vo vybraných častiach územia so záujmami dlhodobo udržateľného lesného hospodárstva.

Po posúdení údajov o výskyte flóry, vegetácie a o pestovaní lesov, cieľom optimalizácie môže byť zabezpečenie prirodzeného rozvoja vodných, močiarnych, brehových (litorálnych), kriačinových a lesných spoločenstiev inundácie, odpovedajúcich hydropedologickému režimu konca 50-tych a začiatku 60-tych rokov. Z týchto rokov existuje vyhovujúca dokumentácia o štruktúre a synekologických vlastnostiach lužných lesov, vrátane ich vtedajšieho hydropedologického režimu, ku ktorému je potrebné priblížiť ciele „optimalizácie". Ostatná flóra sa bude vyvíjať v súlade s hydropedologickým stavom vyhovujúcim lužným ekosystémom.

Z hľadiska lesného hospodárstva bude potrebné vo vybraných častiach inundácie vodný režim prispôsobiť potrebám dobrého zdravotného stavu prevládajúcich lesných drevín a porastov, ako aj snahe po maximálnom drevnom prírastku porastotvorných drevín, za súčasného zachovania ostatných funkcií lesa. Časť lesnej pôdy bude treba ponechať na sukcesívnu obnovu prírodného lesa a postupne ju zväčšovať. V prípade, ak sa ekosystém inundačného územia postupne bude prevádzať do stavu s fungujúcimi samoregulačnými procesmi, bude pravdepodobne potrebné zohľadniť aj súčasný rozsah a rozmiestnenie intenzívne obhospodarovaných hospodárskych lesov.

Prehľad o súčasnej krajinnej štruktúre je znázornený na **Obr. 1.1**.

2 CHARAKTERISTIKA ÚZEMIA

2.1 PREDMET ŠTÚDIE

Posudzovaným územím optimalizácie vodného režimu je staré koryto Dunaja a jeho ľavostranné inundačné územie s ramennou sústavou od obce Dobrohošť (rkm 1842) po Sap (rkm 1811) (**Obr. 2.1**). Inundačné územie leží od Dunaja po pôvodné ochranné protipovodňové hrádze.

2.2 HISTÓRIA

Historické zmeny v dunajskom prírodnom prostredí sú výsledkom geologického vývoja a častých zmien klimatických pomerov vo štvrtohorách. Treba sem zahrnúť aj intenzívny pohyb štrkov a pieskov v Dunaji, prehlbovanie a dvíhanie riečneho koryta, tvorenie a putovanie riečnych meandrov (kľukatenie rieky), ukladanie nánosov, eróziu a zmeny brehovej čiary a časté záplavy územia.

Prvá komplexná etapa budovania ochranných protipovodňových a regulačných opatrení na Dunaji sa realizovala v rokoch 1759-1914. Hlavná plavebná kineta, ktorá sa v zásade odvtedy používa, sa vytvorila reguláciou toku, ktorá začala v r. 1831 a bola dokončená v posledných rokoch 19. storočia (**Obr.2.2**). Dnešné vedenie protipovodňových hrádzí a neprirodzené, kvôli plavbe napriamené koryto, boli realizované po povodni v roku 1853. Tak vzniklo dnešné inundačné územie, o ktorom v tejto štúdii hovoríme. Povodeň v roku 1954 po pretrhnutí pravostrannej hrádze zdevastovala veľkú časť ostrova Szigetköz v Maďarsku (DUB 1954). O rozsahu katastrofy svedčí fakt, že polovica Szigetköz bola zaplavená a voda v Bácsi (okres Győr) stúpla až do výšky okien prvého poschodia domov. Povodeň v roku 1965 zaplavila dolnú časť Žitného ostrova na Slovensku. Plocha zaplaveného územia v roku 1965 bola 71700 ha poľnohospodárskej pôdy, 114000 ha pôdy bolo zamokrených, bolo zničených 3910 domov a evakuovaných 53693 obyvateľov (HRONEC, 1969), (**Obr. 2.3**). Protipovodňová ochrana územia pod Bratislavou bola zahrnutá do projektu Gabčíkovo-Nagymaros.

Dunaj veľmi prispel k rozvoju podunajských štátov. Je to rieka, ktorá bola intenzívne využívaná lodnou dopravou, pre zásobovanie vodou, na lovenie rýb, vodou pre poľnohospodárstvo, inundáciou pre pestovanie lesov, a od pradávna aj ako strategická vojenská hranica. Dunaj je od prvej polovice minulého storočia využívaný aj na výrobu elektrickej energie a na získavanie iných úžitkov. Niet pochybností o tom, že každé takéto využitie Dunaja, ale aj každá prírodná zmena, vplýva na prírodné prostredie. Rovnako niet pochybností o tom, že ak sa zasiahne do toku, ako sa to stalo v projekte výstavby Sústavy vodných diel Gabčíkovo – Nagymaros, vplýva to na prírodné prostredie, z niektorého hľadiska pozitívne a z iného negatívne. Toto platí pre všetky projekty a ľudské činnosti. Moderná technológia, ktorá umožňuje realizovať komplexné vodohospodárske projekty, obsahuje aj metodiku monitorovania, databázového spracovania, interpretácie a hodnotenia vplyvu na prírodné prostredie, s cieľom vyhnúť sa, kompenzovať, zmenšiť alebo napraviť takéto nepriaznivé vplyvy. Slovenskí ekológovia spolu s ochrancami prírody ako aj neskôr nezávislí experti EÚ (Európskej únie) (CEC 1992) vo svojej správe o zistených faktoch konštatovali, že „redukovanie prietoku v Dunaji má nepriaznivý vplyv na prírodné prostredie, pokiaľ nebudú realizované správne opatrenia" (**Foto 3,4**).

Rozsudok Medzinárodného Súdneho Dvora (INTERNATIONAL COURT OF JUSTICE, 1997) konštatuje, že Projekt Sústavy vodných diel Gabčíkovo - Nagymaros „nebol len spoločným investičným projektom na výrobu energie, ale slúžil aj iným cieľom, ako zlepšenie plavby na Dunaji, ochrana pred povodňami, prevádzanie ľadov a ochrana prírodného prostredia". Derivačný kanál bol postavený mimo inundačného územia (na rozdiel od všetkých ostatných priehrad na Dunaji) **Obr. 2.1.** Nezávislí experti Pracovnej skupiny Komisie Európskeho spoločenstva vo svojej správe z 23. novembra 1992 (CEC 1992) k tomu konštatovali: "V minulosti vykonané zásahy pre plavbu obmedzili možnosti pre rozvoj Dunaja a jeho inundačného územia. Za predpokladu, že hlavné riečne koryto sa nebude viac používať na plavebné účely, vznikla unikátna situácia. S podporou technických opatrení sa rieka a záplavové územie môže vyvíjať prirodzenejšie ". Okrem toho na oboch stranách Dunaja boli vybudované objekty na trvalé zásobovanie Malého Dunaja, Mošonského Dunaja a ramenných sústav vodou. Predpokladalo sa, že hladina vody v starom koryte Dunaja sa technickými opatreniami udrží na úrovni podobnej akú mal Dunaj pred prehradením pri prietokoch okolo 1400 – 1500 m^3/s. Starým korytom Dunaja sa dnes nazýva úsek Dunaja medzi Sapom, rkm 1811,0 až Čunovom, rkm 1851,75, o dĺžke 41,75 km, v ktorom po prehradení koryta pri Čunove chýba prevažná časť prietokov odvedená derivačným kanálom na vodnú elektráreň Gabčíkovo (**Obr. 2.1**). V súčasnosti starým korytom Dunaja preteká prietok v zmysle Dohody z roku 1995 od 250 do 600 m^3/s vody, a počas povodní podstatne viac.

V správe Trojstrannej komisie na zistenie faktov Európskeho spoločenstva z 31. októbra 1992 sa objavuje formulácia: "neuvedenie sústavy do prevádzky by viedlo ku značným finančným stratám a viedlo by ku vzniku vážnych environmentálnych problémov" (FFM, 1992). Tieto environmentálne problémy vychádzali zo zistenia, že v dôsledku predchádzajúcich úprav na Dunaji, hlavne kvôli zabezpečeniu plavby pri malých prietokoch a pre zabezpečenie protipovodňových opatrení, koryto Dunaja postupne poklesávalo a poklesávala aj hladina podzemnej vody, **Obr. 01, 02, 03.** Tieto závery, ako aj ďalší pokles hladín podzemných vôd a vysýchanie ramennej sústavy, so všetkými negatívnymi dôsledkami na prírodné prostredie, bez vybudovania Vodného diela Gabčíkovo, sa potvrdili aj v štúdii Prognóza stavu hladín povrchových a podzemných vôd v podmienkach bez vybudovania vodného diela Gabčíkovo

(MUCHA, BANSKÝ, et al., 2001). Podľa expertov Komisie Európskeho spoločenstva (CEC 1992) prietok vo všetkých riečnych ramenách existoval pred prehradením v priemere iba počas 17-tich dní v roku.

2.3 PRÍRODNÉ POMERY

Gabčíkovská časť Sústavy vodných diel Gabčíkovo-Nagymaros leží v centrálnej časti medzihorskej depresie, v dunajskej kotline, nazývanej Podunajská nížina (Danubian Lowland). Dunajská kotlina je vyplnená usadeninami mladších treťohôr (morskými a jazernými pieskami, jemným pieskom, ílom, pieskovcom a bridlicami) a štvrtohôr (od mindelu už dunajským riečnym pieskom a štrkom sedimentujúcim v aluviálnych podmienkach Dunaja) usadzujúcich sa v riečnych alebo jazerných podmienkach. Celková hĺbka štvrtohorných a treťohorných usadenín je až 8000 m, pričom vrchné dunajské riečne sedimenty (od mindelu) vytvárajú hlavnú zvodnenú vrstvu zloženú z vysoko priepustných štrkov a pieskov. Hrúbka dunajských riečnych sedimentov sa pohybuje od niekoľkých metrov pri Bratislave, do viac ako 450 metrov pri Gabčíkove. Ďalej po prúde pod obcou Sap, v smere na Komárno, opäť klesá na hrúbku niekoľkých metrov. Pod touto vrstvou sa nachádza súvrstvie málo až takmer nepriepustných starších kvartérnych (pred mindelom) a hlavne treťohorných sedimentov.

Dôležitým faktorom pri transporte dunajských sedimentov je existencia žulového prahu medzi Alpami a Karpatami v oblasti Bratislavy, s výstupmi žuly do riečneho dna. Podobné kamenné, predovšetkým andezitové, prahy sa nachádzajú aj od miest Štúrovo-Ostrihom po Visegrád-Nagymaros, približne 160 km pod Bratislavou. Obidva skalné prahy predstavujú pre vodný tok prírodné geologické bariéry, stupne alebo prahy. Tesne pod Bratislavou, pod žulovým riečnym prahom, sa od Dunaja oddeľujú toky dvoch jeho ramien - Malého Dunaja na slovenskej strane a Mošonského Dunaja na maďarskej strane. Tieto dve ramená ohraničujú spolu s Dunajom dva podobné ostrovy - Žitný ostrov na Slovensku a Szigetköz v Maďarsku. V tomto priestore, do ktorého je situovaná gabčíkovská časť projektu Sústavy vodných diel Gabčíkovo-Nagymaros, medzi Bratislavou a Medveďovom, Dunaj v minulosti vytvoril "vnútrozemskú deltu" (v geologickej literatúre opisovanú ako náplavový kužeľ). V tomto priestore Dunaj kedysi meandroval a rozvetvoval sa a usadzoval náplavový kužeľ, približne od Malého Dunaja až za Mošonský Dunaj. Táto vnútrozemská delta má svoju svojskú morfológiu: riečne meandre, akumuláciu hrubozrnných štrkov a pieskov a ich eróziu, zmeny sklonu riečneho dna a podobne. Tento veľký náplavový kužeľ pozostáva z extrémne priepustných a rozsiahlych zvodnených vrstiev, schopných zachytávať a transportovať veľké množstvá podzemnej vody. Dunaj tečie na povrchu tohoto kužeľa (**Obr. 2.4**). Voda z Dunaja preniká do náplavového kužeľa a prúdi ako podzemná voda pozdĺž Dunaja a smerom k Malému a Mošonskému Dunaju. V dolnom úseku, tam kde sklon rieky zrazu klesne na štvrtinu oproti sklonu pri Bratislave (**Obr. 2.5**), podzemná voda prúdi späť do Dunaja cez jeho dno, ramená, prítoky a odvodňovacie kanále (**Obr. 2.6**). Všetko toto je výsledkom zníženej priepustnosti a hrúbky zvodnenej vrstvy poniže Gabčíkova, čo je zase spôsobené tým, že andezitový prah pri Nagymarosi spomalil prúdenie a zmenil nad sebou sedimentačné podmienky Dunaja a k nim sa pripojila aj sedimentácia hlavne rieky Váh (Kolárovská formácia).

Na tomto úseku Dunaja, od Bratislavy po Sap, boli jeho brehy opevnené a po oboch jeho stranách boli v minulosti vybudované protipovodňové hrádze medzi ktorými tečie napriamený Dunaj a existuje aj časť dunajských ramien (**Obr. 2.1**). Aj v súčasnosti sa počas vysokých prietokov dostane voda z Dunaja až k týmto hrádzam. Z prírodného a ekologického hľadiska sa územie považuje za veľmi cenné, unikátne a hodné zachovania jeho pôvodných funkcií. Okrem toho má toto inundačné územie aj nenahraditeľné funkcie ako je prevádzanie povodňových prietokov, prirodzenú funkciu poldra, ktorou sa znižujú maximálne prietoky počas povodní, čo sa významne prejavuje aj v nižších maximálnych prietokoch Dunaja v smere toku. Územie má vhodné podmienky na rast prirodzených lužných lesov i komerčnú produkciu dreva. Je esteticky i turisticky atraktívne a v prípade, ak v riečnych ramenách tečie voda, zabezpečuje aj funkciu „samočistiacich procesov“ čistenia riečnej vody.

Po uvedení nápustného objektu do ramennej sústavy inundačného územia pri Dobrohošti do činnosti sa hydrologický režim priblížil stavu ku koncu 60-tych rokov. Bolo to konštatované po porovnaní dynamiky hladiny podzemných vôd z roku 1953 (JURKO 1958) s rokmi 1992-2000 (MUCHA et al., 2001). Neplatí to o drénovanom páse pozdĺž starého koryta a o celom komplexe lesov pod gabčíkovským prístavom. V súhrne preto možno konštatovať, že napriek ozdravným hydropedologickým opatreniam je vodný režim sčasti nepôvodný. Ide približne o 30 % územia lužných lesov, kde je tento stav možné zlepšiť dnovými prehrádzkami, variabilitou prietokov a osobitným režimom zavodňovania širšieho okolia Istragova.

Pôvodné vŕbovo-topoľové lužné lesy, ktoré boli dominantnou časťou vegetácie tohto územia, majú približne z 80 % ich rozlohy zmenenú drevinovú skladbu v prospech rozmanitých šľachtencov topoľov, menej aj vŕb. Len 15 – 20 % rozlohy týchto lesov má prírodnú drevinovú skladbu a to hlavne v menej dostupných porastoch (ostrovčeky, depresie). Bylinný podrast väčšiny dospelých (25-30 ročných) topoľových monokultúr nevykazuje veľké odchýlky od pôvodného floristického zloženia. Potvrdilo to porovnávanie fytocenóz pôvodného lesa a monokultúr urobené v roku 2001 v polesí Gabčíkovo (KRAJŇÁKOVÁ 2001). Bylinný porast je poznamenaný inváziou nepôvodných druhov z rodov *Aster*, *Solidago* a *Impatiens*, pričom neprítomnosť, resp. nedostatočnosť záplav túto inváziu podporuje.

I keď o nelesnej vegetácii existuje len veľmi málo starých podkladov, môžeme ju, pokiaľ ide o brehové jednoročné spoločenstvá riečneho litorálu považovať za pôvodnú (prírodnú), kým kosené lúky a pasienky sú pochopiteľne antropogénne.

Pre detailné posúdenie bola vypracovaná podrobná fytocenologická mapa (1:25000 a 1:10.000) (ŠOMŠÁK et al., 2001, 2002, 2003), ktorá je podkladom pre všetky odbory bioty, ale aj pre posúdenie vplyvu existujúceho, či optimálneho vodného režimu. Táto mapa (ŠOMŠÁK et al., 2003) je tiež pracovným podkladom pre rokovania o implementácii Rozsudku Medzinárodného Súdneho Dvora (INTERNATIONAL COURT OF JUSTICE, 1997).

2.4 PRÍRODNOSŤ, FUNKČNOSŤ A ODVODENOSŤ EKOSYSTÉMU

Pri posudzovaní kvality súčasného stavu akéhokoľvek ekosystému a vývoja, akým k nemu dospel, musíme rozlišovať **prírodnosť, prirodzenosť** a antropicky podmienenú, alebo priam **antropogénne vzniknutú umelosť**. Pri posudzovaní ekosystému rieka-zaplavované územie treba okrem toho vedieť, že ide o azonálny ekologický systém, v ktorom je rozhodujúcim faktorom hydrologický režim.

Aj keď sa názory odborníkov líšia pri posudzovaní toho čo možno považovať za prírodné, teda pôvodné a človekom neovplyvnené a do akej miery je pri antropických zásahoch potlačovaná prirodzenosť, ako aj kde leží hranica medzi prirodzeným a umelým, teda antropogénnym, keďže **aj človek je v konečnom dôsledku len jeden z prírodných druhov** biosféry, existujú isté pragmatické, konvenčne stanovené hranice. Všeobecná zhoda panuje v tom, že ak trváme na kritériu pôvodnosti ako absencii akéhokoľvek ľudského vplyvu, potom pôvodné ekosystémy v súčasnosti prakticky neexistujú, nakoľko minimálne antropogénnymi zmenami atmosféry je priamo či nepriamo ovplyvnená celá biosféra. Naviac, antropogénne ovplyvnený je aj globálny kolobeh vody. Ak však antropický vplyv neponímame takto fundamentalisticky, potom je možné hovoriť o zvyškoch pôvodných ekosystémov v regiónoch, ktoré neboli nikdy v histórii ľudstva súčasťou ekumény, ktoré teda človek priamo nikdy neovplyvňoval, a to ani extenzívnym využívaním. Potom je možné hovoriť napríklad o zvyškoch pôvodných lesných ekosystémov v Južnej Amerike či na Sibíri (pralesoch), kým v Európe ide v najlepšom prípade o pralesovité porasty, ktoré sa vyvinuli po ukončení ľudských zásahov spontánne ako prirodzené. Ako **kritérium** takejto **prirodzenosti** možno použiť práve **zachovanie základných funkčných väzieb ekosystému, ktoré zaručujú jeho spontánnu obnovu po ukončení antropického tlaku**. Takéto prirodzené ekosystémy sa prirodzeným vývojom znova približujú ku kvalite prírodných, z ktorých sú odvodené, možno ich teda označiť aj ako **„blízke prírodným"**, nie však ako pôvodné.

V prípade rieky a jej ohrádzovaného záplavového územia dochádza bez ohľadu na ďalšie hospodárenie či nevyužívanie tohto územia k zásadnej zmene hydrologického režimu. Vplyv záplav sa z väčšiny pôvodnej plochy odstránil, množstvo vody však ostáva rovnaké, a preto je dynamika vodného režimu rádovo intenzívnejšia. Ohrádzované záplavové územie má potom nepôvodnú ekologickú valenciu, tak v hydrologických ako pedologických (a najmä pedogenetických) parametroch. Táto zmenená prirodzenosť vedie k vytvoreniu odvodeného ekosystému, ktorý je odlišný od pôvodného a ponechaný sám na seba neobnovuje kvalitu pôvodnú, ale adaptívnu. Jeho vývoj je totiž usmerňovaný obmedzením, ktoré predstavuje udržiavaná protipovodňová ochrana priľahlého územia.

Antropické zásahy do ekosystémov vedú obvykle k vytvoreniu ostrovčekov prirodzených ekosystémov, ktorých ďalší vývoj a prežívanie sú pri výraznom obmedzení pôvodnej plochy silne ovplyvňované exogénne. V prípade rieky a záplavového územia dochádza k inverzii, kedy prvotný exogénny (antropický) zásah vedie k trvalej podpore endogénneho faktora, ktorý sa po silnej redukcii pôvodnej plochy („spútaní") stáva pre existenciu ekosystému dominantným! V ekosystéme ohrádzovaného záplavového územia sa posilňuje selekcia organizmov smerom k stenotopnosti, viazanej práve na tento typ hydrologického režimu a tvorby pôd. Ak teoreticky pripustíme návrat do stavu bez protipovodňových hrádzí, neprišlo by k samoobnovovaniu ekosystému, ktorý býva v záplavovom území po niekoľkých storočiach existencie hrádzí považovaný za blízky prírodnému či pôvodnému. Naopak ak, znovu teoreticky, pripustíme stav, keď tento dominantný faktor v území vylúčime, akokoľvek benevolentne chápaná prirodzenosť ekosystému sa stráca a jeho prežitie sa stáva závislým na lesohospodárskej pestovateľskej činnosti. Z lesa prirodzeného sa stáva les umelý, neschopný samoobnovy.

Tieto úvahy sa týkajú nielen terestrických, ale aj veľkej časti semiakvatických spoločenstiev. Naproti tomu vodné spoločenstvá možno v regionálnom pohľade považovať za pôvodné, len čiastočne narušené prenikaním, alebo vysadením viacerých nepôvodných druhov živočíchov. Zmeny všetkých štyroch typov potamonu sa týkajú podielu ich zastúpenia vo vodnej biote vyplývajúcich z historických, najmä však recentných antropogénnych hydrogeomorfologických zmien.

Súčasná miera odvodenosti a nepôvodnosti prírodného prostredia v predmetnom území je výsledkom predovšetkým lesníckych, plavebných, vodohospodárskych ale aj poľnohospodárskych a ďalších antropických zásahov. Čím viac ideme do minulosti, tým je prírodnosť ekosystému vyššia a pre oblasť inundácie typickejšia. **Z hľadiska funkčnosti dnešnej inundácie nemôžeme sa vrátiť dozadu pred obdobie, kedy boli postavené protipovodňové hrádze. Pre ďalšie porovnávanie a úvahy o revitalizácii preto považujeme za vhodné približne 50. roky 20. storočia.**

2.5 VÝCHODISKOVÝ STAV

Rieka Dunaj so svojim ramenným systémom za ostatné storočia prekonala veľké zmeny. Splavné ramená pôvodného toku boli opakovane zanášané hrubými vrstvami naplavenín, čím sťažovali lodnú dopravu. Vtedajší užívatelia dunajskej plavby sa preto začiatkom 19. storočia rozhodli pôvodné plavebné koryto odkloniť doprava, čiže približne do terajšej trasy hlavného toku. Plavbe sa tým pomohlo, ale zároveň došlo k zániku bohatej ramennej sústavy okolo terajšej trasy Malého Dunaja. Okrem toho nové prietočné rameno – teraz nové koryto rieky – odvádzalo hlavné masy vôd do územia, ktoré už predtým predstavovalo skultivovanú poľnohospodársku krajinu. Masy vôd okolo nového toku a jeho ramien zlikvidovali provizorné ochranné hrádze, pustošili sídliská, ničili úrodu, strhávali cesty a zamokrovali pôdu. Sústredená výstavba ochranných hrádzí po obidvoch brehoch nového toku, ktorá bola dokončená koncom 19. storočia, mala stlmiť ničivú silu vôd roztekajúcej sa po celej južnej polovici Žitného ostrova, ale aj Szigetközu.

2.5.1 Flóra a vegetácia

Vegetácia lužných ekosystémov je zákonite viazaná na hydropedologické podmienky ovplyvnené riekou, v tomto prípade Dunajom. Platí to o všetkých typoch rastlinstva, t.j. od fytocenóz vyslovene vodných cez močiarne a brehové typy až po kriačinnú a lesnú vegetáciu. Je to zároveň vegetácia veľmi dynamická, ktorá v porovnaní s klimazonálnymi typmi rastlinstva sa dokáže v priebehu relatívne krátkeho obdobia prispôsobiť meniacim sa podmienkam vodného režimu a sukcesívne vytvoriť stabilné ekosystémy.

Odklon a napriamenie rieky a výstavba ochranných hrádzi podstatne zasiahli do pôvodného režimu vôd Dunaja. Zároveň však mali nedozierne následky pre preformovanie sa rastlinstva. Odstavenie vôd pretekajúcich okolo Malého Dunaja podnietilo zarastanie mnohých mŕtvych ramien, čo vyústilo do vzniku zaujímavých spoločenstiev hydro-hygrofytov. Na ich floristické bohatstvo, i keď už značne antropicky pozmenené, poukázal HEJNÝ (1960). Žiaľ, mnohé z nich rozsiahlymi odvodňovacími prácami Žitného ostrova koncom päťdesiatych rokov 20. storočia zanikli.

K druhým významným zmenám došlo v medzihrádzovom priestore nového toku Dunaja a jeho ramien, čiže i v terajšom záujmovom inundačnom území. Záplavy sa tu znásobili a búrlivosť ich vôd narástla. Pretrvávanie takého stavu po niekoľko desaťročí začalo selektívne pôsobiť na celé rastlinstvo, preukazne však na lužné dreviny. Tvrdé listnáče ako je dub letný (*Quercus robur*), menej i jaseň úzkolistý (*Fraxinus angustifolia*) častú prítomnosť takýchto vôd neznášali a z inundačných území medzihrádzového priestoru postupne vymizli. Na ich miesto nastúpili vŕby a to predovšetkým vŕba biela (*Salix alba*), menej i vŕba krehká (*Salix fragilis*) a topole (*Populus nigra, Populus alba, Populus x canescens*). Vŕbovo-topoľové lesy tu existovali aj predtým, avšak v podstatne menšej rozlohe.

Zmena rastlinstva sa dotkla aj nelesnej a vodnej vegetácie. Niekdajšie úseky mŕtvych ramien sa v inundačnom území s častejšími a mohutnejšími záplavami stali prietočnými (eupotamon) a nedovoľovali vznik a existenciu rastlinstva stojatých vôd. Vodná vegetácia mala zabezpečené existenčné podmienky len v ramenách, ktoré boli iba občas prietočné (plesiopotamal) – OŤAHEĽOVÁ (2001). Jej rozvoj ale rapídne začal vo vnútri nížiny a v ramenách odstavených ochrannými hrádzami (paleopotamon). Vývoj brehovej (litorálnej) vegetácie nadväzujúcej na stojaté vody tu bol plošne výraznejší, ale s mnohými prvkami sezónnosti, vyplývajúcimi z kolísania hladín v ramenách (KUBALOVÁ 2001).

K takýmto pomerom inundácie sa lužné ekosystémy v priebehu 50. až 70. rokov dokonale prispôsobili. Preto prvú komplexnú informáciu venovanú pôdne ekologickým pomerom a lužným lesom Podunajskej nížiny (JURKO 1958) možno považovať za takú, ktorá charakterizuje približne 50. roky 20. storočia, kedy ešte stav narušenia „prirodzeného" prostredia nebol tak intenzívny. Pri posudzovaní ďalších zmien tento stav vo väčšine prípadov považujeme za východiskový, predstavujúci vegetáciu blízku prírodnej (nie však pôvodnú v pravom slova zmysle) . Žiaľ o vodných a močiarnych spoločenstvách inundácií z tohto obdobia máme len strohé poznámky (JURKO 1958).

K ďalším zmenám vodného režimu došlo po rozsiahlych úpravách hlavného koryta rieky spojeného s plavbou a aj s protipovodňovou ochranou v 70. rokoch. Bagrovaním štrku z dna Dunaja na slovenskej i maďarskej strane malo za následok pokles hladiny vody v rieke, a aj hladín podzemných vôd. Tendencia klesajúcej hladiny vody bola neustále udržiavaná pokračujúcou eróziou dna rieky aj pričinením vodných stavieb na rakúskom a nemeckom úseku Dunaja a bagrovania v Dunaji nad Bratislavou.

Pokles hladín podzemných vôd ešte pred výstavbou VD bol citeľný zvlášť v hornej časti Žitného ostrova hneď pod Bratislavou, najmä v biskupickom regióne, smerom k Čunovu klesal, ale citeľný bol aj v terajšom inundačnom území. Keďže v inundácii sa už v rokoch úprav koryta Dunaja rozkladali rozsiahle monokultúry šľachtených euroamerických, ale aj našich topoľov, dopad poklesu podzemných vôd tu bol na lesy a ich spoločenstvá menej signifikantný. Už vtedy (dávno pred výstavbou vodného diela) však došlo k poklesu prírastku lesných drevín v úzkom pobrežnom páse Dunaja, najmä na štrkových brehoch (drenážny efekt – ŠOMŠÁK et al. 1995). Citeľnejší dopad mala úprava koryta na vodné močiarne typy vegetácie ramennej sústavy inundačného územia. Väčšina ramien bola prietočná len pri zvýšených stavoch vody. Nepravidelnosťou prietokov v ramenách však došlo k plošným zmenám medzi spoločenstvami typu plesiopotamon, parapotamon a eupotamon. Podľa osobných skúseností z tohto obdobia tu prevládali spoločenstvá typu plesiopotamon. Tento predpoklad potvrdzujú i novšie výskumy (OŤAHEĽOVÁ 2001, KUBALOVÁ 2001, SVOBODOVÁ 1994, MATIS 2001).

Pripravovaná výstavba Sústavy vodných diel Gabčíkovo – Nagymaros si vyžiadala podrobný floristický výskum celého Podunajska. Touto inventarizáciou tu bolo zistených 959 taxónov cievnatých rastlín. Rozbor viazanosti na stanovištné (fytocenotické) skupiny ukazuje (ŠOMŠÁK 1999), že z tohto počtu len jedna tretina (311 taxónov) je takých, ktorých život limitujú podzemné a záplavové vody. Sú to vodné a močiarne rastliny (97 druhov), brehové populácie (litorálna, limózna a terestrická ekofáza) so 70 druhmi a nakoniec rastliny, ktorých životný cyklus je viazaný na lužné lesy a kriačiny (194 taxónov). Medzi ostatnými je však obrovský podiel takých druhov, ktoré dokážu a v skutočnosti aj existujú i vo fytocenózach mimo aluviálnych nív (*Urtica, Glechoma, Alliaria, Symphytum, Rubus, Poa, Viola, Gagea, Sambucus, Lythrum, Lysimachia* a mnohé iné).

Ostatné druhy známe zo spomínanej inventarizácie sa viažu na také stanovištia, ktoré nie sú a ani neboli ovplyvňované vodami Dunaja. Sú to napr. druhy xerotermných štrkov (180 taxónov), populácie ruderálnych stanovíšť (190 populácií), obilnín a okopanín (89 taxónov), introdukované druhy (72 taxónov) a neofytné populácie (43 druhov). Stručne povedané až 68,7 % zistených druhov tu existuje bez závislosti na vodách Dunaja (ŠOMŠÁK 1999). Z ekosozologického hľadiska je však najvýznamnejších práve zvyšných 31%.

Popri analýze fytogenofondu boli navrhnuté i určité opatrenia tak, aby výstavbou vodného diela došlo len k minimálnym stratám (BERTOVÁ et al., 1986). Na prvom mieste išlo o rozšírenie počtu maloplošných chránených území, ktoré popri existujúcich prírodných rezerváciách budú chrániť celkové stanovištné podmienky vrátane tej vegetácie, ktorej súčasťou sú príslušné druhové populácie. Na úseku Bratislava – Hrušov bolo navrhnutých 9 maloplošných chránených území (BERTOVÁ et al., 1986), v terajšej inundácii 7 (Dunajská Sihoť, Šulianske ramená, Kráľovská lúka, Bodícke ramená, Bačianske ramená pri Bake, Istragov a Riečina (Erčéd). Pre sledovanie osudu flóry po výstavbe VD v úseku inundácie boli vyzdvihnuté dva druhy, a to bleduľa letná (*Leucojum aestivum*) a kotvica kužeľoplodá (*Trapa conocarpa*). Posledný predstavuje nový druh pre flóru Slovenska a jeho výskyt bol zaznamenaný v mŕtvom ramene pri Kráľovskej lúke /Bodíky (**Foto 55**).

Napriek týmto teoretickým opatreniam v priebehu prípravných prác pred výstavbou VD došlo k citeľnému zásahu do genofondu rastlín, a to na prvom mieste k zmenšeniu areálu mnohých populácií zabratím pôdneho (lesného i nelesného) fondu pre Hrušovskú zdrž, derivačný a odtokový kanál, priesakové kanály a i., (**Foto 47**).

Údaje o flóre tohoto územia sa tesne pred plánovaným uvedením vodného diela Gabčíkovo do prevádzky spresnili podrobnou inventarizáciou spojenou so zakladaním monitorovacích plôch. UHERČÍKOVÁ (2001) ich uvádza v počte 760 taxónov. Ako uvádza autorka už pred spustením prevádzky VD Gabčíkovo tu chýbali viaceré taxóny vzácnych a ohrozených rastlín, ktoré tu boli zaznamenané v 50. rokoch 20. storočia (*Hottonia palustris, Gratiola offinalis, Senecio paludosus, Veronica catenata, Sagittaria sagittifolia*). Zachovali sa tu však lokality s početným výskytom úplne chráneného druhu *Leucojum aestivum*.

Lesné hospodárstvo realizuje svoje zámery v inundačnej oblasti na rozlohe okolo 3100 ha lesa. Táto rozloha bola od 60-tych rokov len nepatrne pozmenená, a to dokonca jej zväčšovaním. Od 60. rokov dochádzalo k zakladaniu veľkoplošných monokultúr do vopred pripravenej pôdy. V mnohých prípadoch sa zalesnili aj bývalé mŕtve ramená, do ktorých sa počas vytláčania pňov a iných pozostatkov po ťažbe dreva nahrnula skrývka. K hlavným drevinám ako je vŕba biela, vŕba krehká, topoľ čierny, topoľ biely, topoľ sivý sa už v 60. rokoch pridávali kultúry cudzokrajných topoľov. Už okolo roku 1956 sa ich rozloha pohybovala okolo 27 % z existujúcej rozlohy lesov (JURKO 1958). Od roku 1956 sa ich plošný podiel prudko zvyšoval a už okolo roku 1981 dosahovala v dunajských lužných lesoch okolo 80 % (VOJTUŠ 1986). V prvých začiatkoch to boli kultivary *Populus deltoides* – „monilifera“ a *Populus x euroamericana* – „robusta“ a neskôr i rajonizovaný klon „I-214“ vyšľachtený v Taliansku (NEŠTICKÝ, VARGA 2001).

Lesnícky výskumný ústav Zvolen – Výskumná stanica Gabčíkovo už od roku 1956 zakladal v tomto území pokusné plochy. Ich cieľom však bolo overovanie lesopestovateľských zásahov do monokultúr šľachtených drevín (východiskový spon pri zalesňovaní, intenzita výchovných zásahov) a nie ekologický monitoring. Zo získaných poznatkov rozmanitých klonov topoľov a vŕb od začiatkov ich cieleného pestovania až do prehradenia Dunaja sa však potvrdil predpoklad, že ide o dreviny a porasty tolerantné voči menším zmenám vodného režimu (VARGA 1993, NEŠTICKÝ, VARGA 2001). Za pestovanie euroamerických topoľov a ich kultivarov sa prihovárala aj nezvyčajne vysoká produkcia drevnej hmoty. Prvé merania signalizovali ročný prírastok až 25 m^3/ha. Pokles prírastku drevnej hmoty signalizovali len porasty ľavobrežného pásu Dunaja medzi Čunovom a Sapom. Dendroekologické bádania tohto úseku však potvrdili pokles prírastkov dávno pred prehradením Dunaja (bagrovanie dna rieky – ŠOMŠÁK et al., 1995).

Na základe dostupných literárnych prameňov, ale aj z autentických poznatkov Šomšáka z týchto rokov, možno stav inundačného územia Dobrohošť – Sap pred prehradením Dunaja charakterizovať nasledovne:

- Rozsiahly komplex vŕbovo-topoľových lesov (*Salici-Populetum*) so všetkými subtypmi prispôsobenými rôznym hladinám podzemných vôd, avšak s podstatne zmenenou drevinovou skladbou, kde pôvodné dreviny boli nahradené veľkoplošnými monokultúrami euroamerických topoľov iných šľachtencov.
- Zvyšky pôvodných (prírodných) vŕbovo-topoľových spoločenstiev zachovaných v terénnych depresiách a na ťažko dostupných ostrovčekoch (asi 10 % porastovej plochy, **Foto 25, 35**).
- Nepatrná (mozaikovitá) rozloha spoločenstiev prechodného lužného lesa (*Fraxino angustifoliae – Populetum albae*) v podiele asi 11.4 % porastovej plochy.
- Úzky pobrežný pás degradujúcich lesných porastov na štrkovitých laviciach fungujúcich ako drén, vytvorený prehĺbením koryta po ťažbe štrku z Dunaja (asi 3 % porastovej plochy).
- Vysokostebelnatá močiarna vegetácia na čiastočne zazemnených, len občas prietočných ramenách (**Foto 37**).
- Nepatrná rozloha vodno-močiarnej vegetácie typu paleopotamon na odrezaných ramenách (Istragov, Erčéd, Kráľovská lúka, **Foto 48-61**).

- Sezónna, jednoročná vegetácia obnažených brehov ramien závislá na dobe obmývania (**Foto 14, 16**).

2.5.2 Terestrická fauna

Terestrické živočíšne spoločenstvá inundačnej oblasti (ale aj ďalších častí Podunajska snáď s výnimkou xerotermných) sa v minulosti študovali len sporadicky a o väčšine z nich chýbajú údaje, ktoré by umožňovali načrtnúť stav pôvodných zoocenóz dotknutého územia. Väčšina prác z obdobia pred monitoringom je orientovaná faunisticky, prípadne na základné ekologické otázky, napríklad väzbu na pôvodné, neraz už pozmenené alebo zaniknuté biotopy (ŠTEPANOVIČOVÁ 1995). Pri definovaní pôvodného stavu spoločenstiev terestrických živočíchov záujmového územia Podunajska možno vychádzať len čiastočne z údajov získaných priamo z tejto oblasti pred uvedením VD Gabčíkovo do prevádzky, ich informačná hodnota je však obmedzená, pretože aj vtedajší stav bol výsledkom vyše storočného radikálneho zasahovania do hydrologického režimu aluviálnych ekosystémov. Konzistentné dáta boli získané až od začiatku monitoringu bioty v roku 1990, v súvislosti s výstavbou a prevádzkou vodného diela Gabčíkovo (JEDLIČKA et al., 1999). Za relatívne pôvodný stav môžeme považovať zoocenózy zvyškov lužných lesov v medzihrádzovom priestore v úseku Sap – Čičov (**Foto 62, 63**), ktoré bývajú aj v súčasnosti zaplavované a zásobované priesakovou vodou, a štruktúrou sa najviac podobajú pôvodným spoločenstvám najvlhších typov mäkkých lužných lesov, súdiac podľa prevahy polyhygrofilných druhov adaptovaných na podmienky cyklického klimaxu. Pri rekonštrukcii východiskového stavu či zloženia taxocenóz pred prehradením Dunaja a odvedením vôd do derivačného kanála koncom roka 1992 je možné sa čiastočne opierať aj o údaje o zoocenózach z blízkych lokalít alúvií riek Moravy, Malého Dunaja a Váhu. Uvedené materiály môžu slúžiť tak na definovanie prírodného stavu ako aj jednotlivých stavov spoločenstva, viac alebo menej blízkych prírodným.

Terestrická fauna a zoocenózy v inundácii sú typické pre vnútrozemskú deltu Dunaja s bohatou sieťou riečnych ramien a stojatých vôd súvisiacou s ukladaním transportovaných častí a meandrovaním rieky a častými záplavami. Tento dynamický systém je špecifickým komplexom ekosystémov vodného, pôdneho a suchozemského prostredia a tomu zodpovedajúcich ekotonov, v terestrickej časti Phragmition, Magnocaricion elatae, Caricion gracilis, Oenanthion aquaticae, Elatino-Eleocharition ovatae, Chelidonio-Robinion, Lolio-Potentillion, Salicion albae, Ulmenion, Asparago-Crataegetum. Jednotlivé spoločenstvá predstavujú katenu pozdĺž vlhkostného gradientu súvisiaceho s výškou a kolísaním hladiny podzemných vôd a existenciou sezónnych záplav. Celý systém patrí k typu cyklických klimaxov udržiavaných cyklickým hydrologickým režimom rieky a celého územia. Zmeny hladiny podzemných vôd a záplav s následnými zmenami vlhkostného gradientu môžu vyvolať zmeny kateny od jednoduchých posunov v priestore až po posun ku xerickým spoločenstvám a vymiznutie hygrofilných spoločenstiev. Dominantným faktorom ovplyvňujúcim prirodzené spoločenstvá je teda hladina podzemnej vody súvisiaca s infiltráciou z hlavného koryta. Špecifické podmienky ekosystému podmieňujú existenciu špecializovaných druhov adaptovaných morfofyziologicky, životnými cyklami a stratégiou na prežívanie v podmienkach cyklického klimaxu. V zoocenózach sa podstatnou mierou prejavujú druhy ekologicky špecializované, ktorých existencia mimo týchto podmienok spravidla nie je možná. Rovnako je však ohrozená aj v situácii, ak zmeny podmienok sú síce v hraniciach ich ekologickej tolerancie, avšak umožňujú prenikanie široko tolerantných druhov, ktorým špecializované druhy nie sú schopné konkurovať. Existencia vysoko špecializovaných druhov sa prejavuje v sformovaní špecifických zoocenóz, udržiavaných a podmienených práve podmienkami vnútrozemskej delty s cyklickými katastrofami.

V plochých nížinných alúviách sa vytvárali charakteristické spoločenstvá s vysokými nárokmi na vlhkosť, ktoré vďaka šírke nivy neboli v relatívne širokom pásme infiltrované mezohygrofilnými druhmi. K vzájomnému prelínaniu druhov dochádzalo až vo väčšej vzdialenosti od toku, prípadne až na samotnom okraji nivy. Šírku tohto prechodného pásma určovala konfigurácia terénu a vzájomný kompetičný tlak druhov oboch ekologických skupín. Poloha tohto pásma však nebola stála, ale dynamicky sa menila podľa výkyvov vodnatosti toku. Táto situácia umožňovala, podľa zmien polohy koryta, rozsahu záplav a výšky hladiny podzemnej vody na jednom mieste rýchle alternovanie rôznych, ale vždy prírodných spoločenstiev. Ide o situáciu, aká bola v dávnej minulosti typická pre rozsiahle nížinné územia, teda aj pre oblasť širšieho okolia VD Gabčíkovo.

Formovanie tohto prirodzeného gradientu spoločenstiev v záujmovej oblasti obmedzujú protipovodňové hrádze, ktoré odrezali od prirodzeného hydrologického režimu časť lesných porastov v mimohrádzovom priestore. V dôsledku toho sukcesia spoločenstiev v mimohrádzovom priestore má predpoklady smerovať k mezohygrofilným spoločenstvám lesných geobiocenóz normálneho hygrického radu, prípadne pri narušení integrity porastu k spoločenstvám nelesných ekosystémov. Naopak časť spoločenstiev v užšom medzihrádzovom priestore je pravdepodobne vystavená intenzívnejšiemu mechanickému pôsobeniu záplav usmernených do pomerne úzkeho koridoru a zbavených možnosti rozliať sa do odľahlejších častí alúvia. Jeden i druhý stav sa teda odlišuje aspoň na časti sledovaného územia od stavu, ktorý tu panoval v prírodnej, alebo človekom len zanedbateľne zmenenej krajine.

Zoocenózy ako spoločenstvá konzumentov a reducentov sú v celom sledovanom území viazané na (JEDLIČKA et al., 1999):

a) amfibické a prechodné spoločenstvá asociácií *Rorippo - Agrostietum stoloniferae*, *Rorippo amphibiae - Oenanthetum aquaticeae*, *Eleocharitetum palustris*, *Glycerietum maximae*, *Phalaridetum arundinaceae*, *Phragmitetum communis* a *Potametum perfoliati*, *Caricetum gracilis*,

b) mäkké lužné lesy *Salici-Populetum* v rôznych podtypoch a stupni pôvodnosti,
c) prechodné lužné lesy *Fraxino angustifoliae – Populetum albae,*
d) tvrdé lužné lesy *Fraxino angustifoliae – Ulmetum* (Platí len pre časť lesov nad prehradením Dunaja),
e) dunajskú lesostep *Asparago-Crataegetum.*

Taxocenózami, ktoré veľmi dobre dokumentujú nielen stav ale aj vývoj zoocenóz, sú malakocenózy. Je známe, že taxocenózy mäkkýšov (Mollusca) prešli v kvartéri zložitým sekulárnym vývojom (LOŽEK 1955), súčasné spoločenstvá sa formovali postupne v mladšom holocéne (cf. CHEBEN a kol. 2001) avšak pravdepodobne na omnoho rozsiahlejšom území, takže dnešný pás v medzihrádzovom priestore je len ich zvyškom. Podľa doterajších nálezov holocénnej malakofauny je pravdepodobné, že približne v oblasti dnešnej obce Vrakúň kedysi prebiehala hranica oddeľujúca široký pás zaplavovaných luhov od vyvýšeného, suchšieho, čiastočne stepného vnútra Žitného ostrova. Inundačné územie na dnešnej slovenskej strane malo teda v minulosti (mladšom holocéne) šírku približne 10 km (dnes sú to v najširšom mieste pri Bake 3 km) (LOŽEK 1955). Otázke stepných enkláv sa venuje v rámci záplavového územia Dunaja najmä LOŽEK (1955, 1964). Zatiaľ chýba časové datovanie jednotlivých dejov aj znalosti o topografickom rozložení jednotlivých geobiocenóz, čo môže upresniť len ďalší a širší výskum recentnej a fosílnej malakofauny, pravekých sídlisk a doplňanie znalostí z archívnych údajov tejto oblasti. Analýzy tanatocenóz sedimentov Dunaja vo Vlčom Hrdle pri Bratislave kombinované s absolútnym datovaním veku sedimentov (PIŠÚT 2000, ČEJKA 2000) umožnili zrekonštruovať kompletnú sukcesnú líniu lužného lesa od iniciálneho štádia lužného lesa až po dnešný prechodný lužný les (obdobie r. 1791-1999, t.j. 208 rokov) a potvrdili výskyt podobných typov lužného lesa, aké sa na Podunajsku vyskytujú v súčasnosti a tanatocenózy, ktoré štruktúrou zodpovedajú približne dnešným zvyškom najzachovalejších lesných malakocenóz v oblasti medzi obcami Dobrohošť a Sap. Celková plocha najvlhších typov mäkkých lužných lesov s príslušnými malakocenózami bola v minulosti oveľa väčšia než dnes, s prirodzenejšou štruktúrou porastov, čo je zreteľne vidieť dokonca už pri porovnaní fytocenologických zápisov zo 40-50-tych rokov so súčasnými (UHERČÍKOVÁ 1995, 1998).

Charakteristické hlavne pre iniciálne štádiá tzv. mäkkého luhu a iné stanovištia s vysokou pôdnou vlhkosťou sú najmä výrazne vlhkomilné druhy ulitníkov *Succinea putris, Oxyloma elegans, Zonitoides nitidus* a *Pseudotrichia rubiginosa.* Diferenciačnými druhmi vlhkých typov mäkkého lužného lesa (asoc. *Salici-Populetum myosotidetosum* až *Salici-Populetum typicum* JURKO 1958) sú, okrem vyššie uvedených druhov aj polyhygrofilný *Carychium minimum* a lesné hygrofilné druhy *Arianta arbustorum, Vitrea crystallina* a sčasti aj *Urticicola umbrosus*. Pre tzv. prechodný až tvrdý luh (as. *Fraxino-Populetum, Fraxno-Ulmetum*) je zase typická dominancia prevažne lesných mezohygrofilných druhov, ktoré neznášajú ničivý vplyv záplav a dlhodobo podmáčanú pôdu (*Aegopinella nitens, Cochlodina laminata, Semilimax semilimax, Alinda biplicata, Monachoides incarnatus, Petasina unidentata, Clausilia pumila*, čiastočne aj *Carychium tridentatum*). V taxocenózach sú zastúpené aj skupiny druhov, ktoré sú viazané na vyslovene nelesné stanovištia, alebo riedko zapojené porasty stromov či krov (*Vallonia pulchella, V. costata, Euomphalia strigella, Cepaea vindobonensis* a *Xerolenta obvia*).

Analogicky je možné predpokladať podobné pomery (pokiaľ ide o zastúpenie jednotlivých ekoelementov najmä vo vzťahu k vlhkosti, vode, zatieneniu atd.) aj v iných taxocenózach terestrických živočíchov.

Vo faune suchozemských rovnakonožcov (Oniscidea) z Podunajska v dosahu vodného diela Gabčíkovo bolo z obdobia 1986-1990 zistených 16 druhov (FLASAROVÁ 1999), najpočetnejším bol eurytopný *Trachelipus rathkei.*

Stonožkám (Chilopoda) Podunajska bola v období pred zahájením výstavby VD Gabčíkovo venovaná len okrajová pozornosť a podobne ako u predchádzajúcej skupiny netýkajú sa priamo územia tejto štúdie, ale jeho okolia (GULIČKA 1957, ČARNOGURSKÝ et al., 1994).

Za východiskový stav taxocenóz stonožiek sa môže do istej miery považovať druhové zloženie zistené v úseku derivácie pred rokom 1993, na monitorovacích plochách bolo zaznamenaných 9 – 14 druhov. Získané údaje o spoločenstvách suchozemských rovnakonožcov (Oniscidea) a stonožiek (Chilopoda) sú veľmi blízke až totožné s údajmi z lesov alúvií Moravy a Dyje na moravskej i rakúskej strane (TAJOVSKÝ 1999, TUF 2000, ZULKA 1999), môžeme ich považovať za dostatočne charakteristické.

V Dobrohošti - Dunajských krivinách z 13 zistených druhov k eudominantom patril eurytopný *Lithobius forficatus* (D = 21%-23%), z okolia sem prenikal *Lithobius mutabilis*. Z pravidelne sa vyskytujúcich druhov, ktoré sú indikátormi vyššieho stupňa pôdnej vlhkosti (od 20%-30%) boli zistené mezohygrofilné *Lithobius curtipes, L. crassipes, Geophilus flavus. Lithobius microps* tu už po roku 1991 zistený nebol.

Spoločenstvo stonožiek Bodíckej brány tvorilo 13 druhov, medzi ktoré patrili mezohygrofilné *L. crassipes* a *L. curtipes* s vyššími hodnotami dominancie (17%-18%) a hygrofilný *L. agilis*, náročný na pomerne vysoký stupeň pôdnej vlhkosti. Tretinu druhov však predstavovali eurytopné druhy *L. forficatus, L. erythrocephalus* a *L. mutabilis*, ktoré boli a sú zastúpené po celom sledovanom území Podunajska.

Taxocenózu stonožiek Kráľovskej lúky tvorilo pred prehradením 14 druhov, ku ktorým patrili typický ripikolný a hygrofilný *Lamyctes emarginatus* a hygrofilné druhy *L. agilis* a *L. microps*. Eudominantným druhom bol *Lamyctes emarginatus*, dominantnými *Lithobius aeruginosus* a *L. curtipes*. Spoločenstvo stonožiek Kráľovskej lúky pred prehradením Dunaja zaraďujeme medzi najbohatšie. Za obdobie rokov 1991 – 1997 tu bolo zistených 17 druhov. V prvom roku po prehradení (1993) počet zaznamenaných druhov bol zreteľne nižší oproti rokom predchádzajúcim. Absentujúce druhy sa opäť objavili až v roku 1997, naviac v tomto roku bol po prvýkrát zistený *Lithobius pelidnus*, druh s centrom rozšírenia vo východnej Európe preferujúci zalesnené územia.

V spoločenstve stonožiek Istragova bolo zastúpených 9 druhov, z ktorých medzi eudominantné patrili eurytopné *Lithobius forficatus* a *L. mutabilis*. Z typických mezohygrofilných druhov boli vysokým percentom zastúpené tiež *L. aeruginosus, L. crassipes, L. curtipes* a hypogeicky žijúci druh *Pachymerium ferrugineum*. Pred prehradením Dunaja nechýbal ani hygrofilný druh *L. agilis* zistený v rokoch 1991 a 1992.

Z územia, na ktorom je v súčasnosti vybudované VD Gabčíkovo a jeho najbližšieho okolia viacerí autori (BRTEK, ROTSCHEIN 1964, ŠIŠKA 1983, ŠTEPANOVIČOVÁ, LAPKOVÁ 1984, BULÁNKOVÁ 1995, ŠTEPANOVIČOVÁ 1989, 1991) zistili pred začatím výstavby výskyt 177 druhov bzdôch (Heteroptera).

V epigeickej taxocenóze bystruškovitých (Coleoptera: Carabidae) v podunajských lužných lesoch s pravidelnými záplavami prevládali s vysokou dominanciou vlhkomilné druhy. Na Dunajských krivinách to boli *Agonum moestum* (13,35%), *Oxypselaphus obscurus* (22,39%), *Patrobus atrorufus* (11,87%) a *Platynus assimilis* (3,56%). Jednotlivo sa objavovali aj ďalšie vlhkomilné alebo ripikolné druhy (napr. *Bembidion dentellum, Bembidion biguttatum, Oodes helopioides*). Podobne v Bodíckej bráne výrazne prevažovali vlhkomilné druhy *P. assimilis* (12,96%), *P. atrorufus* (12,41%), *O. obscurus* (3,31%) sprevádzané ďalšími početne zastúpenými vlhkostne menej náročnejšími, resp. tolerantnejšími druhmi *Asaphidion flavipes* (30,42%), *Carabus granulatus* (8,09%), *Pterostichus strenuus* (9,65%), *Clivina fossor* (4,32%). Významná bola aj prítomnosť vlhkomilných druhov *B. dentellum* a *Badister sodalis*.

Na Kráľovskej lúke, kde bolo spoločenstvo sledované už od roku 1987, prevažovali paludikolné *A. moestum* (15,95%), vlhkomilné druhy *P. atrorufus* (13,79%), *P. assimilis* (4,96%) a relatívne tolerantné druhy *P. strenuus* (29,31%), *C. granulatus* (7,76%) a *O. obscurus* (4,31%). Vysokej vlhkosti, resp. podmáčaniu zodpovedala prítomnosť *Europhilus fuliginosus, Europhilus micans, Oodes helopioides*. V roku 1989 sa abundancia všetkých vlhkomilných druhov okrem *A. moestum* zvýšila. Veľmi prudko vzrástlo zastúpenie *A. flavipes* (z 2 na 248 jedincov). V rokoch 1990-1991 bol celkový úlovok v dôsledku zaplavenia lokality nižší (z 1348 jedincov v r. 1989 klesol na 727, resp. 372 jedincov), ale štruktúra spoločenstva sa výrazne priblížila pôvodnému stavu z roku 1987 (proporcionálna podobnosť 56,7-57,6%, podobnosť abundancie 39,6-40,5%). Zaplavenie postihlo aj dva vlhkomilné, ale nie vyslovene paludikolné druhy *P. atrorufus* a *P. assimile*. Na Istragove v roku 1989 výrazne prevažovali dva drobné vlhkomilné druhy bystruškovitých *A. flavipes* (47,7%) a *Bembidion femoratum* (15,36%), výrazné zastúpenie mali aj ďalšie vlhkomilné druhy *P. assimile* (15,5%), *P. strenuus* (5,7%), *C. granulatus* (3,6%), *P. atrorufus* (2,4%). Ekologicky významná bola prítomnosť druhov *Europhilus fuliginosus* a *E. micans*. Vysoké zastúpenie vlhkostne menej náročných druhov ešte pred podstatnými zmenami hydrologického režimu odráža prevahu silne piesčitej pôdy na veľkej časti sledovanej plochy.

Načrtnutý stav naznačuje, že taxocenózy bystruškovitých predstavovali charakteristické spoločenstvá druhov s vysokými nárokmi na vlhkosť **(Tab. 2.1, 2.2)**, ktoré neboli v podstatnej miere infiltrované mezohygrofilnými druhmi obývajúcimi geobiocenózy normálneho hydrického radu. Neboli ani výrazne ovplyvnené druhovou skladbou porastov, ktorá bola v ostatných desaťročiach silne narušená náhradou pôvodných porastov topoľovými kultúrami. Príčinou je skutočnosť, že pre hygrofilné druhy lužných lesov je rozhodujúca prítomnosť v podstate akéhokoľvek hustého vegetačného krytu, ktorý zabraňuje vysušovaniu a prehrievaniu hrabanky priamym slnečným žiarením. Takéto podmienky boli schopné pre bystruškovité vytvárať tak topoľové kultúry staršie ako 10 rokov, t. j. počas prevažnej časti svojej existencie ako aj vysoký bylinný porast, ktorý sa (bez ohľadu na svoje floristicky nevyhovujúce druhové zloženie takýchto porastov) vyvinul na rúbaniskách v podmienkach dostatočného zásobenia pôdy vlhkosťou.

Pre semiakvatické, amfibické a prechodné živočíšne taxocenózy je pomerne charakteristickým javom ich väzba nielen na vegetáciu ako potravnú bázu, ale aj viazanosť na vodný režim; jeho nepravidelné zmeny s následnou sukcesiou sa prejavujú na nestabilite zloženia taxocenóz a ich veľkých medziročných zmenách, čo dokumentuje situácia taxocenóz fytofágnych Curculionidae (Coleoptera) brehových vegetačných formácií v systéme dunajských ramien a hlavného toku Dunaja, staršie údaje o ktorých sú v širšie koncipovaných štúdiách (MAJZLAN, RYCHLÍK 1982, MAJZLAN 1988, 1990, KODADA, MAJZLAN 1991) a neskôr boli monitorované. Z uvedených prác vyplýva, že pobrežné územia niektorých skúmaných ramien boli už pred prehradením Dunaja do značnej miery aridizované. Odrazilo sa to aj na pomernom zastúpení eurytopných a stenotopných druhov: hygrofilných a paludikolných na jednej a druhov xerofilných a na biotop nenáročných na strane druhej. Je možné sa oprávnene domnievať, že spoločenstvo nosáčikov (Curculionidea) zistené v rokoch po prehradení Dunaja (1992) žilo na skúmanom území v pobrežnej vegetácii ramien vnútrozemskej delty aj pred jeho prehradením. Z vyschnutých ramien sa táto taxocenóza stiahla do menších enkláv, v ktorých prežívala. S časom prehradenia Dunaja koinciduje šírenie sa na sever hygrofilného a a ripikolného nosáčika *Bagous bagdatensis*. Jeho lokality na území Slovenska predstavujú dosiaľ známu severnú hranicu rozšírenia. Ripikolný a akvikolný *Dicranthus majzlani*, na území Slovenska aj v celej Európe kriticky ohrozený, je indikátorom prírodne zachovalých stojatých a polotečúcich nížinných vôd a vyžaduje vyššiu hladinu vody v ramennom systéme. Obidva druhy neboli do roku 1992 z tohto územia známe.

Tab. 2.1 Štruktúra prirodzeného spoločenstva bystruškovitých v lužnom lese často zaplavovanom prúdiacou vodou; druhy sú zoradené podľa klesajúcich vlhkostných nárokov a počtu jedincov
Carabidae natural structure in the fooodplain forest often flooded by flowing water; species are arranged according to their moisture demand and number of individuals

Druh - Specie	H	V	Jedince - Individuals	
			Priemer - Average	Smer. odch. –St. deviation
Agonum moestum (Duftschmidt, 1812)	8	s	30.67	37.65
Europhilus fuliginosus (Panzer, 1809)	8	s	14.00	12.77
Bembidion biguttatum (Fabricius, 1779)	8	s	9.33	16.17
Pterostichus anthracinus (Illiger, 1798)	8	s	3.67	3.51
Platynus livens (Gyllenhal, 1810)	8	s	2.33	3.21
Oodes helopioides (Fabricius, 1792)	8	i	2.00	1.00
Pterostichus vernalis (Panzer, 1796)	8	r	2.00	2.65
Bembidion mannerheimi (C. R. Sahlberg, 1827)	8	s	1.67	2.89
Badister peltatus (Panzer, 1797)	8	i	1.33	1.53
Dyschirius globosus (Herbst, 1783)	8	r	1.00	1.00
Chlaenius nitidulus (Schrank, 1781)	8	r	0.67	0.58
Bembidion dentellum (Thunberg, 1787)	8	r	0.33	0.58
Pterostichus nigrita (Paykul, 1790)	8	i	0.33	0.58
Pterostichus strenuus (Panzer, 1797)	7	i	187.33	44.46
Platynus assimilis (Paykull, 1790)	7	s	127.67	148.00
Carabus granulatus (Linnaeus, 1758)	7	i	87.67	51.05
Patrobus atrorufus (Stroem, 1768)	7	s	77.00	32.51
Oxypselaphus obscurus (Herbst, 1784)	7	s	72.00	53.03
Europhilus micans (Nicolai, 1822)	7	s	18.67	15.57
Badister sodalis (Duftschmidt, 1812)	7	i	2.67	1.53
Pterostichus diligens (Sturm, 1824)	7	i	0.67	0.58
Asaphidion flavipes (Linnaeus, 1761)	6	s	100.67	130.02
Clivina fossor (Linnaeus, 1758)	6	s	40.00	7.94
Pterostichus niger (Schaller, 1783)	6	s	26.00	26.85
Stomis pumicatus (Panzer, 1796)	6	i	7.67	6.03
Badister lacertosus (Sturm, 1815)	6	i	5.00	5.20
Badister meridionalis (Puel, 1925)	6	i	2.33	3.21
Acupalpus meridianus (Linnaeus, 1761)	6	p	2.00	2.65
Clivina collaris (Herbst, 1784)	6	i	1.33	2.31
Epaphius secalis (Paykull, 1790)	6	s	0.33	0.58
Lasiotrechus discus (Fabricius, 1792)	6	t	0.33	0.58
Panageus cruxmajor (Linnaeus, 1758)	6	i	0.33	0.58
Pterostichus melanarius (Illiger, 1798)	5	i	9.00	6.24
Syntomus obscuroguttatus (Duftschmidt, 1812)	5	i	0.33	0.58
Lorocera pilicornis (Fabricius, 1775)	4	i	2.33	2.31
Trechus quadristriatus (Schrank, 1781)	4	p	1.67	2.08
Poecilus cupreus (Linnaeus, 1758)	4	p	0.67	1.15
Synuchus vivalis (Illiger, 1798)	4	i	0.33	0.58
Amara ovata (Fabricius, 1792)	3	p	0.67	1.15
Anchomenus dorsalis (Pontoppidan, 1763)	3	p	0.67	1.15
Amara aenea (De Geer, 1774)	3	p	0.33	0.58
Amara apricaria (Paykull, 1790)	3	p	0.33	0.58
Brachynus explodes (Duftschmidt, 1812)	3	p	0.33	0.58
Microlestes minutulus (Goeze, 1777)	2	p	0.67	1.15
Počet jedincov – Number of individuals			**788.67**	**459.45**
Počet druhov – Number of species			**29.00**	**3.61**
Vysvetlivky:				

H – hygropreferendum: 1 - suchomilný, 8 - extrémne vlhkomilný.
V – preferéndum vegetačného krytu: s - silvikolný (lesný), i - indiferentný k zatieneniu, p - patentikolný (obývajúci bezlesie), r - ripikolný, t - terikolný (žijúci v chodbách zemných cicavcov a pod.).

Explanation:

H – hygropreferendum: 1 - strongly xerophilous, 8 - extremely hygrophilous.
V – vegetation cover preferendum: s - silvicolous, i - indifferent to shade,
p - open landscape species, r - ripicolous,
t - terricolous, living in galleries of terrestrial mammals, etc.

Tab. 2.2 Spoločenstvo bystruškovitých v silne narušenom zvyšku lužného lesa v blízkosti zvyšku mŕtveho ramena Malého Dunaja
Carabidae taxocoenoses in heavy disturbed rest of floodplain forest close to the rest of Malý Dunaj dead arm

Druh - Specie	H	V	Jedince - Individuals
Bembidion mannerheimi (C. R. Sahlberg, 1827)	8	s	15
Agonum moestum (Duftschmidt, 1812)	8	s	2
Chlaenius nigricornis (Fabricius, 1787)	8	r	2
Demetrias monostigma (Samouelle, 1819)	8	p	1
Pterostichus strenuus (Panzer, 1797)	7	i	6
Badister lacertosus (Sturm, 1815)	6	i	33
Stomis pumicatus (Panzer, 1796)	6	i	9
Asaphidion flavipes (Linnaeus, 1761)	6	s	2
Acupalpus meridianus (Linnaeus, 1761)	6	p	1
Anisodactylus binotatus (Fabricius, 1787)	6	p	1
Pterostichus niger (Schaller, 1783)	6	s	1
Syntomus pallipes (Dejean, 1825)	5	p	31
Pterostichus melanarius (Illiger, 1798)	5	i	12
Trechus quadristriatus (Schrank, 1781)	4	p	123
Pseudoophonus rufipes (De Geer, 1774)	4	p	63
Panageus bipustulatus (Fabricius, 1775)	4	p	10
Laemostenus terricola (Herbst, 1784)	4	i	5
Poecilus cupreus (Linnaeus, 1758)	4	p	2
Harpalus atratus (Latreille, 1804)	4	s	1
Harpalus honestus (Duftschmidt, 1812)	4	p	1
Harpalus latus (Linnaeus, 1758)	4	p	1
Pterostichus ovoideus (Sturm, 1824)	4	i	1
Abax ater (Villers, 1789)	3	s	76
Brachynus explodes (Duftschmidt, 1812)	3	p	54
Calathus fuscipes (Goeze, 1777)	3	p	45
Anchomenus dorsalis (Pontoppidan, 1763)	3	p	28
Bembidion lampros (Herbst, 1784)	3	p	16
Amara aulica (Panzer, 1797)	3	p	8
Brachynus crepitans (Linnaeus, 1758)	3	p	3
Calathus erratus (C. R. Sahlberg, 1827)	3	p	2
Calathus melanocephalus (Linnaeus, 1758)	3	p	2
Amara apricaria (Paykull, 1790)	3	p	1
Amara consularis (Duftschmidt, 1812)	3	p	1
Amara convexiuscula (Marsham, 1802)	3	p	1
Harpalus tardus (Panzer, 1797)	2	p	8
Licinus depressus (Paykull, 1790)	2	p	2
Microlestes plagiatus (Duftschmidt, 1812)	2	p	1
Ophonus azureus (Fabricius, 1775)	2	p	1
Poecilus punctatulus (Schaller, 1783)	2	p	1
Počet jedincov			**573**
Počet druhov			**38**

Symboly ako v Tab. 2.1 – Symbols as in Table 2.1

V priebehu monitoringu sa zistilo, že zatiaľ čo v komplexe pobrežných rastlinných spoločenstiev (asociácie *Rorippo-Agrostietum stoloniferae, Phalaridetum arundinaceae, Rorippo amphibiae-Oenanthetum aquaticae, Glycerietum maximae, Phragmitetum communis, Caricetum gracilis*) bolo v taxocenóze Curculionidae zistených 49 druhov, z toho 13 (29%) každoročne (*Sitona macularis, Sitona suturalis, Bagous collignensis, B. glabrirostris, Tanysphyrus lemnae, Rhinoncus albicinctus, R. perpendicularis, R. inconspectus, Poophagus sisymbrii, Tapinotus sellatus, Nanophyes brevis, N. globiformis, N. marmoratus*) s vyrovnaným pomerom hygrofilné druhy viazané na pobrežnú vegetáciu, ako aj druhov viazaných na rastliny vodnej hladiny, so signifikantnou prevahou charakteristických, stenotopných a hygrofilných druhov, vo vysychajúcom slepom ramene Dunaja v lužnom lese (*Salici-Populetum*) s asociáciou *Phragmitetum communis* s väčším množstvom vody iba v jarnom období (apríl a máj) bolo v taxocenóze Curculionidae zistených 39 druhov, pričom ani jeden druh sa nevyskytoval každoročne a eudominantným bol sprievodný druh *Nedyus quadrimaculatus*.

Zo záujmového územia boli dávnejšie pomerne dobre známe taxocenózy suchozemských resp. amfibických stavovcov.

Na sledovanom území bol známy výskyt 12 taxónov (11 druhov + 1 klepton) obojživelníkov, z nich *Triturus dobrogicus* a *Rana ridibunda* sú v kategórii ohrozených (EN), *Triturus vulgaris* a *Rana lessonae* v kategórii zraniteľných (VU), všetky ostatné v kategórii rizikových (LR) druhov. Z 12 druhov plazov známych z územia Slovenska sa tu vyskytuje 9, z toho 7 chránených, 3 v kategórii zraniteľných (VU: *Coronella austriaca, Natrix tesselata, Lacerta viridis*), ostatné v kategórii rizikových (LR) druhov.

Z ornitologického hľadiska predstavovali podunajské lužné lesy spolu s ramenným systémom Dunaja ešte v nedávnej minulosti územie s vysokou diverzitou a denzitou druhov, kde hniezdili viaceré vzácne a ohrozené druhy vtákov (Balát

1963). Hniezdnu ornitocenózu podunajských lužných lesov pred výstavbou VD Gabčíkovo – t. j. v 70. a 80. rokoch – tvorilo 103 druhov vtákov (**Tab. 2.3**). Z významných hniezdičov to boli predovšetkým haja tmavá (*Milvus migrans* - VU) a chochlačka bielooká (*Aythya nyroca* - EN), ktoré tu vytvárali hniezdne populácie celoslovenského významu, ďalej bučiačik močiarny (*Ixobrychus minutus* VU), bocian čierny (*Ciconia nigra*), včelár lesný (*Pernis apivorus*), rybárik riečny (*Alcedo atthis*), ďateľ prostredný (*Dendrocopos medius*), ktoré tu vytvárali hniezdne populácie nadregionálneho významu. Z celkového počtu 103 hniezdičov boli 3 druhy ohrozené (EN: *Ardea purpurea, Aythya nyroca, Coracias garrulus*), a 4 zraniteľné (VU: *Ixobrychus minutus, Milvus migrans, Nycticorax nycticorax, Upupa epops*).

Tab. 2.3 Prehľad vtákov, ktoré hniezdili v podunajských lužných lesoch a v priľahlom ramennom systéme Dunaja (slovenská strana) pred výstavbou VD Gabčíkovo (1970 - 1990)
Review of fowls nesting in the Danube floodplain forest and river arm system on the Slovak side before putting the Gabčíkovo project into operation (1970 - 1990)

	Druh - Specie	Hniezdenie – Nesting
1	*Tachybaptus ruficollis*	h
2	*Podiceps cristatus*	h
3	*Phalacrocorax carbo*	h **H**
4	*Ixobrychus minutus*	h
5	*Ardea cinerea*	h **H**
6	*Ardea purpurea*	h **H**
7	*Nycticorax nycticorax*	h **H**
8	*Ciconia nigra*	h
9	*Ciconia ciconia*	sh
10	*Cygnus olor*	h
11	*Anas strepera*	h
12	*Anas platyrhynchos*	h
13	*Aythya ferina*	h
14	*Aythya nyroca*	**X**
15	*Pernis apivorus*	h
16	*Milvus migrans*	h
17	*Circus aeruginosus*	h
18	*Accipiter gentilis*	h
19	*Accipiter nisus*	nzh
20	*Buteo buteo*	h
21	*Falco tinnunculus*	nzh
22	*Falco subbuteo*	h
23	*Phasianus colchicus*	h
24	*Rallus aquaticus*	h
25	*Porzana parva*	h
26	*Gallinula chloropus*	h
27	*Fulica atra*	h
28	*Charadrius dubius*	h
29	*Actitis hypoleucos*	**X**
30	*Columba palumbus*	h
31	*Streptopelia turtur*	h
32	*Cuculus canorus*	h
33	*Strix aluco*	h
34	*Asio otus*	h
35	*Alcedo atthis*	h
36	*Coracias garrulus*	nzh
37	*Upupa epops*	h
38	*Jynx torquilla*	h
39	*Picus canus*	nzh
40	*Picus viridis*	h
41	*Dryocopus martius*	h
42	*Dendrocopos major*	h
43	*Dendrocopos syriacus*	sh
44	*Dendrocopos medius*	h
45	*Dendrocopos minor*	h
46	*Riparia riparia*	**X**
47	*Hirundo rustica*	sh
48	*Delichon urbica*	sh
49	*Anthus trivialis*	h
50	*Motacilla alba*	h
51	*Troglodytes troglodytes*	h
52	*Prunella modularis*	h
53	*Erithacus rubecula*	h
54	*Luscinia megarhynchos*	h
55	*Phoenicurus ochruros*	Sh
56	*Phoenicurus phoenicurus*	h
57	*Saxicola torquata*	h
58	*Turdus merula*	h

	Druh - Specie	Hniezdenie – Nesting
59	*Turdus philomelos*	h
60	*Locustella naevia*	h
61	*Locustella fluviatilis*	h
62	*Locustella luscinioides*	h
63	*Acrocephalus schoenobaenus*	h
64	*Acrocephalus palustris*	h
65	*Acrocephalus scirpaceus*	h
66	*Acrocephalus arundinaceus*	h
67	*Hippolais icterina*	h
68	*Sylvia nisoria*	h
69	*Sylvia curruca*	h
70	*Sylvia communis*	h
71	*Sylvia borin*	h
72	*Sylvia atricapilla*	h
73	*Phylloscopus sibilatrix*	nzh
74	*Phylloscopus collybita*	h
75	*Phylloscopus trochilus*	h
76	*Muscicapa striata*	h
77	*Ficedula albicollis*	h
78	*Aegithalos caudatus*	h
79	*Parus palustris*	h
80	*Parus montanus*	h
81	*Parus caeruleus*	h
82	*Parus major*	h
83	*Sitta europaea*	h
84	*Certhia familiaris*	h
85	*Certhia brachydactyla*	h
86	*Remiz pendulinus*	h
87	*Oriolus oriolus*	h
88	*Lanius collurio*	h
89	*Garrulus glandarius*	h
90	*Corvus monedula*	nzh
91	*Corvus corone cornix*	h
92	*Sturnus vulgaris*	h
93	*Passer domesticus*	sh
94	*Passer montanus*	h
95	*Fringilla coelebs*	h
96	*Serinus serinus*	h
97	*Carduelis chloris*	h
98	*Carduelis carduelis*	h
99	*Carduelis cannabina*	h
100	*Coccothraustes coccothraustes*	h
101	*Emberiza citrinella*	h
102	*Emberiza schoeniclus*	h
103	*Miliaria calandra*	h

Vysvetlivky:
H – druh hniezdi na protiľahlej, maďarskej strane Dunaja, jeho potravný revír však zasahuje aj na slovenskú stranu
h – hniezdil v období tesne pred výstavbou i po sprevádzkovaní VD
nzh – nepravidelný zriedkavý hniezdič
sh – synantropný hniezdič, preniká popri horárňach a chatových osadách
X – druh hniezdil pred výstavbou, po sprevádzkovaní nebolo hniezdenie zistené

Okrem lužných lesov dôležitých pre hniezdiče bol Dunaj významnou trasou migrácie vodného vtáctva. Na hlavnom toku Dunaja zimovalo v jednotlivých rokoch 25-30 druhov vtákov (KALIVODOVÁ, DAROLOVÁ 1998, ÁČ et al., 1996). Medzi dominantných hibernantov patrili *Anas platyrhynchos* a *Bucephala clangula*.

Vo faune cicavcov (Mammalia) bolo zistených 49 druhov. Bobor (*Castor fiber*), na území vyhynutý, sa v súčasnosti po reštitúcii v Rakúsku spontánne šíri, nenachádza však v študovanom území optimálne podmienky. V taxocenóze drobných zemných cicavcov, tvorenej druhmi *Sorex araneus, Apodemus flavicollis, Clethrionomys glareolus, Sorex minutus, Crocidura leucodon, Crocidura suaveolens, Microtus arvalis, Microtus oeconomus, Pitymys subterraneus, Apodemus sylvaticus, Micromys minutus* dochádza v závislosti najmä na vlhkostnom gradiente k zmene štruktúry dominancie. V mäkkom lužnom lese sú eudominantné *Sorex araneus, Apodemus flavicollis* a *Clethrionomys glareolus*, s posunom na vlhkostnom gradiente smerom ku xerickým podmienkam sa ich dominancia znižuje a vo zvýšenej miere sa v spoločenstve uplatňujú iné druhy vrátane tu nepôvodných *Microtus arvalis* a *Mus musculus*.

2.5.3 Vodná fauna

Štruktúra, dynamika a produkcia planktónu, bentosu, nektónu i neustónu verne odráža pôvodnosť tokov a kvalitu vôd. Spoločenstvá týchto organizmov predstavujú významnú zložku charakterizujúcu tok a jeho ramennú sústavu a sú významnými indikátormi zmien, schopnými odpovedať na zmeny v rôznych časových rovinách a tak sa z ich charakteru môžu vyvodzovať závery o zmenách, ktoré prebehli, prebiehajú a umožňujú aj v základných rysoch predpokladať ďalší vývoj.

Technické zásahy, s cieľom znížiť riziká povodní a zlepšiť plavebné podmienky, sa sústredili pôvodne predovšetkým na prehlbovanie a upravovanie dna, regulácie brehov, likvidáciu lužných pralesov, uzatváranie ramien (DUB, SZOLGAY, 1966). Výsledkom toho bola výrazne zvýšená rýchlosť prúdenia v rieke a silná erózia dna, výrazné zníženie a prerušenie prúdenia v pôvodne prietočných ramenách typu eupotamál a parapotamál. Pôvodná heterogenita mezohabitatov bola potlačená. Výrazne sa sťažili podmienky migrácie lariev, ale aj reprodukcie imág vodného hmyzu a iných vodných organizmov (KRNO, 1995). Uzatváraním vtokov ramien pre zabezpečenie plavby a v dôsledku poklesu riečiska Dunaja sa vytvorili predovšetkým podmienky pre rozšírenie ramien typu plesiopotamál charakterizovaných rozvojom makrofýt, eutrofizáciou a ich postupnú premenu na vysýchajúce typy periodických mokradí. Vybudovanie protipovodňových hrádzí spôsobilo stratu spojenia ramien v mimohrádzovom priestore s aktívnym hlavným tokom a ich premenu na ramená typu paleopotamál. Takéto podmienky znamenali ústup reofilných, potamofilných a stenoekných foriem makrozoobentosu a ich nahradenie skôr eurytopnými formami. Negatívne pôsobilo aj postupné rozpojovanie systému siete ramien v priestore medzi protipovodňovými hrádzami. STÖSSEL (1988) a FRUGET (1991, 1992) poukázal na vplyvy regulácií na štruktúru makrozoobentosu veľkých európskych riek (Rýn, Rhôna), v ktorých dochádza komplexne k homogenite spoločenstiev a k narušeniu longitudinálnej zonácie.

Pre Dunaj a jeho inundáciu boli v minulosti typické viac-menej pravidelne sa opakujúce vyššie prietoky začiatkom jari v marci a začiatkom leta v júni a júli (MUCHA et al., 2001). To svedčí o špecifickosti prietokového režimu tejto rieky, a preto ju nemôžeme označiť ako typicky alpský typ (HOLČÍK et al., 1981). Výrazné jarné maximá sú výsledkom topenia snehov v predpolí Álp a Hercynika, takže ide o zmiešaný typ vysokohorského a podhorského prietokového režimu. Takémuto vodnému režimu boli podriadené aj vývinové cykly temporárnej epifauny Dunaja a jeho inundácie. Záplavy, periodické i neperiodické, boli hlavným prírodným faktorom genézy ekosystémov Dunaja (ROVNÝ et al., 1996). Záplavy preplachovali mediál ramien, zabraňovali kolmatácii dna, najmä jarné bohato zásobovali ramená živinami, priaznivo ovplyvňovali kyslíkový i teplotný režim, umožňovali tak úspešný ontogenetický vývin hydrobiontov a v neposlednom rade uľahčovali aj ich pasívnu i aktívnu migráciu. Protipovodňovými hrádzami a smernými stavbami v toku bol tento režim zmenený, nastalo k rýchlejšie a väčšie kolísanie hladín, zrýchlenie rýchlosti toku najmä v prehlbovanom úseku napriameného hlavného koryta, nastal pokles hladín povrchových i podzemných vôd. Od 60. rokov 20. storočia bol tento proces sprevádzaný aj postupným uzatváraním ramien, fragmentáciou vnútrodunajskej delty, poklesom frekvencie preplachovania ramien až ich úplným vyschnutím.

Faunistické údaje mikro-meiozoobentosu tejto oblasti boli publikované vo viacerých prácach (ERTL, 1966, 1970). Najviac údajov bolo známych o perifytóne, ktorý tvorili predovšetkým malé meňavky (*Amoebina*), niektoré druhy nálevníkov a sesilných *Rotifera* (MATIS, TIRJAKOVÁ (1992, 1995a, 1995b), TIRJAKOVÁ (1992, 1999), BALÁŽI, TIRJAKOVÁ (1999), BALÁŽI, MATIS (2002)).

Makrozoobentos Dunaja, jeho ramien a periodických vôd bol predmetom štúdia viacerých autorov: BALTHASARA (1936, 1938), HRABĚHO (1941), TRPIŠA (1957, 1962), RAUŠERA (1957), LICHARDOVEJ (1958), ERTLOVEJ (1963, 1968, 1970, 1973, 1987), BRTEKA a ROTHSCHEINA (1964), RUSSEV (1979), POMICHALA (1984), LANDU (1969), NAGYA a ŠPORKU (1990), KRNA (1990), MAJZLANA (1992), DAVIDA (1994), BULÁNKOVEJ (1995, 1999, 2001), BULÁNKOVEJ a HALGOŠA (1995, 1997), HALGOŠA (1995), ŠÍBLA et al. (2001), ŠPORKU, KRNA (1995), KOŠELA (1995a) a ŠPORKU (1980a, 1980b, 1982, 1983, 1984, 1994, 1998), ŠPORKU, NAGYA (1998). Z týchto prác vyplýva, že Dunaj a priľahlé inundačné územie je už vyše storočia pod silným antropickým tlakom, ktorého výsledkom je napríklad vyhynutie viac než 90% druhov dunajských pošvatiek, viac než 50% podeniek a viac než 30% potočníkov (KRNO a kol., 1999).

Územie Žitného ostrova bolo od dávna známe kvantitatívnym i kvalitatívnym bohatstvom komárov (neustón), ako i každoročnými kalamitami súvisiacimi s premnožením niektorých druhov. Kalamity spôsobovalo vyliatie vôd z Dunaja do inundačného územia. TRPIŠ (1962) udáva z územia Žitného ostrova 28 druhov komárov. Od tohto obdobia prešlo územie veľkými zmenami súvisiacimi s výraznými antropickými zásahmi (HALGOŠ, 1981; HALGOŠ, 1984).

Spoločenstvá zooplanktónu pred výstavbou vodného diela

Hlavný tok Dunaja

Pred prehradením Dunaja (1971-1972) (VRANOVSKÝ 1974) a v rokoch 1991-1992 (ILLYOVÁ 1995; VRANOVSKÝ, ILLYOVÁ 1999) dominovali medzi planktonickými vírnikmi hlavného toku spravidla euplanktonické druhy, najmä z rodov *Keratella (K. cochlearis)*, *Polyarthra (P. vulgaris, P. remata)*, *Synchaeta (S. oblonga, S. tremula, S. stylata)*, *Brachionus (B. calyciflorus, B. angularis)*, a v zimnom období aj *Rotaria rotatoria*. V krustáceoplanktóne podobne prevládali pravé planktonty, avšak v hornej časti monitorovaného úseku (na profile Dunajské kriviny) značný podiel z celkovej abundancie pripadal aj na tychoplanktonické (litorálne a bentické) druhy, t.j. nepravé planktonty. Z perloočiek (Cladocera) dominovala *Bosmina longirostris*, prípadne spolu s druhom *Daphnia longispina* a/alebo *D. cucullata*, z veslonôžok (Copepoda) najčastejšie *Acanthocyclops robustus*, a to buď so vznášavkou *Eudiaptomus gracilis* alebo s druhmi *Cyclops vicinus* a *Thermocyclops oithonoides*, prípadne aj s druhom *Eurytemora velox* (imigrant, zistený v našom úseku Dunaja prvýkrát v roku 1991). Z tychoplanktonických perloočiek k najhojnejším patrili *Alona quadrangularis* a *A. affinis*, z veslonôžok *Eucyclops serrulatus* .

Ramená typu parapotamál

Pred prehradením Dunaja vo vodách tohto typu sa v teplej časti roka v obdobiach stagnácie prietočnosti spravidla vyvinul kvantitatívne bohatý zooplanktón tvorený výlučne euplanktonickými druhmi (VRANOVSKÝ 1974, 1985; VRANOVSKÝ, ILLYOVÁ 1999). Z vírnikov dominovali viaceré druhy rodov *Brachionus, Keratella, Polyarthra* a *Synchaeta*. Z perloočiek to boli *Bosmina longirostris* spolu s *Daphnia longispina* a *D. cucullata* (v ramenách nad Gabčíkovom), resp. s *D. cucullata, Diaphanosoma brachyurum* a *Moina brachiata* (v Istragovskom ramene - pod Gabčíkovom). Podobne z druhej významnej komponenty krustáceoplanktónu - veslonôžok - v stredovej zóne boli zastúpené iba pravé planktonty, najmä *Thermocyclops oithonoides* a *Th. crassus* (v Istragovskom ramene) spolu s niektorými ďalšími druhmi.

Ramená typu plesiopotamál

Z monitorovaných ramien, nielen v hlbšom ramene na Kráľovskej lúke pri Trstenej, ale aj v plytkom zvyšku ramena na Spornej sihoti pri Kľúčovci v krustáceoplanktóne dominovali typické planktonty, ba v prvom roku boli jeho jedinou zložkou (VRANOVSKÝ, ILLYOVÁ 1999). V ramene na Kráľovskej lúke to bola z perloočiek *Diaphanosoma brachyurum* alebo *Bosmina longirostris*, z veslonôžok *Thermocyclops oithonoides*, v ramene na Spornej sihoti medzi najčastejšie a aj v ročných priemeroch dominujúce druhy patrila perloočka *Bosmina longirostris* a veslonôžky *Cyclops vicinus, Thermocyclops oithonoides, Th. crassus, Eudiaptomus gracilis., Eurytemora velox* a tiež *Acanthocyclops robustus.*

Po zátopách inundačného územia sa v tomto type ramien vytváralo spoločenstvo s dominanciou euplanktonických druhov, najmä veslonôžok *Cyclops vicinus* a *Thermocyclops crassus*. V iných obdobiach tu nadobúdali kvantitatívnu prevahu druhy charakteristické pre litorál, resp. plytké občasné (temporárne) stojaté vody: z perloočiek najmä *Chydorus sphaericus* a *Ceriodaphnia reticulata*, z veslonôžok *Megacyclops viridis, Metacyclops gracilis, Eudiaptomus transylvanicus* a *Cryptocyclops bicolor.*

Pôvodné spoločenstvá zoobentosu

Hlavný tok Dunaja

Spoločenstvá nálevníkov (MATIS, TIRJAKOVÁ, 1995 a, b) sa ukázali byť pomerne chudobné z hľadiska druhového zloženia i abundancie. Zastúpené boli hlavne euryékne druhy (bakteriovorné – *Cyclidium glaucoma, Aspidisca cicada, A. lynceus, Glaucoma scintillans* a i.). V relatívne malom počte boli zastúpené planktonické druhy. Ostatné sledované zložky mikrozoobentosu a meiozoobentosu boli nachádzané sporadicky. Bolo to spôsobené nedostatkom vhodných substrátov, veľkou rýchlosťou prúdu, zanášaním kalom, vyplavovaním turbulenciami a nestabilitou výšky hladiny. Po záplavách Dunaja sa opakovane zisťovali inaktivácie jedincov (pravdepodobne vplyvom splavených toxických látok).V tomto období sa objavili na jednotlivých lokalitách aj zriedkavejšie sa vyskytujúce druhy napr. *Ophryoglena flava, Tintinnopsis cilindrata, Stegochilum fusiforme, Frontonia anbigua, Strombidium turbo.*

Permanentná fauna makrozoobentosu mala v sledovanom úseku rieky v litorálnej zóne kvalitatívne jednotný charakter (KRNO et al., 1999). Medzi dominatné druhy patrili - *Eunapius fragilis* (Porifera), *Dendrocoelum lacteum* (Turbellaria), *Dina punctata* (Hirudinea), *Ancylus fluviatilis, Lymnaea ovata, Bithynia tentaculata* (Gastropoda), *Dreissena polymorpha, Sphaerium corneum* (Bivalvia) (KOŠEL, 1995a). Z máloštetinavcov to boli druhy z čeľ. Naididae a *Stylodrilus heringianus* (Lumbriculidae), zriedkavo sa vyskytovali druhy z čeľ. Tubificidae. Významný bol aj výskyt druhu *Hypania invalida* (Polychaeta) a *Dikerogammarus haemobaphes* a *Corophium curvispinum* (Amphipoda). Isté rozdiely vo faune boli na profile Kľúčovec, ktorý leží už poniže spádového zlomu Dunaja (ŠPORKA, KRNO 1995).

V taxocenózach temporárnej fauny v litoráli Dunaja dominovali *Baetis fuscatus, Heptagenia sulphurea, Caenis pseudorivulorum* (Ephemeroptera). *Hydropsyche contubernalis, H. bulgaroromanum, Psychomyia pusilla Brachycentrus subnubilus, Ceraclea dissimilis* (Trichoptera). Oproti výskumom z 80. rokov (KRNO, 1990) sme už nezaznamenali viaceré druhy podeniek - *Heptagenia coerulans* a rod *Ecdyonurus* a ďalšie druhy sa vyskytovali veľmi zriedkavo - *Baetis vardarensis, Heptagenia flava, Ephemerella ignita* a *Potamanthus luteus*. Kvantitatívne bola dunajská fauna najbohatšia pod vyústením ramien pri Gabčíkove, pričom bol výrazne bohatšie osídlený skalnatý substrát (Krno, 1995). Na skalnatom substráte dominoval druh *H. bulgaroromanum*, na štrkovitom *H. contubernalis*. Celkove prevládali filtrátory (Hydropsychidae, *Brachycentrus*).

Mediálna časť hlavného toku Dunaja (r. km 1816), ktorú sledovala ERTLOVÁ (1968) bola osídlená hlavne máloštetinavcami (*Nais elinguis, Chaetogaster crystallinus, Propappus volki, Rhynchelmis limosella* a *Stylodrilus heringianus*), pijavicami *(Erpobdella octoculata)*, pakomárovitými *(Polypedilum sk. laetum, P. sk. scaleanum, Ablabesmyia sk. lentiginosa a Euorthocladius rivicola).*

Ramená typu parapotamál

Na našom území sa z hľadiska štúdia mikrozoobentosu venovala pozornosť predovšetkým ramenám (MATIS, TIRJAKOVÁ, 1992; TIRJAKOVÁ, 1992; SZENTIVÁNY, TIRJAKOVÁ, 1994). Z hľadiska štruktúry sledovaných skupín nie je možné sledované ramená hodnotiť ako celok. Spoločenstvá každého z nich vzhľadom na svoj charakter a meniace sa podmienky sa vyvíjali špecificky. Spoločným znakom všetkých sledovaných ramien pred napustením vodného diela je dlhodobý postupný pokles hladín vody, ich premena na ramená s prúdiacou vodou len počas vyšších prietokov v Dunaji. V období po ich odrezaní od hlavného toku sa tu vyskytovali bohaté spoločenstvá typické pre stojaté vody.

Ramená so stojatou vodou a preplachované počas povodní sa vyznačovali širokým druhovým spektrom a abundanciou všetkých skupín mikrozoobentosu (*Ciliophora, Mastigophora, Heliozoea, Amoebina*).

V permanentnej faune slepých ramien, sa pôvodne vyskytovali jednak rovnaké druhy ako v hlavnom toku *Corophium curvispinum, Dikerogammarus haemobaphes* (Amphipoda), *Hypania invalida* (Polychaeta), *Stylodrilus heringianus* a rody *Psammoryctides* a *Potamothrix* (Oligochaeta) (KOŠEL, 1995a; KRNO et al., 1999). V prietočnom ramene pri Istragove dominovali, ako zistila v roku 1966 ERTLOVÁ (1970), Oligochaeta (*Potamothrix moldaviensis, Tubifex tubifex, Tubifex ignotus* a rod *Limnodrilus*) a Chironomidae (*Prodiamesa olivacea, Chironomus* sk. *thummi, Cryptochironomus* sk. *defectus*). Vysokú abundanciu v hlavných ramenách Bačianskej ramennej sústavy v rokoch 1976 – 1978 na štrkopiesčitom dne mediálu dosahovala *Dreissena polymorpha* (Bivalvia), ktorej agregácie boli vyplnené jemnými sedimentami a osídlené osobitým bentickým spoločenstvom, druhové zloženie ako aj početnosť bentickej fauny bola vysoká (ŠPORKA, NAGY 1998) Vysoké stavy síce spôsobovali dočasné ochudobnenie fauny, po krátkom období, cca 35 dní, sa pôvodné spoločenstvo dokázalo zotaviť.

V rámci temporárnej fauny v prietočných ramenách LICHARDOVÁ (1958), pred rokom 1960 zistila viaceré taxocenózy podeniek v ktorých sa pravidelne vyskytovali druhy – *Potamathus luteus, Heptagenia sulphurea, Ecdyonurus aurantiacus, Baetis rhodani, B. fuscatus, Serratella ignita.* Svedčí to o výrazne väčšej reofilnosti týchto ramien. Podobná situácia v dunajských ramenách bola s taxocenózou potočníkov (MAYER, 1935) – *Rhyacophila pascoei, Agapetus* sp., *Hydroptila* sp., *Plectrocnemia* sp., *Neureclepsis bimaculata, Polycentropus flavomaculatus, Hydropsyche* spp., *Cheumatopsyche lepida, Setodes interruptus, Potamophylax latipennis, Halesus* spp., *Goera pilosa, Silo pallipes* a *Brachycentrus subnubilus.* V ramenách Bačianskej ramennej sústavy v rokoch 1976 – 1978 bolo z podeniek zistených 6 taxónov a z potočníkov zástupcovia dvoch čeľadí, okrem toho z pakomárovitých bolo zistených 22 taxónov (ŠPORKA, NAGY 1998). V rokoch 1991 – 1992 temporárna fauna prietočných ramien bola pomerne chudobná, zastúpená druhmi *Cloeon dipterum, Caenis horaria, C. luctuosa* (Ephemeroptera) a rodmi *Ecnomus, Cyrnus, Anabolia, Athripsodes* (Trichoptera). Z vážok (MAJZLAN, 1992) dominovali v parapotamáli druhy *Calopteryx splendens* a *Lestes viridis.* Spoločenstvo pakomárovitých sa vyznačovalo prítomnosťou druhov uprednostňujúcich tečúce typy vôd (*Cricotopus bicinctus, Tanypus kraatzi*) ako aj druhmi preferujúcimi pomalšie tečúce, alebo stojaté vody (*Dicrotentipes* spp., *Polypedilum* spp.) (KRNO a kol., 1999).

Ramená typu plesiopotamál

V mŕtvych ramenách Dunaja sa vyskytovali pomerne stabilné spoločenstvá mikrozoobentosu (najmä na lokalitách Kráľovská lúka a Sporná sihoť). Na lokalite Kráľovská lúka vplyvom zníženia hladiny však dochádzalo v letných mesiacoch k prehrievaniu vody, čo malo za následok zmeny v štruktúre spoločenstva hlavne nálevníkov (masové premnoženie niektorých druhov, napríklad *Coleps nolandi*) (MATIS, TIRJAKOVÁ, 1995a,b) .

V litoráli ramien typu plesiopotamál sa vyskytovalo jednak štrko-piesčité dno a jednak bahnité dno. Na štrko-piesčitom dne bolo druhové zloženie permanentnej fauny pestrejšie, vyskytovali sa tu okrem druhov z čeľ. Tubificidae aj druhy z čeľ. Naididae, teda druhy živiace sa nárastami, kdežto v bahnitom dne prevládali druhy z čeľ. Tubificidae, prípadne amfibiotické druhy čeľ. Enchytraeidae, veľké druhy *Criodrilus lacuum* a *Eiseniella tetraedra* (NAGY, ŠPORKA, 1990). Druhove chudobné boli aj ostatné skupiny, pričom prevažovali ulitníky so 14 druhmi. Abundancia väčšiny druhov bola pritom veľmi nízka, jedine kôrovec *Asellus aquaticus* sa v roku 1992 zistil vo zvýšenom množstve (ŠPORKA, KRNO, 1995). Z temporárnej fauny sa tu vyskytovali hlavne stagnikolné druhy vážok *Sympetrum flaveolum, Lestes barbarus, Cordulia aenea* ale bol tu zistený semireofilný druh *Platycnemis pennipes* (MAJZLAN, 1992). Spoločenstvo pakomárovitých bolo druhove chudobné, pričom dominantné postavenie zaujímali pelofilné druhy *Cryptochironomus defectus* a *Polypedilum nubeculosum* (KRNO et al., 1999).

V ramene Žofín v roku 1971 medzi dominantné skupiny patrili Oligochaeta a Chironomidae ERTLOVÁ (1973). K rovnakým záverom dospeli aj NAGY a ŠPORKA (1990) v rokoch 1981 – 1987 na ramene pri Kráľovskej lúke, kde najvyšší počet taxónov u permanentnej fauny bol zistený v litoráli (bez zárastov a so zárastami), mediálna zóna bola osídlená len chudobne. Mediálnu zónu s bahnitými sedimentami osídľovali v prevažnej miere larvy pakomárovitých, ktoré sa druhovo početne vyskytovali aj v litorálnej zóne ramena.

Pôvodné ichtyocenózy v hlavnom toku a v ramenných sústavách

Pôvodné ichtyocenózy v hlavnom toku a ramenných sústavách od ústia rieky Moravy po ústie rieky Ipľa opisuje BALON (1966), na základe prác Laboratória rybárstva v rokoch 1953–1961. Udáva existenciu 56 druhov rýb s komentárom ich výskytu. Výskumy v nasledujúcich troch desaťročiach však ukázali, že počet žijúcich druhov v tomto úseku Dunaja je výrazne vyšší, takže je v porovnaní s ostatnými tokmi na Slovensku druhovo najbohatším. Najnovší zoznam druhov rýb slovenského úseku Dunaja obsahuje 76 položiek. Z toho 61 druhov je pôvodných, 10 (11) introdukovaných exotických a 3(4) druhy sem invadovali z dolných úsekov Dunaja (HOLČÍK 2003). V porovnaní so všetkými slovenskými riekami ichtyocenóza tohoto úseku Dunaja je druhovo najbohatšia. Autor si to vysvetľuje dvomi faktormi:

1) skutočnosťou, že ide o začiatok podhorskej zóny, presnejšie, o prechod medzi podhorskou a nížinnou zónou – medzi hyporitrálom-epipotamálom a metapotamálom v zmysle klasifikácie ILLIES A BOTOSANEANU (1963);
2) zmenou spádu koryta Dunaja, ktorá zapríčinila vznik rozsiahlej vnútrozemskej delty s komplikovaným systémom ramien.

Toto spôsobuje, že na relatívne krátkom úseku Dunaja sa nachádzajú veľmi rôznorodé typy prostredia, čo vytvára druhovo bohaté spoločenstvo rýb.

Antropické zásahy ovplyvnili ichtyocenózy v Dunaji. Výstavba vodného diela „Železné vráta" na dolnom Dunaji zamedzila výskyt migrujúcich druhov. Naviac v Dunaji pribudli introdukované – allochtónne druhy. V období rokov 1970 – 1980 pri kulminácii organických a toxických polutantov došlo skoro k vymiznutiu lososovitých druhov citlivých na znečistenie, ako aj *Cottus gobio*, *Phoxinus phoxinus*, *Alburnoides bipunctatus* a *Barbus barbus*. Zlepšenie kvality vody v rokoch 1980 -1990 sa prejavilo k ich opätovným výskytom. Od r.1994 sa začali objavovať aj nové druhy rýb z čeľade Gobiidae, predtým známe iba z dolných úsekov Dunaja.

Konektivita hlavného toku Dunaja s ramennými systémami priaznivo ovplyvňovala ich druhovú diverzitu. Ako konštatuje HOLČÍK (2001), hodnoty počtu druhov, druhovej diverzity a vyrovnanosti sú v hlavnom toku vyššie a laterálne smerom od hlavného toku ku okraju vnútrozemskej delty vykazujú pokles. Príčinou sú rozdielne podmienky prostredia v ekosystémoch jednotlivých typov vôd vnútrozemskej delty. Nebyť vnútrozemskej delty, druhová diverzita v hlavnom toku by bola nižšia. Spôsobuje to hlavne existencia vhodných neresísk v ramenách a vhodné refúgia hlavne počas povodní, ako aj dobrá potravinová ponuka ramien.

Vyhodnotenie pôvodného stavu ichtyocenóz na monitorovacích plochách a v Dunaji, tesne pred prehradením Dunaja v roku 1992, podáva ČERNÝ (1999).

3 FUNKCIE ÚZEMIA

3.1 PRIORITNÉ FUNKCIE ÚZEMIA

3.1.1 Protipovodňová ochrana (prevádzanie povodňových prietokov a ľadov)

Záplavové územie (inundačné územie) je formované eróznou a sedimentačnou činnosťou rieky, meandrovaním rieky a riečnych ramien v celom údolí. V čase povodní rieka vystupuje z koryta, usadzuje sedimenty za brehmi vlastného koryta a medzi ramenami. Prirodzene fungujúca rieka mení a vytvára nové ramená a zanáša staré. Záplavové územie býva pravidelne zaplavované. Dnes siaha len po protipovodňové ochranné hrádze, ktoré sa nachádzajú vnútri pôvodného záplavového územia.

Hydrologickou funkciou inundácie, o ktorej v tejto štúdii hovoríme, je predovšetkým previesť povodňové prietoky tak, aby sa povodňová voda nedostala za ochranné protipovodňové hrádze na slovenskom a maďarskom území. Ďalšou funkciou je funkcia prirodzeného poldra, čo znamená, počas povodne dočasne zadržať časť vody z povodňového maximálneho prietoku, aby sa zmenšil maximálny povodňový prietok v Dunaji poniže inundácie. Tejto hydrologickej funkcii napomáhajú aj „kaskády". Tieto dve protipovodňové funkcie inundácie majú absolútnu prioritu. To bol hlavný dôvod prečo inundácia v tomto úseku Dunaja ostala zachovaná a derivačný kanál bol postavený mimo inundáciu.

V súlade s touto hydrologickou prioritou špecifickou pre postavené vodné dielo je **ekologické hľadisko** zrejmé. Treba **zachovať špecifické vlastnosti inundácie a pre inundáciu typický akvatický až terestrický ekosystém**, ktorý má početné charakteristické biotopy a ekotopy. Záplavové územie je v tomto zmysle považované za systém, v ktorom **živá zložka predstavuje ústredný bod záujmu** a v ďalších rozhodovaniach o úpravách vodného režimu je považovaná za rozhodujúcu v priestore inundácie a v čase, a to sezónne i dlhodobo. Z hľadiska ekosystému je typické, že inundácia je viac-menej pravidelne zaplavovaná v závislosti od prietokov v Dunaji. Je tiež zrejmé, že vzhľadom na predchádzajúci vývoj zahlbovania koryta rieky, záplavy sú menej časté, ako by sa to dalo očakávať v závislosti od prietokov v Dunaji. Je tiež zrejmé, že aj hladiny v starom koryte Dunaja sú dnes preto nižšie, a ešte sú dodatočne znížené o časť povodňovej vody, ktorá prechádza počas povodní derivačným kanálom. Je zrejmé, že ak záplavy a výška ich hladiny majú byť pre inundačné územie typické, mali by byť častejšie, a hladiny vody vyššie, a to až do výšky, ktorá odpovedá množstvu vody, ktoré preteká počas povodní cez Bratislavu. Záplavám inundačného územia teda treba v súčasnej situácii do určitej miery pomôcť. Táto pomoc sa môže principiálne uskutočniť zvýšením hladiny vody v starom koryte Dunaja, zásobovaním záplavového územia vodou z derivačného kanála a rôznymi úpravami priamo v ramennej sústave, napríklad regulovaním prietoku na kaskádach a medzi ramenami. Ak sme hovorili o závislosti prietokov v ramenách od prietokov v Dunaji, potom je optimálne takýto stav dosahovať autoreguláciou, so zásahmi človeka len v kritických a zvláštnych prípadoch.

Sústava dunajských riečnych ramien, výsledok predchádzajúceho hydromorfologického vývoja rieky, leží medzi ochrannými protipovodňovými hrádzami a bývalým hlavným tokom rieky (**Obr. 2.1**). Tohoto územia sa nedotkla priamo výstavba derivačného kanála, hydroelektrárne, ani iných stavebných objektov. Na Dunaji je to skutočne unikátna situácia. V zásade boli pri výstavbe vodného diela navrhnuté dve základné myšlienky. Prvý zámer, zásobovať vodou inundačné územie a riečne ramená, bol uskutočnený na oboch stranách rieky, na slovenskej strane výstavbou odberného objektu v hornej časti záplavového územia pri Dobrohošti, na maďarskej strane výstavbou odberného objektu priamo v hati pri Dunakiliti, v hornej časti maďarskej inundácie. Druhým zámerom bolo obnoviť výšku hladiny vody v starom koryte Dunaja, pretože táto už v minulosti klesala a po prehradení Dunaja a odvedení väčšej časti vody do derivačného kanála poklesla ešte viac. Zvýšenie hladín v starom koryte Dunaja a prepojenie s dunajskými ramenami sa malo riešiť sériou pretekaných prehrádzok v starom koryte Dunaja. Zámer sa realizoval čiastočne pri Dunakiliti.

3.1.2 Ochrana prírody a krajiny (súčasný stav a návrh)

Medzi prioritné funkcie územia patrí, popri prevedení povodňových prietokov tak, aby sa povodňová voda nedostala za ochrannú hrádzu, na prvom mieste, aj **zachovanie špecifického a pre inundáciu typického akvatického až terestrického ekosystému, ktorý by spontánne konvergoval k prírodnému**. To zároveň podporuje plnenie protipovodňovej funkcie inundačného územia.

Vzhľadom na **prioritné postavenie rastlinstva v ekosystémoch prírodných či prírodným blízkych**, hneď na začiatku úvah treba zdôrazniť, že **lužný ekosystém je z hľadiska flóry a vegetácie veľmi dynamický**, ale na druhej strane **vysoko adaptabilný**. I krátkodobé zmeny hydropedologického režimu (záplavy, hĺbka stojatých a pomaly tečúcich vôd, spádová krivka ramien, hladina podzemných vôd, fyzikálno-mechanické vlastnosti pôd a i.) vyvolávajú adekvátnu zmenu v štruktúre vegetácie. Tieto zmeny majú veľmi krátke časové úseky, a to od jedného roka (jednoročné fytocenózy litorálu), cez niekoľko málo rokov (močiarna vegetácia), končiac 10-20-timi rokmi pri vegetácii mokrých a vlhkých typov lužného lesa. Pritom zmeny a adaptácie nevybočujú z celkového rámca lužných ekosystémov, ale odohrávajú sa výlučne v jeho vnútri. Ide teda o zmeny odohrávajúce sa v kvantitatívnej rovine. K zmene kvality, t.j. napr. k zániku niektorého typu vegetácie, alebo rastlinnej populácie tu dochádza len výnimočne. Názorne to bolo demonštrované v prognózach zmien už v spojitosti s pripravovanou výstavbou Sústavy VD Gabčíkovo–Nagymaros

(JURKO 1976), alebo Wolfsthal (ŠOMŠÁK 1994). V obidvoch prípadoch bolo konštatované, že očakávané zmeny budú mať len relatívny charakter, to znamená, že **tam, kde sa hladina podzemných vôd zníži vzniknú suchšie typy lužných ekosystémov a opačne**. Zmeny v hydropedologickom režime však nesmú prekročiť existenčný limit rastlinstva lužných ekosystémov (trvalé vysúšanie, zaplavenie ekotopov). Takýto stav sa začal uplatňovať od začiatku 70-tych rokov 20. storočia (celkové úpravy toku Dunaja vrátane prehlbovania dna) a pokračoval až do prehradenia Dunaja v októbri 1992, V máji r. 1993 začalo fungovať náhradné zásobovanie vodou ramenného systému inundácie.

Vzhľadom na mimoriadnu dynamiku a zároveň aj vysokú adaptabilitu rastlinstva a inundačného územia je problémom stanoviť ideálny – optimálny vodný režim. Na základe prevládajúcich názorov väčšiny odborníkov, **za optimálne hydropedologické podmienky pre inundáciu možno považovať koniec 50-tych a začiatok 60-tych rokov, kedy asi 70 % rastlinstva tohto územia malo fytocenózy prírodné, alebo prírodným blízke.**

Dynamika flóry a vegetácie v období tesne pred prehradením a niekoľko rokov po prehradení bola sledovaná na biologických monitorovacích plochách rozmiestnených po celom dotknutom území. V inundácii sa vyhodnocovalo 6 monitorovacích plôch (UHERČÍKOVÁ et al., 1999, UHERČÍKOVÁ 2001). Pri sledovaní súvislosti zmien rastlinstva a vodného režimu bol zvýraznený význam fyzikálno-mechanických vlastností fluvizemných pôd (CAMBEL 2001).

Ekosystémy inundačného územia Dunaja v úseku rieky medzi Viedňou, Bratislavou a Komárnom predstavovali koncom 20. storočia európsky unikát. Okrem rozmanitosti to bola aj plocha, na ktorej sa rozprestierali. Ich najcennejšia časť s ramenným systémom Dunaja, známa aj ako vnútrozemská delta vznikla medzi Bratislavou a Sapom na náplavovom kuželi Dunaja. Územná ochrana sa však zabezpečovala iba lokálne, formou niekoľkých prírodných rezervácií.

O potrebe veľkoplošnej územnej ochrany prírody Podunajska sa zmieňuje RANDÍK (1965) a ŠTOLLMANN (1966). Prvý návrh na vyhlásenie veľkoplošného chráneného územia, ktoré by riešilo územnú ochranu inundačnej oblasti Dunaja v úseku medzi riečnymi kilometrami 1810 - 1842, je z roku 1969. Podľa návrhu vyhlášky MK SSR rozloha navrhovanej chránenej krajinnej oblasti Dunaj bola 13.687 ha, ochranné pásmo malo plochu 19.702 ha. Pôvodný návrh mal byť vypracovaný v dvoch variantoch - bez prítomnosti vodného diela a s ním. Návrh bol však v súvislosti s pripravovanou výstavbou vodného diela zamietnutý. V roku 1986 kolektív členov Mestskej organizácie Slovenského zväzu ochrancov prírody a krajiny v Bratislave vypracoval vôbec najkomplexnejší projekt veľkoplošného chráneného územia v Podunajsku (vrátane oblasti Malého Dunaja, Klatovského ramena, Vážskeho Dunaja, časti Čiernej vody, Čilizského potoka, Váhu, Nitry, Žitavy a ďalšie vodné toky a ich priľahlé územie ľavobrežného Podunajska medzi ústím Vážskeho Dunaja a Ipľa). V r. 1987 bol tento návrh predložený Ministerstvu kultúry SSR a ústredným straníckym a štátnym orgánom SSR ako "Návrh vládneho nariadenia na vyhlásenie národného parku Podunajsko" (HUBA, ŠREMER 1990, HUBA, ŠREMER et al. 1990a, 1990b). V r. 1991 pripravilo Stredisko rozvoja ochrany prírody Bratislava pri Ústredí štátnej ochrany prírody Liptovský Mikuláš ďalší návrh na vyhlásenie CHKO Dunaj (Návrh na vyhlásenie Chránenej krajinnej oblasti Dunaj (KRAMÁRIK 1991). Úsilie o vyhlásenie veľkoplošného chráneného územia, zabezpečujúce územnú ochranu predmetnej časti inundačného územia Dunaja, sa zavŕšilo až **vyhlásením CHKO Dunajské luhy 1. mája 1998 (Vyhláška MŽP SR č. 81/1998 Z. z. o Chránenej krajinnej oblasti Dunajské luhy**). CHKO pozostáva z piatich, priestorovo nespojitých častí. Inundačné územie vymedzené riečnymi kilometrami 1810 až 1842 je treťou časťou CHKO.

Inundačné územie Dunaja v úseku riečných kilometrov 1810 - 1842 si zasluhuje mimoriadnu pozornosť ochrany prírody. Od r. 1989 bolo zaradené medzi **významné vtáčie oblasti** v Európe pod označením SR-04 (017) Podunajsko (HORA, KAŇUCH et al., 1992, BOHUŠ 1992); KAŇUCH (2000) uvádza lokalitu pod názvom Niva Dunaja (River Danube flood-plain). Jej medzinárodný kód je IBA 007, národný kód SR-04. Od roku 1993 je oblasť **súčasťou územia, zahrnutého do Zoznamu mokradí medzinárodného významu v rámci Ramsarského dohovoru** (SLOBODNÍK, KADLEČÍK 2000) a je aj súčasťou **územia osobitného záujmu ochrany prírody** Emerald Network.

V súvislosti s úsilím o zavedenie environmentálne akceptovateľného lesného hospodárenia treba spomenúť aktivity Oddelenia ekosozológie a monitoringu Ústavu zoológie a ekosozológie SAV (v súčasnosti Ústav zoológie SAV), zamerané na **vytvorenie mozaiky biocentier**. V pôvodnom návrhu bolo vybratých 28 lokalít, ktoré boli významné svojím charakterom a v krajine vytvárali ekosozologicky funkčnú štruktúru (LISICKÝ, ROVNÝ 1987). Zásady tohoto alternatívneho lesného hospodárenia boli zohľadnené v LHP od r. 1990. Neskôr bol počet biocentier upravený na 26 a v r. 1993 bol pre ne vypracovaný návrh lesohospodárskych opatrení (PIŠÚT et al. 1993). Od r. 1994 sú lesné porasty týchto biocentier prekategorizované na **lesy osobitného určenia**. Ako genofondovo významné lokality lesných ekosystémov bolo definovaných 25 lokalít (f 1 - f 25); ako genofondovo významné lokality fauny 10 lokalít [z 15, z 16, z 17, z 29 - 32, z 40, z 41, z 48] (IZAKOVIČOVÁ et al., 1994).

Na ľavostrannom inundačnom území úseku Dunaja medzi riečnymi kilometrami 1810 - 1842, ktoré je časťou CHKO Dunajské luhy, platil podľa Zákona NR SR č. 287/1994 Z. z. o ochrane prírody a krajiny druhý stupeň ochrany. Aj podľa Zákona NR SR z 25. júna 2002 o ochrane prírody a krajiny, ktorý nadobudol 1.1.2003, platí v celom území druhý stupeň ochrany. T.č. sú v oblasti dve **chránené územia s piatym, teda najprísnejším stupňom ochrany** - NPR Ostrov orliaka morského a PP Kráľovská lúka. Národná prírodná rezervácia Ostrov orliaka morského bola vyhlásená v r. 1953 pôvodne ako Štátna prírodná rezervácia na ploche 173,78 ha. Novelizácia v r. 1988 zmenšila jej rozlohu na 22,77 ha. Pôvodným účelom rezervácie bola ochrana lužných porastov ako hniezdiska orliaka morského (*Haliaeetus albicilla*), orliak tu však paradoxne práve od roku 1953 prestal hniezdiť (ŠTOLLMANN 1966). Povrch rezervácie tvorí sústava agradačných valov (pri brehu ramena) a depresií (lagún vo vnútrozemí riečneho ostrova - pravdepodobne zvyškov niekdajších, dnes zazemnených ramien). Väčšinu drevinnej vegetácie tvoria porasty domácich drevín (*Salix* sp. a *Populus nigra*) asociácie *Salici - Populetum*, časť tvoria vysadené porasty hybridov topoľov *Populus* x *canadensis*. Tvar chráneného územia, približný obdĺžnik a nepravidelný päťuholník, ktoré sa dotýkajú vrcholmi, sú výsledkom lesohospodárskych a nie ekosozologických argumentov. Ako veľkosť plochy, tak i pôdorys rezervácie možno považovať za nevhodné z hľadiska funkčnosti chráneného územia. ŠTOLLMANN (1966) vo svojom hodnotení funkčnosti rezervácie nepovažuje za dostatočnú ani jej pôvodnú veľkosť.

Prírodná pamiatka Kráľovská lúka predstavuje relikt zazemňujúceho sa ramena v miestach niekdajšieho meandra rieky. Relatívne malé chránené územie (plocha 3,24 ha) sa nachádza v bezprostrednom susedstve protipovodňovej ochrannej hrádze a je intenzívne navštevované rybármi. Vzhľadom na túto skutočnosť plní len funkciu ochrany rastlinných spoločenstiev a spoločenstiev bezstavovcov, viazaných na fyziotop plesiopotamálu.

Tab. 3.1 Kategorizácia lesov a podiel maloplošných chránených území v Chránenej krajinnej oblasti Dunajské luhy k r. 2002
Forest categorisation and a ratio of protected small areas in the Protected landscape area Dunajské luhy at 2002

Okres	LHC s dobou platnosti	Lesné pozemky v ha					Všetky druhy pozemkov spolu	Maloploš. chránené územia PR, CHA	MCHÚ PR, CHA z celkovej plochy v %	MCHÚ PR, CHA z lesných plôch v %
		Lesné porasty								
		Hospod. Lesy	Ochran. lesy	Lesy osobitného určenia	Ostatné lesné pozemky	Spolu				
Bratislava II.	Rusovce 2005	0	97,56	706,58	128,36	932,50	1136,89	134,00	11,78	14,36
Bratislava V.	Rusovce 2005	0	21,58	402,52	0	424,10	738,65	54,83	7,42	12,93
Senec	Šamorín 2004	0	8,07	12,13	0	20,20	529,17	0	0,00	0,00
Dunajská Streda	Šamorín Gabčíkovo 2004	2594,40	0	439,95	150,73	3185,08	7233,78	26,87	0,37	0,84
Komárno	Čalovo 2004	751,36	44,46	0	102,26	898,08	2619,23	89,01	3,39	9,91
ChKO celkove		3345,76	171,67	1561,18	381,35	5459,96	12257,72	304,71	2,48	5,58

Zdroj: Správa CHKO Dunajské luhy, 2002. Územie štúdie leží v okrese Dunajská Streda

Tab. 3.2 Spracované návrhy nových chránených území (2002)
Elaborated proposals of new protected areas (2002)

Pracovný názov	Kategória	LHC	JPRL – porasty	JPRL biele plochy	Výmera LPF v ha
Časť III.					
Forrás	Prírodná rezervácia	Gabčíkovo	164a, 164b, 164c, 164d, 164e, 167b, 169, 170a, 170b, 170c, 171a, 171b,171c, 178a, 178b, 285a1, 285a2, 285b, 285c, 286 a, 286 b, 286 c,286d, 286e, 287,288, 290a, 290b, 291, 292, 293, 294, 295a, 295b, 296a, 296b, 297, 298a, 298b, 298c, 298d		148,00
Ostrov orliaka morského – rozšírenie	Prírodná rezervácia	Gabčíkovo	245, 246, 248c, 250 I., 250 II., 250 III.	35, 37, 38, 39, 40	29,05
Hajóšok	Prírodná rezervácia	Šamorín	135I.,135II., 136a,136b,136c		26,03
Čilizská sihoť	Prírodná rezervácia	Gabčíkovo	343, 350, 352, 353, 354, 355, 356, 357, 358, 359, 336aI, 336aII, 336bI, 336bII, 337 a, 337b, 337c, 337d, 337e, 342 II, 342 I, 351 I, 351 II,		73,91
Istragov	Prírodná rezervácia	Gabčíkovo	285a, 285b, 285c, 286a, 286b, 286c, 286d, 286e, 287, 288, 290a, 290b, 291a, 291b, 292, 293, 294, 295, 296a, 296b, 297, 298a, 298b, 298c, 298d, 298e + priľahlý (súčasne nezaplavovaný) trsťový močiar		77,27

Zdroj: Správa CHKO Dunajské luhy, 2002

Zastúpenie chránených území v záujmovom území je nedostatočné z hľadiska pomeru ich plochy k celkovej ploche územia aj z hľadiska reprezentatívnosti zastúpenia ochrany jednotlivých ekosystémov, respektívne ich sukcesných štádií. O tomto dáva výpoveď aj nasledujúca **tabuľka 3.1**. Súčasný stav biocentier, existujúcich a navrhovaných chránených území je znázornený na mape chránených území (**Obr. 3.1a, 3.1.b**). Správa CHKO Dunajské luhy pracuje ďalej na projektoch nasledujúcich maloplošne chránených území - **tabuľka 3.2.**

3.2 ĎALŠIE FUNKCIE ÚZEMIA VO VÄZBE NA PRIORITNÉ FUNKCIE

3.2.1 Lesné hospodárstvo

Z lesníckeho pohľadu možno samozrejme hovoriť o tých istých drevinách, ktoré sa uplatňujú i pri tvorbe rastlinných spoločenstiev – základnej zložky ekosystémov. **Rozhodujúcim kritériom je tu však produkcia drevnej hmoty**. Toto kritérium sa stalo žiaľ rozhodujúcim aj v prípade lesov záplavového územia Dunaja. Vzhľadom na celoeurópsky a celosvetový trend pestovania rýchlorastúcich drevín (VOJTUŠ 1986, VARGA 1993, VARGA et al., 1997, NEŠTICKÝ 1996) boli už v rokoch 1925-1938 založené porasty v inundácii Dunaja Váhu a Moravy. Ich mimoriadne vysoký ročný prírastok drevnej hmoty bol impulzom pre ich veľkoplošné zakladanie v 50-tych rokoch (1956-60), kedy bolo vysadených okolo 30 miliónov topoľových a vŕbových sadencov (VOJTÚŠ 1986). Keďže rozloha týchto porastov sa v inundačnom území pohybuje okolo 80 % z celkovej plochy lesov, hlavné dreviny týchto monokultúr (šľachtence typu „Robusta“ a „I-214“) sú predmetom sledovania prírastkov pred prehradením Dunaja, ale i v jednotlivých rokoch po prevádzkovaní Vodného diela Gabčíkovo. Rozsiahle výskumy prírastkov drevnej hmoty (ŠMELKO et al., 1996, 1997, NEŠTICKÝ, VARGA 2001) sú dávané do vzťahu s hladinami podzemných vôd, pôdnou vlhkosťou a záplavami. Kritériom je aj dobrý **zdravotný stav lesných drevín a celých porastov**, hodnotený aj fotogrametricky (VARGA et al., 1997). Mimoriadne vážnym ukazovateľom zdravotného stavu lesa je zmena stavu olistenia lesných drevín. V inundácii Dunaja sú pomery olistenia sledované na 10-tich monitorovacích plochách (OSZLÁNYI 1995, 1996, 1999).

3.2.2 Rekreácia

Inundačné územie bolo už v minulosti predmetom záujmu, poľovníkov, rybárov, turistov (pešia turistika a cykloturistika) ako aj ďalších návštevníkov využívajúcich najmä možnosti na kúpanie a vodné športy. Po roku 1990, ešte pred ukončením vodného diela Gabčíkovo, ale už v nových podmienkach vlastníckych vzťahov, boli vypracované pre územie medzi starým korytom Dunaja a derivačným kanálom viaceré rozvojové dokumenty. Ich cieľom bolo hľadať riešenia ďalšieho rozvoja územia po výstavbe vodného diela s prihliadnutím na unikátne prírodné hodnoty územia. V r. 1990 bol vypracovaný komplexný urbanistický návrh tohto rekreačného ostrova s obcami Dobrohošť, Vojka nad Dunajom a Bodíky (Stavoprojekt Nitra, 1990). V rokoch 1991 až 1993 boli spracované ďalšie prognostické dokumenty pre toto územie (Vodohospodárska výstavba, š.p. Bratislava, 1991, URBION Bratislava, 1992). V r. 1993 bola vypracovaná špeciálna štúdia venovaná zmenám poľnohospodárskej výroby v časti medzi korytom Dunaja a deriváciou, ktorá zhodnotila aj podmienky pre rozvoj rekreačného využitia tohto územia (KRÁLIK et al., 1993). Všetky vyššie uvedené materiály sa zhodli v tom, že územie má vysoký rekreačný potenciál a po vybudovaní potrebnej vybavenosti môže byť rekreácia významnou doplnkovou ekonomickou aktivitou obyvateľov týchto troch obcí. Predpokladá sa, že vybudovanie zariadení rekreácie vyvolá rozvoj rôznych druhov služieb, čo sa môže následne prejaviť na vytvorení nových pracovných príležitostí a na stabilizácii obyvateľov týchto troch obcí.

Vyššie uvedené štúdie a rozvojové dokumenty odporúčajú pre územie „umelého“ ostrova, t.j. územia medzi starým korytom Dunaja a derivačným kanálom, tieto rekreačné aktivity:

- Obnovenie tradícií vodných športov v ramennom systéme Dunaja aj s možnosťou využitia derivačného kanála (po doriešení technických podmienok).
- Intenzívne rekreačné využitie štrkových jám A a B pri obci Vojka nad Dunajom (Vojčianske jazero a Šulianske jazero) na kúpanie a vodné športy. Podmienkou je vybudovanie prírodného kúpaliska, úprava jeho dna, brehov, pláže, základná hygienická športovo-rekreačná vybavenosť a pod.
- Rozvoj agroturistiky - plánuje sa napr. vybudovať areál agroturistiky v priestore hospodárskeho dvora v Dobrohošti s ubytovaním, športovým vybavením a stajňou na jazdecké a kočiarové kone. Navrhuje sa tiež vytvoriť podmienky pre vidiecku turistiku s využitím foriem ubytovania v súkromí vo všetkých troch obciach.
- Využitie hrádzí na medzinárodnú cykloturistickú trasu. Uvažuje sa na medzinárodnú cykloturistickú trasu napojiť miestnu sieť cyklistických trás na vytipovaných spevnených lesných cestách aj v rámci inundačného územia.
- Vybudovanie jazdeckých trás pre jazdu na koni vo väzbe na navrhovaný areál agroturistiky v Dobrohošti.
- Rozvíjanie podmienok pre rybárstvo a poľovníctvo.
- Vytváranie podmienok aj pre celoročné využitie územia. Výhľadové možnosti sú napr. v realizácii zámeru výstavby areálu kúpeľnej liečby a komunálneho kúpeľníctva, ktorý sa plánuje do navrhovaného areálu agroturistiky v intraviláne obce Dobrohošť. Podmienkou je navŕtanie geotermálnej vody.

V súčasnosti prevládajú v území individuálne formy rekreácie. Rozvoj cestovného ruchu a rekreácie pozitívne ovplyvnilo vybudovanie slovenského úseku medzinárodnej Dunajskej cyklistickej trasy (v r. 1995), ktorá vedie po hrádzi po obidvoch stranách derivačného kanála Vodného diela Gabčíkovo a tiež po ľavostrannej protipovodňovej ochrannej hrádzi.

V území sa t.č. nachádza viacero chatových osád. Azda najstaršou je chatová osada v katastri obce Bodíky. V blízkosti obce Bodíky sa nachádzajú tri osady individuálnych rekreačných chát (v práci KRÁLIKA et al., 1993 sa uvádza počet chát cca 120, v záverečnej správe z r. 2000 sa ich počet odhaduje už na 150), ide o priestor chatovej osady Rybárske domky. Pri obci Bodíky sa nachádzajú chaty v niekoľkých radoch medzi ochrannou hrádzou a brehom ramena Dunaja. Chatová osada sa ťahá takmer súvislo od Bodíkov až po líniu „F" v dĺžke viac ako 3 km. Rôzne „maringotky" sa vyskytujú aj pozdĺž samotnej línie „F". V tejto oblasti existuje nový zámer výstavby rekreačných chát aj na niekdajšom pasienku (lokalita Alsó sziget).

Nové osady chát (legálnych aj nelegálnych) boli vybudované v oblasti novovytvorených materiálových jám po ťažbe štrkopieskov v inundačnom území medzi Dobrohošťou a Vojkou nad Dunajom. Ide o najväčšiu koncentráciu chát v tomto území. V katastrálnom území Gabčíkovo, ktoré leží v tejto časti na „umelom ostrove" sa nachádza chatová oblasť Hodrácka s cca 20 individuálnymi rekreačnými chatami. Niekoľko chát a chalúp sa nachádza aj v lokalite Dedinský ostrov pri Istragove. Rozsiahla rekreačná oblasť sa nachádzala v k. ú. obce Dobrohošť v lokalite Hrušov, ktorá však bola v dôsledku výstavby Vodného diela Gabčíkovo zlikvidovaná.

Na rekreačné využitie slúžia aj neobývané domy v samotných obciach Dobrohošť, Vojka nad Dunajom a Bodíky. Podľa posledného sčítania, ktoré sa uskutočnilo v máji 2000 (ŠÚ SR, 2001), vo všetkých obciach záujmového územia je percento neobývaných domov od 24 až do 35 %. V obci Dobrohošť sa uvádza 52 neobývaných domov z celkového počtu 175 domov, v obci Vojka nad Váhom 48 neobývaných domov z celkového počtu 204 domov a v obci Bodíky je počet neobývaných domov dokonca až 56 z celkového počtu 164 domov.

Nové zámery na rozvoj rekreačných zón navrhované do inundačného územia

Aktuálne rozvojové lokality na vybudovanie intenzívne využívaných rekreačných areálov sú v súčasnosti v priestore bývalých materiálových jám, teraz jazier s podzemnou vodou. V novom zámere pre využitie Vojčianského a Šulianského jazera, ktorý bol vypracovaný v r. 2002, sú obidve jazerá navrhované na intenzívne rekreačné využitie s predpokladanou spoločnou dennou návštevnosťou až 6 500 návštevníkov. Pri špičkovej dennej návštevnosti sa uvažuje v tomto rekreačnom území dokonca s viac ako 10 000 návštevníkmi (SIRECO, 2002). Odhad počtu prítomných obyvateľov v jednotlivých obciach, to znamená trvalo bývajúci spolu s dočasne prítomnými chalupármi, chatármi a ďalšími rekreantmi v letnej sezóne je cca 2 000 – 2 500 obyvateľov. Podľa sčítania obyvateľov v máji 2000 je spolu v obciach Dobrohošť, Vojka nad Dunajom a Bodíky 1 085 trvalo žijúcich obyvateľov (ŠÚ SR, 2001).

Návrh rekreačnej zóny pri Vojčianskom jazere obsahuje agroturistický areál (stajne koní s výbehom, ubytovne, ihriská, parkoviská, športoviská), chatovú osadu, hotelovú časť a rekreačnú dedinu (individuálna chatová rekreácia). Pre rekreačnú zónu pri Šulianskom jazere bol už schválený územný plán s účinnosťou od 1.1.2001. Táto rekreačná zóna má obsahovať: ubytovanie a stravovacie zariadenia, športoviská, detské ihriská, lodenicu.

Ďalšie aktivity súvisiace s výstavbou a prevádzkovaním rekreačných zón pri jazerách, ktoré sa požadujú vybudovať sú: stavebný dvor (jeho umiestnenie ešte nie je známe) počas výstavby, nové zberné komunikácie a prístupové cesty ku všetkým zariadeniam v rekreačných zónach, parkoviská, výstavba nového vodovodu a vybudovanie nového zdroja pitnej vody, rekonštrukcia elektrických vedení, vybudovanie nových vedení a výstavba nových trafostaníc a vybudovanie kanalizácie v obciach, rozšírenie ČOV vo Vojke nad Dunajom a dobudovanie ČOV v Bodíkoch (SIRECO, 2002).

Ako je zrejmé z vyššie uvedeného rozsahu aktivít súvisiacich s plánovaným zámerom rozvoja rekreácie v inundačnom území a jeho blízkom okolí ide o rozsiahle aktivity. Ich realizáciou by došlo k významným stretom záujmov s prioritnými ochrannými funkciami inundačného územia. Negatívne vplyvy na prírodné prostredie možno sledovať už teraz a očakávať počas výstavby navrhovaného rekreačného zámeru. Pomerne rozsiahle by mali byť aj samotné zemné práce, nepriaznivé vplyvy spôsobí pohyb ťažkých stavebných mechanizmov, budú vznikať stavebné a komunálne odpady, zvýšená prašnosť, emisie, hluk a vibrácie. Vybudovanie rekreačných objektov a zariadení si vyžiada ako podmieňujúce stavby vybudovanie vodovodnej siete, kanalizácie s čistiarňou odpadových vôd, plánuje sa vybudovanie pomerne veľkých parkovísk (až na cca 1900 osobných áut súčasne). Predpokladané výrazné zvýšenie dopravy spôsobí aj zvýšenie emisií a hlukovej záťaže. Vysoký stav návštevníkov môže v sezóne ohroziť čistotu samotných jazier (kúpanie, ale najmä vjazd automobilov až k brehom jazier, umývanie áut, kúpanie psov a pod). Celoročné využívanie bude nabaľovať ešte ďalšie dobudovanie areálov, v podstate v rozpore so zámermi ochrany prírody. Môže tiež dôjsť k priamemu vyrušovaniu živočíchov, k zašľapávaniu vegetačného krytu, vytváraniu bariér pre lokálny pohyb živočíšstva a pod., čo si nutne vyžiada reguláciu pohybu návštevníkov v okolitom území a monitorovanie dodržiavania stanovených požiadaviek. Pohyb návštevníkov by mal byť usmernený iba po vyznačených chodníkoch do tých priestorov, kde by nedochádzalo k nepriaznivým stretom so záujmami ochrany prírody a krajiny.

Predložený zámer na rozvoj rekreačných aktivít bol už pripomienkovaný a je reálny predpoklad, že sa bude v určitej modifikovanej forme s prihliadnutím na pripomienky realizovať. Podľa predbežného zámeru predpokladaný termín začatia výstavby rekreačných objektov bol rok 2002, termín ukončenia je plánovaný na rok 2007 (SIRECO, 2002).

Projekt nových rekreačných zón v oblasti materiálových jám A a B, teraz nazývaných Vojčianske a Šulianske jazero, je situovaný do inundačného územia v kontakte s ľavostrannou ochrannou hrádzou. Z jeho lokalizácie v tomto území vyplýva, že musí spĺňať prísne obmedzenia. Severná strana jazier, kde sa výstavba plánuje, býva síce v porovnaní s južnou a východnou stranou oveľa menej zatápaná, avšak aj tu dochádza pravidelne k záplavám. Pritom na zabezpečenie vyžadovaných hygienických podmienok pre kúpanie a vodné športy by nesmela povodňová voda vtekať do jazier, ako sa to stalo aj v roku 2002. Plánované vybudovanie objektov a zariadení pre šport, rekreáciu a cestovný ruch predstavuje určité narušenie plynulého prevádzania povodňovej vody. Prípadné vyňatie areálu z inundačného územia neprichádza do úvahy, nakoľko by zásadne ovplyvnilo kapacitu záplavového územia pod obcou Dobrohošť. Okrem toho sa musí pri výstavbe prihliadať aj na vplyv uskutočňovaných simulovaných záplav.

V auguste 2002 bol predložený na pripomienkovanie návrh nového zákona o ochrane pred povodňami (MP SR, august, 2002). Podľa tohto návrhu zákona v aktívnej (prúdiaca voda počas povodne) zóne, kde prebieha väčšina povodňového prietoku, je zakázané umiestňovať, povoľovať a prevádzkovať stavby, ktoré môžu zhoršiť odtok povodňových prietokov, vykonávať terénne úpravy zhoršujúce odtok povrchových vôd, zriaďovať oplotenie, živé ploty a iné obdobné prekážky, zriaďovať tábory, kempy a iné dočasné ubytovacie zariadenia vrátane plávajúcich a pod. Zostávajúca časť inundácie patrí do pasívnej zóny, teda do územia zasahovaného rozlievaním vôd mimo koryta starého Dunaja a ramennej sústavy v menšom rozsahu a je charakterizovaná podstatne nižším podielom povodňového prietoku. Aj v tejto časti inundácie je však zakázané umiestňovať, povoľovať a realizovať napr. aj ubytovacie zariadenia. Treťou kategóriou v rámci členenia inundačného územia je potenciálna zóna, do ktorej sa zaraďuje územie ohrozené zaplavením pri prekročení projektovaných parametrov ochranných opatrení alebo pri závažnej poruche vodnej stavby. Ohraničenie potenciálnej zóny v prípade sledovaného územia prekračuje hranice sledovaného inundačného územia. V takýchto kritických situáciách by bolo potenciálne ohrozené zaplavením aj územie medzi ochrannou hrádzou a derivačným kanálom.

V tejto súvislosti však treba brať na zreteľ, že už aj súčasný stav využívania územia na rekreačné účely nie je priaznivý. Doterajší spôsob využívania vodných plôch Vojčianskeho a Šulianského jazera a priľahlého územia, ktoré ležia priamo v inundačnom území, je neorganizovaný, živelný, bez zabezpečenia hygienických požiadaviek, ochrany bezpečnosti návštevníkov a má negatívny vplyv na životné prostredie. V priestoroch jazier sa realizujú nevhodné športové činnosti (napr. používajú sa vodné skútre), ktoré územie nadmerne zaťažujú hlukom a súčasne ohrozujú čistotu vody v jazerách aj bezpečnosť kúpajúcich. Aj v ďalších častiach inundačného územia spôsobuje neriadená rekreácia environmentálne problémy. V území je evidovaných niekoľko neriadených skládok odpadov (len v Bodíkoch sú evidované tri neriadené skládky), veľa súčasných stavieb rekreačných objektov je nevhodne umiestnených a viaceré nemajú stavebné povolenie.

Iba za predpokladu, že sa dôsledne dodržia všetky nevyhnutné požiadavky a regulačné opatrenia, môžu mať nové rozvojové zámery pre priestor „umelého ostrova" aj určitý pozitívny prínos. V zámere sa predpokladá zabezpečiť ešte pred samostatnou realizáciou zámeru zlikvidovanie nelegálnych rekreačných objektov (cca 400 rôznych starých maringotiek, železničných vagónov, unimo-buniek a iných nelegálne vybudovaných stavieb postavených okolo jazier), odstránenie a rekultiváciu skládky odpadu (na ploche 46 000 m^2 s objemom 184 000 m^3), výsadbu pôvodných drevín na severnej strane jazier a likvidáciu všetkých vysadených nepôvodných druhov rastlín. Formy rekreácie by mali byť regulované a usmernené. Pre miestnych obyvateľov bude dôležitým prínosom aj vytvorenie cca 330 nových pracovných príležitostí v rekreačných zónach (počas výstavby pôjde o cca 80 pracovných príležitostí).

2 CHARACTERISTICS OF THE AREA

The area of water regime optimisation is the old Danube riverbed and its left-side floodplain, with the Danube arm system in the stretch between Dobrohošť (river km 1842) and Sap villages (river km 1811) (**Fig. 2.1**). The floodplain lies between the old Danube riverbed and the original flood protection dikes.

Historical changes in the natural Danube environment are a result of geological development and climatic changes during the Quaternary period. They also include an intensive transport of gravels and sands in the Danube, deepening and elevating of the riverbed bottom, forming and moving of river meanders, deposition and erosion of sediments, changes of riverbanks, and frequent flooding of this area.

The first phase of a complex development of flood protection dikes and regulatory measures in the Danube covers the period 1759-1914. Regulation of the navigation way started in 1831 and was finished in late 19th century (**Fig. 2.2**). The present setting of flood protecting dikes and the riverbed having been unnaturally straightened for the sake of navigation were constructed after the flood of 1853. In this way, the present floodplain arose, which we are speaking about. The flood of 1954, after breaking the right-side dike, devastated the major part of the Szigetköz Island in Hungary (DUB 1954). The extent of this catastrophe can be illustrated by the fact that a half of the island was flooded and water in the Bács village (district Győr) rose up to level of the second floor windows. The flood of 1965 flooded the downstream part of the Žitný Ostrov Island in Slovakia. The surface of the area flooded included 71,700 ha of arable land, 114,000 ha of arable land were waterlogged, 3,910 houses were destroyed and 53,693 citizens were evacuated (HRONEC, 1969), (**Fig. 2.3**). Flood protection of the area downstream from Bratislava was included into the Gabčíkovo-Nagymaros project.

As the International Court of Justice has pointed out, the Project of Gabčíkovo-Nagymaros system of hydropower stations "was not only a joint investment project for the production of energy, but it was designed to serve other objectives as well: the improvement of the navigability of the Danube, flood control and regulation of ice-discharge, and the protection of the natural environment" (INTERNATIONAL COURT OF JUSTICE, 1977, paragraph 135). The Gabčíkovo part of the Project was elaborated as a way to protect first of all the areas behind of the flood protective dikes (mainly the Szigetköz area and the upstream part of the Žitný Ostrov Island). The by-pass canal leading water to and from the power station was constructed outside of the floodplain (on the difference from other dam's on the Danube upstream Bratislava it preserved the floodplain in pre-dam state), **Fig. 2.1.** The independent experts of the Working Group of the Commission of European Community stated in their Report of 23 November 1992 (CEC 1992): "In the past, the measures taken for navigation constrained the possibilities for the development of the Danube and the flood-plain area. Assuming that navigation will no longer use the main river over a length of 40 km, a unique situation has arisen. Supported by technical measures, the river and flood-plain can develop more naturally". Besides this, facilities for permanent supplying the Malý Dunaj (Little Danube), the Mosonyi Duna (Danube) and the river arm system with water were constructed on both sides. It was expected that by means of the technical measures the water table in the Danube old riverbed will be maintained at a similar level as occurred in the Danube before its damming, at discharges of about 1,400 – 1,500 m^3/s. The old Danube is a term used at present for the 41.75 km stretch of the Danube between the Sap (river km 1811.0) and Čunovo villages (river km 1851.75). In this stretch, a major part of the flow rate is diverted throughout the by-pass canal to the Gabčíkovo hydropower station. At present, in accordance with the international Agreement from 1995, the flow rates in the Danube old riverbed range from 250 to 600 m^3/s, and in time of flood events even much more (AGREEMENT 1995).

It emerges from the Report of the Commission of the European Communities Tripartite Fact-Finding Mission, dated 31 October 1992, that "not using the system would have led to considerable financial losses, and that it could have given rise to serious problems for the environment" (FFM, 1992). In pre-dam conditions, sinking of the Danube riverbed bottom and thus also sinking of ground water levels existed, **Figs. 0.1, 0.2, 0.3**. According to experts of the Commission of the European Communities (CEC 1992), the discharge in all river arms existed before the Danube damming in average only during 17 days in a year.

The floodplain area is situated in the central part of an intermountain depression, the Danube basin, called in Slovakia "Podunajská nížina" (Danubian Lowland). The basin consists from Late Tertiary (marine and lacustrine sand, fine sand, clay, sandstone and shale) and Quaternary sediments, which since the glacial Mindel epoch are sand and gravel deposited in the Danube alluvial fluvial and lacustrine conditions. The total depth of the Tertiary and Quaternary sediments reaches 8,000 m. The Danube river sediments (since the Mindel epoch) form the main aquifer consisting of highly permeable gravels and sands. Its thickness ranges from a few meters at Bratislava to more than 450 m at Gabčíkovo. Further downstream, downwards the Sap village, their thickness decreases to several meters. Under this high permeable aquifer there is a complex of low permeable or almost impermeable older Quaternary and mainly Tertiary sediments.

The important factors influencing transport of the Danube sediments are the existence of the granite threshold between the Alps and Carpathians, crossing the Danube in the area surrounding Bratislava, with an outcrop of granites in the Danube River bed. Similarly, stony threshold, predominantly of andesite rocks, also occurs in the stretch between the towns Štúrovo/Estergom and Visegrád/Nagymaros, some 160 km downstream from Bratislava. Both hard rock thresholds are natural geological and hydraulic barriers, steps, in the riverbed. Just downstream from Bratislava, the Danube forms two branches; the Malý Dunaj (Little Danube) in Slovakia and the Mosonyi Duna in Hungary. These branches, together with the Danube main stream, border two similar islands – the Žitný Ostrov Island in Slovakia, and the Szigetköz Island in Hungary. In the stretch between Bratislava and Medveďov, the Danube formed an inland delta (in the geological literature called as alluvial fan), through which it once meandered. The "inland delta" has its specific morphology, characterised by river meandering, accumulation and erosion of coarse gravel and sand, changes in riverbed slope, etc. The alluvial fan consists of extremely permeable and thick aquifer, capable of carrying and transferring high volumes of ground water. The Danube flows on the surface of this alluvial fan (**Fig. 2.4**). Water from the Danube penetrates into the alluvial fan sediments and flows downwards as ground water along the Danube and in the direction towards the Little Danube or Mosonyi Duna. In the lower part, where the slope of the river and the surrounding area suddenly decreases to one quarter of its gradient at Bratislava (**Fig. 2.5**), the ground water flows back into the Danube via its own river arms, tributaries and drainage canals (**Fig. 2.6**). All this is a result of reduced permeability and thickness of the aquifer downstream from Gabčíkovo.

In the Danube stretch between Bratislava and Sap, the Danube banks were fortified, and flood protection dikes were built up on both sides. The straightened Danube flows between these dikes and a part of the river arms is also situated there (**Fig. 2.1**). Also at present, at times of high discharges in the Danube, water reaches these dikes and the flooded the area between flood protective dikes. This floodplain is considered to be highly valuable from ecological viewpoint, and worthy of preservation of its original functions. Besides this, it has irreplaceable functions like transferring of peek flood discharges, function of a natural polder moderating maximal discharges during flood. Both these functions are significantly manifested in reduced maximal discharges in the downstream stretches of the Danube. The area has favourable conditions for growth of natural floodplain forests as well as for timber production. It is aesthetically attractive for tourists, and, because the arms are with flowing water, it also fulfils the self-purification function of the Danube water.

Comparison of the ground water regime in 1953 (JURKO 1958), and in 1992-2000 (MUCHA et al. 2001), showed that the hydrological regime in the floodplain approximated to the state of the late 1960-ies after the intake structure at Dobrohošť bringing water into the arm system had been put into operation. However, this cannot be said about the drained strip along the old Danube, nor about the entire complex of forests downstream from the port of Gabčíkovo. It can be generally concluded that in spite of the realised measures the hydrological regime is partially not suitable. This concern about 30% of the area of floodplain forests where the existing state can be improved, for example, by means of overflowing weirs, varying flow rates and artificial flooding.

For a detailed assessment of phytocoenoses, a detailed phytocoenological map in the scale 1:25,000 and 1:10,000 (ŠOMŠÁK et al., 2001, 2002, 2003) was elaborated. The map can serve all other biological branches as a background and also for assessment of the impact of the changes in hydrological regime. This map (ŠOMŠÁK et al., 2003) is also working material for further negotiations about implementation of the Judgement of the International Court of Justice (INTERNATIONAL COURT OF JUSTICE, 1997).

When assessing the quality of the present state of any ecosystem and of the way in which it reached the present state, we must distinguish a **purely natural state (original), quasi natural state coming into being naturally,** and an **anthropogenic conditioned or even anthropogenic artificial state.** When assessing the system river/floodplain it is to be stressed that it represents an azonal ecological system, in which the hydrological regime is the deciding factor.

Although the opinions of experts differ as to what can be considered as natural, hence original and not influenced by human kind, and to what extent the natural character is suppressed by the anthropogenic interventions, as well as where the boundary is between the natural and anthropogenic (**because the human kind itself is, as a matter of fact, just one of many biologic species**) and between certain pragmatic and conventionally stated limits. A general consensus exists as to the following; if we insist that the criterion of originality is absence of any human influence, the original ecosystems do not exist at present, because the entire biosphere is directly or indirectly influenced at least by the anthropogenic changes in the atmosphere. In addition, the global water circulation is also anthropogenically influenced. However, if the anthropogenic influences are not understood so fundamentally, than it is possible do speak about relicts of natural ecosystems in the regions, which never earlier in the history of the human kind were a part of the ecumena, hence which never were directly influenced by humans, inclusively of the extensive exploitation. Then it is possible to consider as natural only relics of virgin forest ecosystems in South America or of the virgin forests of Siberia, whereas in Europe, in the best case, only the virgin-like forests having been developed spontaneously after ceasing of human interventions. **As a criterion of such kind of natural character** just the **preservation of elementary functional relationships of ecosystem, which guarantee its spontaneous re-naturalisation after stopping the anthropogenic pressure** can be used. Such nature-like ecosystems again approximate to the quality of the virgin ecosystems, from which they are derived. Thus, they can be considered as being **nature-close**, but not as original.

In the case of the river and the floodplain, the hydrological regime is being essentially changed without regard to further economic exploitation or non-exploitation of that area. Floods has been removed from the major part of the original extent of the floodplain, however the water mass remains unchanged and, for this reason, the dynamics of the hydrological regimens is much more intensive. Thus the floodplain has an unoriginal ecologic valence, as in the hydrological and pedological (mainly pedogenetical) parameters. This changed naturalness leads to the formation of a derived ecosystem, which differs from the original ecosystem. If it has possibility of an autonomous development, it does not regenerate the original quality, but an adaptive one, because its development is determined by limits represented by the maintained flood protection of the adjacent territory.

Anthropogenic interventions in ecosystems usually lead to forming islets of natural ecosystems whose further development and survival are strongly exogenously influenced due to the considerable reduction of their original area. In the case of a river and its floodplain, an inversion begins in which the primary exogenous (anthropogenic) intervention leads to a permanent support of the endogenous factor, after which the strong reduction of the original area becomes decisive for the further existence and development of the ecosystem. In the ecosystem of the floodplain within-dike area, the selection of organisms favours the stenotopic species bound to this type of hydrologic regime and pedogenesis. If we theoretically admit a return to the state without flood protection dikes, after some centuries of their existence, a spontaneous regeneration of ecosystems considered to be close to the natural or original state would not appear. On the contrary, if we admit, again theoretically, that this deciding factor is excluded from the territory, any benevolently understood naturalness of ecosystems would disappear and its survival becomes dependent of silviculture measures. A natural forest becomes an artificial forest, incapable of spontaneous regeneration.

These considerations refer not only to the terrestrial communities, but also to a majority of the semi-aquatic communities. On the contrary, the aquatic communities can be considered, in regional context, to be natural or only partially deteriorated by penetration or introduction of some unoriginal animal species. Changes in all four types of potamon refer to the proportion of their representations in the water biota resulting from the historical, but mainly the recent anthropogenic hydrogeomorphological changes.

The present degree of deriving the unoriginality of the natural environment results from interventions of silviculture, navigation, water management, but also of agricultural and other anthropogenic activities. The more we return to the past, the higher and more typical the naturalness of this area appears. **From the viewpoint of functioning of the present floodplain, we cannot return to the period before the flood protection dikes were constructed (to the original state). Therefore we take the 1950s to be suitable for the following comparisons and considerations about revitalisation.**

Vegetation of floodplain ecosystems

Vegetation of floodplain ecosystems is closely bound to the hydropedological conditions influenced by the Danube. This applies to all types of vegetation, i.e., the expressively aquatic phytocoenoses; the wetland and riverbed types; and the shrub and tree stands. At the same time, this vegetation is very dynamic. In contrast to climazonal types, this vegetation is able to adapt within a relatively short period to changing conditions of hydrological regime and gradually to form other stable ecosystems.

The limiting of the Danube and its arms into the within-dike floodplain caused significant changes. The floods multiplied and turbulence of their waters increased. Persistence of such a state for several decades influenced selectively the whole vegetation, but most evidently the floodplain trees. The hardwood broad-leaved trees like pedunculate oak (*Quercus robur*) and to a lower degree also ashes (*Fraxinus angustifolia*) did not tolerate the presence of such waters, and gradually disappeared from the within-dike floodplain. Willows replaced them, first of all by white willows (*Salix alba*), then also crack willow (*Salix fragilis*) and poplars (*Populus nigra, Populus alba, Populus x canescens*). The willow-poplar forests also existed here earlier, but on a considerably smaller surface.

Changes in vegetation also affected the non-forest and aquatic vegetation. Due to stronger and more frequent flooding, the former stretches of dead arms became again through-flowing arms (eupotamon) and did not allow existence of the vegetation of stagnant water bodies. Suitable conditions for aquatic vegetation remained only in those arms that were only temporarily discharging (plesiopotamal) – OŤAHELOVÁ (2001). However, a rapid development of this vegetation type started in waters and arms of the out-of-dike area (paleopotamal). Development of littoral vegetation bound to stagnant water bodies covered larger areas, but showed many features of seasonality resulting from fluctuation of water table in the arms (KUBALOVÁ 2001).

The floodplain forests had perfectly adapted to such a situation in the floodplains in the course of 1950s to 1970s. Therefore, the first complex report dedicated to soil ecological relationships and floodplain forests of the Podunajská Nížina Floodplain (JURKO 1958) can be taken as characteristic of the state typical for the 1950s, when the degree of deterioration of the "natural" environment still was intensive. In the assessment of subsequent changes, we consider this state, in a majority of cases, to represent the starting point representing vegetation close to the natural state (but not original in the proper sense of the word). Unfortunately, there exist only austere notes about the aquatic and wetland communities of the Danubian floodplain of that period (JURKO 1958).

Further changes in water regime were begun after extensive channelling of the main riverbed carried out in connection with the navigation and flood protection during the 1970s. Gravel excavation from the Danube resulted in the decline of the water level in the river and a decline of ground water levels. A tendency forward declining water levels was continuously supported by erosion of riverbed, construction of dams on the Austrian and German stretches of the Danube, and by gravel excavation upstream from Bratislava.

Decline of ground water levels before construction of the Gabčíkovo project was particularly sensible in the upstream part of the Žitný Ostrov Island, immediately downstream from Bratislava, especially in the Biskupické Rameno arm. In its direction downward this decline was smaller, but it was still significant in the within-dike floodplain. Because the extensive monocultures of cultivated euro-american poplars, but also of autochtonous poplars, had stretched in the within-dike zone in the years of the Danube riverbed channelling, the impact of the ground water level decline on the forest communities was less significant. At the same time (long before the Gabčíkovo project construction), the increment of timber decreased in the narrow littoral zone, particularly on the gravel riverbank (drainage effect – ŠOMŠÁK et al. 1995). A more significant impact of riverbed channelling was observed in the aquatic and wetland types of vegetations in the river arm system. Most arms had flowing water only during high water levels in the Danube. The irregularity of the water flow in the arms, however, resulted in changes in the spatial proportion of the communities of the plesiopotamon, parapotamon and eupotamon types. According to the data from that period, the plesiopotamon type communities predominated there. This statement is also confirmed by recent investigations (OŤAHELOVÁ 2001, KUBALOVÁ 2001, SVOBODOVÁ 1994, MATIS 2001).

Preparation for construction of the Gabčíkovo – Nagymaros Project required a detailed floristic investigation on the whole territory along the Danube. During this inventory, 959 taxa of vascular plants were recorded. Analysis of their relationships to habitat (phytocoenotic) groups shows (ŠOMŠÁK 1999) that only one third (311 taxa) of these taxa are bound to floods and high levels of ground water. They are represented by: aquatic and wetland plants (97 species), 70 species of littoral communities (littoral, limose and terrestric eco-phase), and, finally, 194 taxa of plants, whose life cycle is bound to floodplain forests or shrub formations. However, among other species there is a high proportion, they are also able to exist, and do exist, in the phytocoenoses outside of alluvium (*Urtica, Glechoma, Alliaria, Symphytum, Rubus, Poa, Viola, Gagea, Sambucus, Lythrum, Lysimachia* and many others).

Other species recorded during the inventory are bound to ecotopes, which are not and have not been influenced by the Danube. They are represented, for example, by species of xerothermic gravels (180 taxa), ruderal sites (190 taxa), cultures of cereals and root crops (89 taxa), introduced species (72 taxa) and neophytic taxa (43 species). In short, even 68.7% of species recorded exist here without any relationship to the Danube water (ŠOMŠÁK 1999). From the ecosozological aspect, the remaining 31% is of high significance.

In spite of the measures carried out during the preparatory works before the Gabčíkovo project construction, a sensible intervention into the plant genofond has been made. First of all, the area of populations of many species was reduced due to construction of the Hrušov Reservoir (Čunovo Reservoir), by-pass canal, seepage canals, etc.

The data on flora obtained before putting the Gabčíkovo structures into operation were made more precise by a detailed inventory carried out during establishment of monitoring plots. UHERČÍKOVÁ (2001) recorded 760 taxa. As mentioned by UHERČÍKOVÁ (2001), many taxa of rare or endangered plants (*Hottonia palustris, Gratiola offinalis, Senecio paludosus, Veronica catenata, Sagittaria sagittifolia*), recorded there in 1950s, were absent. However, there are preserved localities with an abundant occurrence of the strictly protected species *Leucojum aestivum*.

On the base of literature and from the authentic data gathered by professor Šomšák, the state of the within-dike floodplain between the Dobrohošť and Sap villages before the Danube damming can be characterised as follows:

- An extensive complex of willow-poplar forests (*Salici-Populetum*) of all subtypes adapted to different levels of ground water, but with a substantially changed composition of woody plants, in which the original woody plants were replaced by extensive monocultures of cultivars of the euro-american poplars.
- Remnants of original (natural) willow-poplar communities preserved in terrain depressions and on the hardly accessible islets (about 10% of the wooded land).
- Negligible (mosaic) areas covered by the transition floodplain forests (*Fraxino angustifoliae – Populetum albae*) form about 11.4% of the wooded land.
- A narrow littoral strip of the degrading forest stands on gravely banks functioning as a drainage system triggered by the riverbed deepening after the gravel excavation from the Danube (about 3 % of wooded land).
- Tall-grass wetland vegetation on the partially terrestrised and only temporarily discharged arms.
- Negligible extent of aquatic-wetland vegetation of the paleopotamon type in the cut-of arms (Istragov, Erčéd, Kráľovská Lúka).
- Seasonal, annual vegetation on the denuded banks of the river arms, dependent on time of washing.

The forest management carries out its activities in the floodplain on an area of about 3,100 ha. Since the 1960s, this area has been little changed, though somewhat enlarged. Since the 1960s, the large-surface monocultures were founded on the previously prepared soil. In many cases the former dead arms were also afforested after they had been filled by rotting trunks of trees and other wastes after wood exploitation and stripped soil. Already in the 1960s, cultures of introduced poplars were added to the main woody plants like white willow, crack willows, black poplar, white poplar and grey poplar. By 1958, their area reached about 27% of the existing forest (JURKO 1958). Since 1956, their proportion rapidly increased and around the year 1981 it reached ca. 80% (VOJTUŠ 1986). At the beginning, the cultivars *Populus deltoides* – „monilifera" a *Populus x euroamericana* – „robusta" were planted, and later also the "regionalized clone" I-214 bred in Italy (NEŠTICKÝ et VARGA 2001).

The Forestry Research Institute in Zvolen – Research Station Gabčíkovo has established experimental plots in this area since 1956. However, their aim was not ecological monitoring, but verification of silvicultural measures in monocultures of bred woody plants (plantation spacing, intensity of silvicultural measures). The data about different poplar clones and willows obtained since their cultivation until the Danube damming confirmed the assumption that these trees and their stands are tolerant to small changes in hydrological regime (VARGA 1993, NEŠTICKÝ, VARGA 2001). One argument for the cultivation of the euro-american poplars and their cultivars was an extraordinarily high timber production. The first data signalled an annual increment of 25 m^3/ha. A decrease in the increment of woody mass was observed, however, in the stands on the left-side littoral strip along the old Danube. The dendroecological investigations in that strip, however, confirmed decrease in increments a long time before the Danube damming (due to river bottom lowering, ŠOMŠÁK et al. 1995).

About 80% of the original willow-poplar floodplain forests, which formed the dominant part of vegetation in that area, have a changed composition of woody plants in favour to different cultivars of poplars, and, to a limited extent, of willows. Only 15-20% of surface covered by forests has an original composition, mainly on the less accessible places (small islands, terrain depressions). The herbage stratum in most mature (25-30 years old) poplar monocultures does not show significant deviations from the original floristic composition. This was confirmed by comparison of phytocoenoses of the original forest and monocultures made in 2001 in the forest district of Gabčíkovo (KRAJŇÁKOVÁ 2001). Spreading of the invasion species of the genera *Aster, Solidago* and *Impatiens* influences the herbage cover. Absence or insufficiency of floods supports their invasion.

Terrestrial zoocoenoses

Terrestrial zoocoenoses (JEDLIČKA et al. 1999), as communities of consumers and reducers, are bound in the whole territory on:

a) amphibiotic and transitional communities of the associations *Rorippo - Agrostietum stoloniferae*, *Rorippo amphibiae - Oenanthetum aquaticeae, Eleocharitetum palustris, Glycerietum maximae, Phalaridetum arundinaceae*, *Phragmitetum communis* and *Potametum perfoliati, Caricetum gracilis*,
b) soft-wood floodplain forests *Salici-Populetum* in different subtypes and degrees of originality,
c) transitional floodplain forests *Fraxino angustifoliae – Populetum albae*,
d) hard-wood floodplain forests *Fraxino angustifoliae – Ulmetum* (it applies only for a part of the forests situated upstream of the Čunovo dam),
e) Danubian forest steppe *Asparago-Crataegetum*.

In the flat lowland parts of alluvia, characteristic communities of species requiring high humidity existed. Due to the alluvium extent they were not infiltrated in a relatively wide zone by the mesohygrophilous species. The mutual pervading of species began only at larger distances from the water flow or at the alluvium margin. Width of the transition zone was determined by the terrain configuration and mutual competition pressure of species of both major ecologic groups. However, the position of this transition zone was not stable. It dynamically changed according to fluctuations of the water level in the river. Such a situation made possible (according to changes in the position of riverbed, extent of floods and changes in ground water level) a quick altering of different, but always natural communities. In the remote past, this situation was typical for the extensive lowland area, hence, also for the wider area surrounding of the Gabčíkovo project.

Forming of the natural gradient of the communities is limited by the flood protection dikes, which cut off a part of forest standing outside of the floodplain hydrologic regime. In consequence, the community succession outside of the floodplain has a predisposition to converge toward mesohygrophilous communities of the forest geobiocoenoses of the normal hydric series (in sense of RAUŠER & ZLATNÍK 1966) or, at disintegration of forests stand, toward the communities of the non-forest ecosystems. On the contrary, a part of the communities in the narrow within-dike zone is probably exposed to a more intensive mechanic effect of the flood closed into the relatively narrow corridor without any possibility to spill into the more remote parts of the alluvium. Hence both states differ, at least on a part of the area in question, from the state, which was characteristic of the natural, or anthropogenic negligibly influenced landscape.

The characteristic species, in particular of the initial stages of the so-called softwood floodplain forests and of other habitats with high soil moisture, are especially the strongly hygrophilous gastropode molluscs *Succinea putris*, *Oxyloma elegans*, *Zonitoides nitidus* and *Pseudotrichia rubiginosa*. Differential species of the moist types of soft-wood floodplain forests (assoc. *Salici-Populetum myosotidetosum* to *Salici-Populetum typicum* JURKO 1958) are, out of the species mentioned above, the polyhygrophilous species *Carychium minimum* and the forest hygrophilous species *Arianta arbustorum*, *Vitrea crystallina* and from a part also *Urticicola umbrosus*. The typical feature of the transition to hard-wood floodplain forests (assoc. *Fraxino-Populetum*, *Fraxino-Ulmetum*) is dominance of the predominantly forest mesohygrophilous species which do not tolerate the destroying impact of flood and the long-term waterlogged soils (*Aegopinella nitens*, *Cochlodina laminata*, *Semilimax semilimax*, *Alinda biplicata*, *Monachoides incarnatus*, *Petasina unidentata*, *Clausilia pumila*, partly also *Carychium tridentatum*). The taxocoenoses also consist of the species groups, which are bound to non-forest habitats or sparse stands of trees or shrubs (*Vallonia pulchella*, *V. costata*, *Euomphalia strigella*, *Cepaea vindobonensis* and *Xerolenta obvia*).

As a starting stage of the chilopoda taxocoenoses, we can consider, to a certain degree, the community found in the by-passed zone before 1993. In individual monitored plots, 9-14 species were recorded. The data on the communities of Oniscidea and Chilopoda are very similar or even identical with those from the floodplain forests along the Morava and Dyja rivers on the Moravian and Austrian territory (TAJOVSKÝ 1999, TUF 2000, ZULKA 1999). They can be taken as sufficiently characteristic.

The Carabidae taxocoenoses were represented by the characteristic communities of species requiring high soil moisture (**Tab. 2.1**), which were not substantially infiltrated by the mesohygrophilous species inhabiting geobiocoenoses of the normal hydric series. They have not been influenced by changes in species composition of the forest stands in which the original trees were replaced by the poplar monocultures. The reason of this is that the determining factor for survival of the hygrophilous Carabids inhabiting the floodplain forests is the presence of any high and dense vegetation cover, which inhibits drying, and warming of the litter by direct insulations. The Carabids can find such condition in the poplar monocultures older than 10 years, hence during the major part of the presence of the monocultures on a place, as well as in high herbage growth which developed (irrespective of the floristically undesirable species composition of such growths) on clearings with soils sufficiently supplied by water.

From the ornithological point of view, the Danubian floodplain forests together with the Danube arm system in the past represented a territory with a high diversity and density of species, in which many rare and endangered species bred (BALÁT 1963). The breeding ornithocoenosis of the Danubian floodplain forests, in 1970s and 1980s, consisted of 103 bird species (**Tab. 2.3**). Among the significant breeders, red kite (*Milvus migrans* VU) and ferruginous duck (*Aythya nyroca* - EN) are to be mentioned. They formed breeding populations of the all-Slovakian significance. Further remarkable species were little bittern (*Ixobrychus minutus* VU), black stork (*Ciconia nigra*), honey bizard (*Pernis apivorus*), kongfisher (*Alcedo atthis*), middle spotted woodpecker (*Dendrocopos medius*), which formed breeding populations of super-regional significance. Among the total of 103 breeders, 3 species were endangered (EN: *Ardea purpurea*, *Aythya nyroca*, *Coracias garrulus*) and 4 vulnerable (VU: *Ixobrychus minutus*, *Milvus migrans*, *Nycticorax nycticorax*, *Upupa epops*).

The Danube also represented a significant migration way for waterfowl. In individual years, 25-30 bird species wintered in the Danube main stream (KALIVODOVÁ a DAROLOVÁ 1998, ÁČ et al., 1996). *Anas platyrhynchos* and *Bucephala clangula* belonged to the dominant hibernants.

The Danube floodplain in the stretch of the river km 1810-1842 deserves extraordinary attention from the nature protection viewpoint. Since 1989, it was ranked among the **significant bird territories** in Europe marked as SR-04-(017) Podunajsko. (HORA, KAŇUCH et al. 1992, BOHUŠ 1992), KAŇUCH (2000) mentioned this area under the name Niva Dunaja (River Danube flood-plain). Its international code is IBA 007, national code SR 04. Since 1993 this area is **a part of the territory included into Ramsar Convention List of Wetlands of International Importance** (SLOBODNÍK, KADLEČÍK 2000) and also is a part of **a territory of special interests of nature protection** Emeral Network.

The mammal fauna consisted of 49 species. Beaver (*Castor fiber*), having been extinct in this area, spontaneously spread after its restitution in Austria, but in the area in question it does not find suitable conditions. Structural changes in the taxocoenosis of small terrestrial mammals consisting of the species *Sorex araneus, Apodemus flavicollis, Clethrionomys glareolus, Sorex minutus, Crocidura leucodon, Crocidura suaveolens, Microtus arvalis, Microtus oeconomus, Pitymys subterraneus, Apodemus sylvaticus* and *Micromys minutus* depend on the moisture gradient. In the softwood floodplain forests, the eudominant species are *Sorex araneus, Apodemus flavicollis* and *Clethrionomys glareolus*. Their dominance decreases towards more xeric conditions and they are replaced by other species inclusive of *Microtus arvalis* and *Mus musculus*, which are unoriginal in this area.

Aquatic fauna

Invertebrate communities of the Danube main stream (eupotamal) in pre-dam conditions

Communities of zooplankton

In pre-dam conditions (1971-1972) (VRANOVSKÝ 1974) and in the years 1991-1992 (ILLYOVÁ 1995; VRANOVSKÝ, ILLYOVÁ 1999), the dominant species among the planktonic rotatorians of the main stream were, as a rule, the euplanktonic species, in particular representatives of the genera *Keratella (K. cochlearis)*, *Polyarthra (P. vulgaris, P. remata)*, *Synchaeta (S. oblonga, S. tremula, S. stylata)*, *Brachionus (B. calycilforus, B. angularis)*, and in winter also *Rotaria rotatoria*. Among the planktonic crustaceans, the true plankton predominated, but in the upstream part of the monitored area (at Dunajské Kriviny) the tychoplanktonic (benthic and littoral species) species, i.e. "false" plankton, also reached a considerable cumulative abundance and dominance. Among Cladoceras, the dominant species was *Bosmina longirostris* and in some cases also *Daphnia longispina* and/or *D. cucullata*. Among the Copepods the most frequently occurring species was *Acanthocyclops robustus* co-occurring with *Eudiaptomus gracilis* or with the species *Cyclops vicinus* and *Thermocyclops oithonoides* or even with *Eurytemora velox* (a migrant recorded in the Slovak stretch of the Danube for the first time in 1991). Among the tychoplanktonic Cladocera and Copepoda the most abundant species were *Alona quadrangularis* and *A. affinis* and *Eucyclops serrulatus* respectively.

Communities of zoobenthos

The infusorian communities (MATIS, TIRJAKOVA, 1995 a, b) appeared to be relatively poor in number of species and individuals. The euryecious species (bacteriovorous - *Cyclidium glaucoma, Aspidisca cicada, A. lynceus, Glaucoma scintillans* and others) were represented most significantly. The planktonic species were represented in a relatively small number. Other studied components of the microzoobenthos and meiozoobenthos were recorded only sporadically. It was caused by lack of suitable substrates, high velocity of water flow, sedimentation of mud, flushing by turbulent water flow and fluctuating water levels. After floods, inactivation of individuals was repeatedly observed (probably due to the transferred toxic substances). In that period, the rarely occurring species, e.g. *Ophryoglena flava, Tintinnopsis cilindrata, Stegochilum fusiforme, Frontonia anbigua, Strombidium turbo* also appeared in individual localities.

The permanent fauna of macrozoobenthos had a qualitatively homogeneous character in the littoral zone of the studied river stretch (KRNO et al., 1999). The dominant species were *Eunapius fragilis* (Porifera), *Dendrocoelum lacteum* (Turbellaria), *Dina punctata* (Hirudinea), *Ancylus fluviatilis, Lymnaea ovata, Bithynia tentaculata* (Gastropoda), *Dreissena polymorpha,* and *Sphaerium corneum* (Bivalvia) (KOŠEL, 1995a). Among Oligochatea, the dominant species were representatives of the Naididae family and *Stylodrilus heringianus* (Lumbriculidae). The representatives of Tubificidae family occurred sporadically. Occurrence of *Hypania invalida* (Polychaeta) a *Dikerogammarus haemobaphes* and *Corophium curvispinum* (Amphipoda) was also significant. Some differences were found in the Danube main riverbed downstream the lowering of the river slope and flow velocities, at Kľúčovec village (ŠPORKA, KRNO 1995).

The dominant species in the taxocoenoses of the temporary fauna of the Danube littoral were *Baetis fuscatus, Heptagenia sulphurea, Caenis pseudorivulorum* (Ephemeroptera), *Hydropsyche contubernalis, H. bulgaroromanum, Psychomyia pusilla, Brachycentrus subnubilus, and Ceraclea dissimilis* (Trichoptera). When compared with the investigation results from 1980s (KRNO, 1990) we did not recorded several species of Ephemenoptera – *Heptagenia coerulans* and genus *Ecdyonurus* whereas further species (*Baetis vardarensis, Heptagenia flava, Ephemerella ignita* and *Potamanthus luteus*) occurred very sporadically. The species *H. bulgaroromanum* predominated on the rocky substrate, whereas *H. contubernalis* were common on the gravely substrate. In general, the filtrators predominated (Hydropsychidae, *Brachycentrus*) there.

The medial part of the Danube main stream (river km 1816) was inhabited primarily by Oligochatea (*Nais elinguis, Chaetogaster crystallinus, Propappus volki, Rhynchelmis limosella* a *Stylodrilus heringianus*), hirundinea *(Erpobdella octoculata)* and Chironomids *(Polypedilum gr. lateum, P. gr. scaleanum, Ablabesmyia gr. lentiginosa a Euorthocladius rivicola)* (ERTLOVÁ (1968).

Invertebrates of Danubian floodplain arms and temporary waters

Parapotamon (communities of the parapotamal type)

In pre-dam conditions a quantitatively rich zooplankton developed in water bodies of this type, as a rule during stagnation of flow in warm period. It consisted exclusively of the euplanktonic species (VRANOVSKÝ 1974, 1985; VRANOVSKÝ, ILLYOVÁ 1999). Among the rotatorians, the dominant species were some representatives of the genera *Brachionus, Keratella, Polyarthra* a *Synchaeta*, among the Cladocera *Bosmina longirostris* together with *Daphnia longispina* and *D. cucullata* (in the arms upstream of Gabčíkovo) or with *D. cucullata, Diaphanosoma brachyurum* and *Moina brachiata* (in the Istragovské Rameno arm - downstream of Gabčíkovo). The other significant component of the planktonic crustaceans – the Copepods – were represented in the medial zone only by the true plankton, mainly *Thermocyclops oithonoides* and *Th. crassus* (in the Istragovské Rameno arm) accompanied by some other species.

The microzoobenthos was studied first of all in the Danube river arms (MATIS, TIRJAKOVÁ, 1992; TIRJAKOVÁ, 1992; SZENTIVÁNY, TIRJAKOVÁ, 1994). From the aspect of community structure of microzoobenthos, the river arms cannot be viewed as a whole. Communities, according to their character and changing conditions in each arm, developed specifically. A common feature of these arms in the pre-dam conditions was a gradual long-termed decline of water level and water flow limited to periods with higher flow rates in the Danube. In the period after cutting the arms from the main stream, the rich communities typical for stagnant water occurred there. The arms filled with stagnant water and flushed during floods showed a high species number and a high abundance of all groups of microzoobenthos (*Ciliophora, Mastigophora, Heliozoea, Amoebina*).

The permanent fauna originally consisted of the same species as the fauna of the main stream *Corophium curvispinum, Dikerogammarus haemobaphes* (Amphipoda), *Hypania invalida* (Polychaeta), *Stylodrilus heringianus* and of the genera *Psammoryctides* and *Potamothrix* (Oligochaeta) (KOŠEL, 1995a; KRNO et al, 1999). The dominant groups in the discharged arm near Istragov, studied in 1966 by ERTLOVÁ (1970), were Oligochaeta (*Potamothrix moldaviensis, Tubifex tubifex, Tubifex ignotus* and genus *Limnodrilus*) and Chironomidae (*Prodiamesa olivacea, Chironomus* gr. *thummi, Cryptochironomus* gr. *defectus*). In the main arms of the Baka arms system, *Dreissena polymorpha* (Bivalvia) was very abundant on the gravel-sandy bottom substrate, in 1976-1978. Its aggregations were filled by fine sediments, which were inhabited by a specific benthic community showing a high number of species and abundance (ŠPORKA, NAGY 1998). The high water level caused a temporary impoverishment of the fauna, but the original community was able to regenerate within a short period of ca. 35 days.

Before 1960, the temporary fauna of through flowing arms was studied by LICHARDOVÁ (1958). She described several taxocoenoses of mayflies (Ephemenoptera) regularly including the species *Potamathus luteus, Heptagenia sulphurea, Ecdyonurus aurantiacus, Baetis rhodani, B. fuscatus and Serratella ignita.* These species indicate rheophile conditions in the arms under consideration. It was also indicated by the trichopteran taxocoenoses (MAYER 1935) consisting of the species *Rhyacophila pascoei, Agapetus* sp., *Hydroptila* sp., *Plectrocnemia* sp., *Neureclepsis bimaculata, Polycentropus flavomaculatus, Hydropsyche* spp., *Cheumatopsyche lepida, Setodes interruptus, Potamophylax latipennis, Halesus* spp., *Goera pilosa, Silo pallipes* and *Brachycentrus subnubilus.* In the years 1976-1978, 6 species of mayflies and 22 species of Chironomids were recorded in the arms of the Baka arm system (ŠPORKA, NAGY 1998). In the years 1991-1992, the temporary fauna of the through flowing arms was relatively poor. It consisted of the species *Cloeon dipterum, Caenis horaria, C. luctuosa* (Ephemeroptera) and genera *Ecnomus, Cyrnus, Anabolia, Athripsodes* (Trichoptera). According to MAJZLÁN (1992), the dragonflies *Calopteryx splendens* and *Lestes viridis* dominated in the parapotamal. The Chironomid taxocoenosis was characterized by the species preferring flowing water (*Cricotopus bicinctus, Tanypus kraatzi*) as well as by the species preferring slowly flowing or stagnant waters (*Dicrotentipes* spp., *Polypedilum* spp.), (KRNO et al., 1999).

Plesiopotamon (communities of the plesiopotamal type)

After flooding the inundation within-dike zone, a community characterized by dominance of euplanktonic species, in particular the Copepods *Cyclops vicinus* and *Thermocyclops crassus,* formed fauna in this type of arms. In other periods, the species characteristic of the littoral or shallow temporary waters became predominant. Among the Cladocera were the species *Chydorus sphaericus* and *Ceriodaphnia reticulata*, whereas among the Copepods the species *Megacyclops viridis*, *Metacyclops gracilis*, *Eudiaptomus transylvanicus* and *Cryptocyclops bicolor*.

The microzoobenthos in the plesiopotamal type arms formed relatively stable communities (MATIS, TIRJAKOVÁ, 1995a,b).

The bottom in the littoral of these arms consisted of sandy-gravel or mud. On the sandy-gravely bottom, the permanent fauna was richer. Out of the Tubificidae family, species of the Naididae family also occurred there, hence, the species eating vegetation. The muddy bottom was predominantly inhabited by species of the Tubificidae family eventually by amphibiotic species of the Enchytraeidae family and large species *Criodrilus lacuum* and *Eiseniella tetraedra* (NAGY, ŠPORKA, 1990). Other animal groups were also poor in number of species, Gastropoda represented by 14 species being the richest. Abundance of most species was very low. Only the crustacean *Asellus aquaticus* was recorded in an increased number in 1992 (ŠPORKA, KRNO, 1995). The temporary fauna was represented mainly by the stagnicolous dragonflies *Sympetrum flaveolum, Lestes barbarus, Cordulia aenea,* but the semi-rheophilous *Platycnemis pennipes* was also recorded (MAJZLAN, 1992). The Chironomid taxocoenosis was poor in species number and was dominated by the pollen-phileous species *Cryptochironomus defectus* and *Polypedilum nubeculosum* (KRNO at al. 1999).

In the Žofín arm, the dominant groups were Oligochaeta and Chironomidae in 1971 (ERTLOVÁ 1973). The same groups also dominated in the arm on the Kráľovská Lúka meadow in 1981 – 1987 (NAGY, ŠPORKA 1990). They found the highest number of taxa of the permanent fauna in the littoral zone (with vegetation and without vegetation), while the medial was little inhabited. The medial zone with the muddy sediments was inhabited predominantly by Chironomid larvae, which occurred abundantly also in the littoral zone of this arm.

Original ichtyocoenoses in the mainstream and arm systems

The original ichtyocoenoses in the main stream and in arm systems in the stretch between mouthing of the Morava and Ipeľ rivers were described by BALON (1966) of the period 1953-1961. He mentioned the existence of 56 fish species and commented on their occurrence. However, investigations made in next three decades showed that number of the fish species occurring in this stretch of the Danube was much higher. So the Danube is much richer in species than other Slovakian rivers. HOLČÍK (2001) explains this fact by two circumstances:

1) This stretch represents beginning of the submontane zone, more exactly sad, a transition between the submontane and lowland zone, between the hyporitral-epipotamal and metapotamal in the sense of classification of ILLIES and BOTOŞANEANU (1963);
2) The Danube riverbed declination decreases there from 0.31 ‰ (river km 1880.2) to 0.1 ‰.

It causes, very heterogeneous types of habitats to co-occur in a relatively short stretch of the Danube allowing an ichtyocoenoses rich in species to arise there.

The same author in his last work (HOLČÍK, 2003) states that, up to the present, 76 fish species were recorded in the Slovak stretch of the Danube, among which 61 species are original, 11 exotic and 4 species are invasion species spreading from the Danube downstream.

Anthropogenous interventions affected the ichtyocoenoses of the Danube. Construction of the dam "Iron gates" on the Danube downstream limited occurrence of migrating species. In addition, some allochtonous species have been introduced. In the period 1970-1980, when the level of organic and toxic pollutants peaked, the salmonid fish species sensitive to pollution, as well as the species *Cottus gobio*, *Phoxinus phoxinus*, *Alburnoides bipunctatus* and *Barbus barbus*, almost disappeared. After the water quality improvement in 1980-1990, these species reappeared and another species *Neogobius kessleri* began to occur.

Connectivity of the Danube main stream with the arm system favourably influenced the species diversity of fish. As HOLČÍK (2001) stated, the number of species, and indices of diversity and equitability, are higher in the main stream and decrease laterally, in the direction from the main stream to the margins of the inland delta. The causes of this are different conditions in ecosystems of individual types of water bodies of the inland delta. Without existence of the inland delta, the number of fish species in the main stream would be lower. It results mainly from the existence of different types of spawning places and suitable refuges in the arms, mainly at the time of floods, as well as a favourable food situation in the arms.

A similar evaluation of the original state of the ichtyocoenoses in the monitoring plots and in the Danube immediately before the Danube damming in 1992 was presented by ČERNÝ (1999).

3 FUNCTIONS OF THE TERRITORY

The main **hydrological function of the floodplain** (inundation area between the flood protective dikes) is to transfer the peak flood discharges, and to protect the areas behind the protective dikes from flooding on Slovak and Hungarian territory. The next function is that of a natural polder, whose task is to store a part of the water from the maximal flood discharge in order to reduce the peak maximum flood discharge downstream the Danube. These two flood protection functions have the absolute priority. It was the main reason why, when conceiving the Gabčíkovo project, the floodplain zone in this stretch of the Danube was preserved, and why the by-bass canal was constructed outside of the floodplain, behind the left side old protective dikes (**Fig. 2.1**).

In conformity with this hydrological priority the **ecological viewpoint** is obvious. It is necessary to preserve the specific hydrological properties of the floodplain between the flood protective dikes and the aquatic and terrestrial ecosystems typical for functioning floodplain as well as its numerous characteristic biotopes and ecotopes. In this sense, the within-dike zone is understood as a system in which **the biota represents the central point of interest.** Further decisions about modification of hydrological regime within the territorial extent of the within-dike zone are considered to be decisive criterion from the ecological short-term, as well as from the long-term aspects. From the viewpoint of the ecosystem, it is typical that the floodplain is flooded more or less regularly, depending on the flow rate in the Danube. It is also obvious that, in regard to the preceding development of the riverbed depth, the floods are less frequent than could be expected according to flow rates in the Danube. It is also obvious that in consequence of this, the water levels in the old Danube are lower at present and, in addition, that they are reduced due to transferring a portion of flood water through the by-pass canal. If the floods and level of floodwaters have to be typical in the within-dike zone, it is evident that they should occur more often and the water levels have to be higher, namely, up to heights, that corresponded in the past to the water quantities flowing through Bratislava at the time of floods. At present, it is necessary to help by flooding the floodplain, and to increase the water levels artificially during flooding. This can be done by increasing water level (impoundment) in the Danube old riverbed, by supplying the floodplain zone with water, and by different modifications in the arm system, for example, by regulating the water levels on cascades between the arms and by rearranging the system of river branches. As to the dependence of flow rates in the arms on the flow rates in the Danube, the optimal way to improve the existing state is using a natural auto-regulative mechanism. The human interventions are, however, acceptable in critical or special cases.

Besides the hydrological flood protective function, **the preservation of specific aquatic to terrestrial ecosystems typical for the functional floodplain, which would spontaneously converge to the natural state, belongs to the priority at this territory**. At the same time, it supports fulfilling of the flood protective function of this territory and vice versa.

In respect to the **primary position of vegetation in the natural or nature close ecosystems**, it is necessary to stress that the **floodplain ecosystem is very dynamic from the viewpoint of flora and vegetation**, but, on other hand, also **highly adaptable**. Even short-term changes in the hydropedological regime (floods, depth of flowing and stagnant waters, slope of arms, ground waters level, physical and mechanical properties of soils, etc.) trigger changes in vegetation structure. These changes are very fast and range from one year (annual littoral phytocoenoses), to several years (wetland vegetation), and 10-20 years at the vegetation of moist and humid types of floodplain forests. At the same time, **these changes and adaptations do not exceed the general variability range of the floodplain forests, but run exclusively within them**. Hence, these changes have a quantitative nature. Changes of quality, i.e. extinction of a vegetation type or a plant population occur only exceptionally. It was illustratively demonstrated by prognoses of changes made already in connection with the Gabčíkovo-Nagymaros project (JURKO 1976) or the Wolfsthal dam project (ŠOMŠÁK 1994). In both cases, it was stated that the expected changes would have only a relative character. It means that **where the ground water level would decrease, the drier types of floodplain forest would appear, and vice versa**. However, the changes in hydropedological regime cannot exceed the existential limit of vegetation of floodplain forests (permanent drying, permanent flooding of ecotopes). Such a state began to be observed since early 1970s (regulation of the Danube inclusive of deepening its riverbed) up to the Danube damming in October 1992. Then, in May 1993, the supplementary system for supplying the floodplain river arm system with water was put in operation.

In respect to extraordinary dynamics, and, at the same time, high adaptability of vegetation in floodplain area, it is difficult to define and ideal - optimal hydrological regime. Based on the predominating opinions of most experts, the **hydropedological conditions existing in 1950s and at the beginning of 1960s, when about 70% of vegetation of this territory consisted of natural or quasi-natural phytocoenoses, can be considered optimal for the Danube floodplain, the zone between the flood protective dikes (Fig. 2.1).**

From the point of view of forestry, it is, of course, possible to speak about the same woody plants, which form the plant communities - ecosystem edificators. However, the deciding criterion is timber production. Another criterion is a state of good health for forest trees and whole stands (VARGA et al. 1997). An extraordinarily significant indicator of the health of forests is a change in the forest tree foliage (OSZLÁNYI 1995, 1996, 1999).

In the past, the within-dike zone was an object for interest of hunters, anglers, tourists (walkers and cyclists), as well as other visitors, searching for bathing and water sports possibilities. After 1999, still before finishing the Gabčíkovo project, but already under new conditions of ownership relations, several development projects were elaborated for the territory between the old Danube and the by-pass canal. Their aim was to search for solutions involving further development of this territory with regard to its unique natural values. At present, individual forms of recreation prevail here. Opening of the Slovak part of the international cyclist rout (in 1995), which uses Gabčíkovo project dikes (reservoir and by-pass canal) and also old flood protecting dikes, improved tourism and recreation possibilities.

4 NATURE AND LANDSCAPE PROTECTION - STARTING POINTS AND LIMITS FOR NEW SOLUTIONS

Act No. 543/2002 defines nature protection as "limiting of interventions, which can endanger, damage, or destroy life forms and their conditions, nature heritage, appearance of landscape and reduce its ecological stability, as well as relieve of impact of such interventions. Nature protection also includes care of ecosystems.

The water regimen is the basic abiotic factor limiting the functioning of the floodplain ecosystem. In spite of the fact that supplying the river arm system with the water, using the intake structure at Dobrohošť, offers inflow of sufficient water for some components of biota, it does not assure a sufficient dynamic of water levels, erosion, and accumulation processes in the within-dike zone. The present artificial, water regimen does not follow the natural range of water level fluctuations. During simulated floods, water overflows the terrain only locally. Stagnant or slowly flowing water does not cause erosion, does not transport and subsequently deposit material (suspended solid, sand and gravel, decaying organic substances in the form of detritus and debris), and these natural processes are not in balance there.

After the change of water regime, the most conflicting factor from the viewpoint of nature protection is **forestry** (silviculture). In this area, regarding natural conditions, the softwood floodplain forests are cultivated. Since 1950s, the original stands of the association *Salici-Populetum* are replaced after clear-cutting almost exclusively by monocultures of hybrid poplars *Populus* x *canadensis* and other cultivars.

The water levels and flow rates were measured on several stations (**Fig. 4.1**). The **Fig. 4.2** shows fluctuations of flow rates in the Danube at Bratislava and Komárno. The regression line shows that the long-term changes in flow rate are, at least at Bratislava, negligible. The average annual discharge at Bratislava is 2025 m^3/s. The lowest measured discharge was 570 m^3/s, the largest one 10 400 m^3/s (10390 m^3/s at Bratislava-Devin in August 2002). The expected discharges with occurrence probability once for 100, 1000 and 10,000 years are 10,600 (after flood in 2002 this value was corrected to 10,000 m^3/s), 13,000 and 15,000 m^3/s, respectively.

The maximal discharge in August 2002 at Bratislava-Devín was 10,390 m^3/s, at Medveďov 9,420 m^3/s and at Budapest 8,250 m^3/s. The difference of 2,140 m^3/s between Bratislava-Devín and Budapest was not caused by a break of dikes and flooding a territory as happened in 1954 and 1965. Downstream of Gabčíkovo, the rivers Váh, Hron, Ipeľ and some other smaller tributaries on the Slovak and Hungarian side mouth into the Danube. At the time of the flood they also had increased discharges. The difference between the maximum flood discharges between Bratislava (together with the discharges of its tributaries) and Budapest represents the decrease of peak flow due to the anti-flood conception of the Gabčíkovo-Nagymaros Project. Ground water storage played also an important role here.

The water sources for floodplain are as follows: first of all the Čunovo dam with the hydroelectric station allowing an discharge of 400 m^3/s, the regular weir and the weir in inundation at Čunovo (the discharge through the Čunovo dam can be continuously regulated up to the value of 11,200 m^3/s); intake structure into the Mosonyi Duna with a capacity of 40 m^3/s (a part of its water also supplies river arms on the Hungarian side); intake structure at Dobrohošť with a capacity of 200 m^3/s; and the water seepage from the Čunovo Reservoir which is estimated to 30-50 m^3/s. Impoundment of water level in the old Danube (for example as at Dunakiliti) offers to the floodplain river arm system water flowing in the old Danube. Impoundment would additionally increase the ground water level. According to International

Agreement of 1995 (AGREEMENT 1995), the minimum and maximum discharge through the Čunovo dam is 250 and 600 m^3/s, respectively.

Before the closing and separation of the arms from the Danube, hence still before the concentration of all water into the Danube main stream, but already after straightening the Danube, and after construction of the flood protection dikes, **the water continuously flowed** throughout the arms on the Slovak and Hungarian side, even in the periods of low flow. The data about this are preserved in the publication of MUCHA, DUB (1966), **Tab. 4.2** and **4.3**. The basic data about the flow rates are illustrated in the **Table 4.4**. For comparison with the levels, when the arms were permanently through flowing (**Tab. 4.2 and 4.3**), we also give the typical discharge situations in the arm system from the later period, when the arms were closed and, as the matter of fact, separated from the Danube (**Tab. 4.5**). Some discharge situations, mainly at lower discharges, can repeat several times a year.

The following conclusions can be derived from the above tables:
- Before the fortifying and raising of the Danube banks and before the closing of the river arm inlets (before 1962), the water flowed in the arms at any water level in the Danube main stream; in some places the water flowed into the arms and on other places flowed out from them, on both the Hungarian an Slovak sides. In the main river arms the water never stagnated.
- Before putting the Gabčíkovo project into operation, but already at the state of the Danube riverbed in 1980, the water flowed in almost all arms only when the discharges in the Danube exceeded 3,500 m^3/s. Such a situation occurred only about 17 days a year (CEC 1992). In some main arms, the water flowed when the discharges in the Danube exceeded 2500 m^3/s. Such a situation lasted only about 3 months a year. The state immediately before 1992 was probably a little worse than that described by the CEC report.
- The typical high discharges occurred in summer, mainly in June and July, when the water flowed in the majority of larger arms, in the pre-dam period.
- The typical low discharges occurred in October, November and December, when the water usually did not flow and stagnated in a part of the arms, while some other parts of arms were dry (state before 1992).
- The ratio of the maximal average monthly discharge in summer and the minimal average monthly discharge in winter in the Danube is 1.93. The discharge in summer is about twice as large as in winter **Tab. 4.3.**
- The regime of water flow in the arms always depended on flow rates in the Danube. This was influenced by fortification of the Danube riverbanks, height of the bank spillways and inlets of original arms, as well as by level of the Danube bottom.
- Similarly, **the ground water level,** mainly in the river close zone, but also in a wider territory, always depended on the water level in the Danube and was influenced by the water level in the arm system.

The occurrence probability of discharges in the Danube exceeding 4,000 m^3/s is important for the water regime in the floodplain. According to **Tab. 4.5** this value represents discharges at which the water is flowing in almost all arms. In the Slovak side arms, it corresponded to discharges of about 60-70 m^3/s in the pre-dam conditions. HOLČÍK (1992) states that in the past the whole within-dike zone was flooded at the discharges of 4500 m^3/s. **Table 4.6** presents maximum monthly discharges in the Danube at Bratislava. The discharges exceeding 4500 m^3/s are made expressive. The table shows that the highest discharges are expected in July and August, rather than in March, whereas the lowest discharges are expected in October and November.

For flood flow rates measured at Bratislava diagrams were constructed. The course of floods is represented in **Figures. 4.9a – 4.9b** as lines of discharges in time. They show that they are very steep at the beginning. At the same time these curves also define the course and duration of floods for a concrete state of the floodplain and the Danube banks. These data, plus some data in further tables and figures, represent the auxiliary data for simulating the natural flood in the flood plain system. The figures show that the beginning of Danube floods is about twice as fast than their fading away. In the arm system, the beginning increase of water levels during floods, the increase of water levels occurring mainly after over-spilling the riverbanks, will still be faster and the decrease of water levels after floods will be slower.

Low **cascade dikes,** forming a series of blocks across the within-dike zone, **regulate the water level in the floodplain river arm system.** In the dikes there are sluices for the regulation of the water level (**Fig. 4.10**). These lines of cascade dikes (A to J) are raised, fastened forest ways, built up in the past, and they are inconspicuous in the terrain. The water level at the cascade dikes, which are often situated in the places of previous dikes, were established so that the water levels correspond approximately to the water levels recorded around the year 1960.

Water temperature is an important ecological factor influencing management of simulated floods. **Fig. 4.12** shows, in a long-time scale, the daily fluctuations of water temperature in the Danube at Bratislava (MUCHA et al. 1994). This figure shows a close correlation of the temperature with the calendar date. **Figures 12** and **4.13** shows, for example, that water temperatures of 10°C occur in the Danube on average around 20 April with a possible dispersion from 22 March to 15 May, when the average flow rates are, according to **Fig. 4.5,** about 2,500 m^3/s, minimal discharges ranges from 1,000 to 1,500 m^3/s and the flood discharges could reach almost 7,000 m^3/s. Expected probability of flood occurrence is given in **Fig. 4.7.**

Flood discharge is defined as a discharge exceeding the value of 6,000 m^3/s at Bratislava. This corresponds to the 1st degree of the flood protection activities. In case that there is in the Danube a higher discharge that can pass via the by-pass canal and Gabčíkovo hydroelectric station, surplus water is discharged into the old Danube and its inundation. The Gabčíkovo project has been projected to stand the 1,000-year water discharge without endangering the flood protection and prescribed flooding security. It corresponds to the discharges reaching at Bratislava 13,000 m^3/s. **The maximal (total) discharge capacity of the Čunovo dam structures in the direction towards the Danube floodplain within-dike area amounts 11,200 m^3/s** [VODOHOSPODÁRSKA VÝSTAVBA š.p. 2000 p. 61, (Provisory management regulation)]. **This is the discharge, which is to be taken into consideration in the old Danube and its floodplain**. The maximum discharge of 8 turbines of the Gabčíkovo hydroelectric station amounts 3,800 m^3/s under conditions that in the Danube at Bratislava discharge reaches 10,000 m^3/s and it declines at the higher discharges. At a 1,000-year flood with discharges of 13,000 m^3/s in the Danube, the discharge through the Gabčíkovo hydroelectric station decreases to 3,160 m^3/s. If the navigation locks are open, they allow releasing additional discharge of 2,800 m^3/s. In such a case, the by-pass canal is able to lead in total a discharge of 4,000-4,500 m^3/s. The discharge trough of the Gabčíkovo power station depends on the number of active turbines, discharge through the navigation locks, as well as on the water level downstream of the station, which is at present higher as projected.

Let us repeat that the **real maximum discharge that is to be considered in the old Danube and in the within-dike floodplain zone with its arm system** moves around **11,200 m^3/s.** It is a short lasting discharge of the flood culmination. However, the lower, but long-lasting discharges are also dangerous, as shown by the flood in 1965. The real discharge in the old Danube at a 1000-year flood can be estimated and expected to be 10,300 m^3/s.

For flood protection in winter, regulation of discharges into the old Danube, the middle weir of the Čunovo dam is used. In co-ordination with the Dunakiliti dam, it allows suitable velocity of water flow and passing the ice floes. Freezing of water in the old Danube is not expected, because the old riverbed is supplied with the warmer ground water in winter.

The diverting of flood discharges through the floodplain must be done under the condition that the level of the floodwater should not exceed the level that would have been reached without construction of the Gabčíkovo project. It means that in any possible alternative it must be calculated with discharge in the Danube at Bratislava minus 3,000-4,000 m^3/s flowing through the by-pass canal (under the presumption that the turbines are working and the locks are open). At present, without regulation of the Danube riverbed downstream of Gabčíkovo in accordance with 1977 Treaty, the function of turbines is substantially limited at the discharges exceeding the 100-year Danube water discharge.

In order to obtain an **adequate picture of a flood situation**, let us assume the following hypothetical but realistic consideration. Assume that a discharge of 10,000 m^3/s can be released through the Čunovo dam during the hypothetical 1000-year flood (possibly a larger flood as 1000-year flood occurred in the year 1501). Then we assume, that the discharge capacity of the Danube old riverbed, floodplain, and its arms, should be close to the state existing during the flood of 1954, of course, with better flood protection measures inhibiting seeping and breaking of dikes. The situation that would arise under such circumstances can be seen in the example of the flood of 1965, when about 90,000 ha were flooded, 693 houses were destroyed and 3,170 houses were damaged in Hungary by increase and seepage of ground waters above the surface, and this in spite of the fact that the dikes withstood the load (HRONEC, 1969). We stress again that the dike on the Hungarian side did not break in 1965. And still the discharge in 1965 in the Danube did not reached 10000 m^3/s.

If the discharge capacity of the old Danube will be in the state, which existed before 1992, it will have such carrying capacity. If the water level in the old Danube would be impounded, e.g. by underwater weirs, they must be constructed in a way not to increase water level during the floods. If the old Danube riverbed would be narrowed or partially grown by vegetation, it is necessary to find a method to lead more water through the river arms and over the floodplain surface.

Theoretically it is possible to increase the discharge capacity of the river arms. The more we would wish to increase the discharge capacity of the main river arms, the more we would have to dredge their bottom, widen the arms and fortify their banks. It is impossible to form a meandering arm, which would be able to take the whole required flood discharge. The hydraulic gradient of such meandering arms would be half of the gradient in the old Danube. The flow velocity in such arms would be considerably lower. The discharging profile of the meandering arms should be considerably larger than that of the old Danube in 1992. Such an arm or new meandering Danube would be neither natural nor the Danube.

Part of the floodwater can flow over the floodplain surface. From an ecological viewpoint there are no objections against an increase in the extent of meadows maintained by mowing or grazing. By means of modelling, it would be possible to find the most suitable spaces ("hydraulic corridors") for leading water during the flood. They would be deforested and maintained in such state. However, we cannot use for this purpose the stands growing on the arm banks, because they play a role of bio-corridors and shadow the littoral. There are principal objections against the so-called hydraulic forests (sparse canopy and removal of shrub stratum). Leading of the water over the floodplain surface means that a part of this floodplain must remain without tree vegetation and the terrain must have a corresponding declination to lead large water amounts. It is also necessary to accept erosion of the terrain surface. The old Danube is ready to take such a function over.

Limiting factors of further considerations

The first limiting factor is the maximum flood discharge, which should pass through the floodplain. Its water level should not exceed the levels occurring in the pre-dam conditions. **The second limiting factor is discharge in the old Danube and its regime.** The natural regime was as follows: The average low discharge in December is approximately the half from the average high summer discharge in June, **Tab. 4.4**. This relation should be preserved in a way that considerably more water will flow in the old Danube during the growing season than in winter. According to the Slovak-Hungarian Agreement of 1995 (AGREEMENT 1995) such discharges correspond at present to the minimum of 250 m^3/s and maximum of 600 m^3/s. The discharges may include all water that cannot be passed through the by-pass canal. The Hungarian side (December 1999) defines the ecologically minimal discharge in the growing season as 400 m^3/s and in winter considerably less. On the other hand, at discharges exceeding at Bratislava 4,000 m^3/s and not reaching 6,000 m^3/s, the water level in the arms and in the floodplain should reach the values occurring here in the pre-dam conditions. It means simulation of flooding the floodplain in relation to discharges in the Danube at Bratislava. Based on the present experience, the Hungarian side intakes about 130 m^3/s water from the Danube into its arm system though it could intake considerably more. Similarly, the Slovak side supplies its arm system usually by less than 100 m^3/s. At the beginning, we can assume that about 200 m^3/s water can be put into the arm systems on both sides without the necessity to build up and fortify the main (meandering) arms. The discharges in the arms can be gradually increased. A total discharge of 400 m^3/s can be taken as a desirable value, which can be, but inevitably must not be achieved. However, such discharge will need regulation of the banks and dredging of the bottom, in case we create a unified system of a single meandering new riverbed. If we do not create such a system, but we reconnect the arms with the old Danube riverbed, the discharges into the arms may considerably differ in individual stretches of the old Danube riverbed and its arms. The discharge of 400 m^3/s can be accepted as a limiting discharge for the arms in the growing season. It can be reached gradually, more in a natural way, and it must not be reached at once, by means of regulation and dredging of the present existing arms. Any larger discharges in the arm systems would require expensive works, whose results might contradict ecosozological concepts, because they would require creating a riverbed profile and fastening of banks, that would correspond to the pre-dam Danube at low water discharges.

Requirements of the flood protection measures are evident from the previous data. If not, a completely new riverbed for the Danube should be realised, than the old Danube riverbed together with the floodplain surface, within the protective dike zone, must allow to lead that part of the discharge, which cannot pass through the floodplain arms - a new Danube riverbed (new eupotamal). In such a case, the old Danube riverbed must be maintained in such a way, which assures existence of the same discharging profile as in the pre-dam conditions. In the case of solution without the water table impoundment, it means a regular removal of spontaneous growth. In the case of solution with water level impoundment to a level covering the whole riverbed (a state which corresponded to discharges of 1,000 - 1,300 m^3/s in the pre-dam conditions) it means only a minimal cleaning and maintaining of the old Danube riverbanks.

In the case that the old Danube overtakes the function of leading the flood discharges, there will be **minimal requirements to the arm system in connection with the flood protection measures**. As the matter of fact, they will be almost the same as at present. Probably, some minimum terrain regulations will be necessary in selected places along the banks of the old riverbed. It also applies when discharges into the arms will be a little higher. However, any such proposals must be verified by means of numerical modelling.

In the case that the old Danube should not be preserved in the pre-dam form (for example partial raising and narrowing of its river bed), than it is necessary to find a new space for leading the flood discharges in the area between the right- and left-side flood protection dikes. The proposal must be verified by means of modelling and subsequently realised before starting to raise the old river bed and before its natural terrestrialization.

5 STATE OF THE NATURE ENVIRONMENT 10 YEARS AFTER THE DANUBE DAMMING

When speaking about the influence of the Gabčíkovo project and the underwater weir at Dunakiliti on environment and nature, it is clear that the main role is played by the **ground water level fluctuation** in the geological profile of aquifer. It determines the capillary height and changes in availability of the ground water for the soil and root systems of plants. For agriculture it is important, first of all, whether the ground water level reaches sediments showing a good capillary elevation.

In the territory of Szigetköz and Žitný Ostrov Islands the depth of border between the gravely stratum and covering fine sediments or soil is an important factor for interaction between the ground water and soil moisture. It is optimal for agriculture, when the ground water level in the growing season reaches the fine soil sediments. A high level of ground water and its fluctuations in the floodplain are welcome, because such a state is suitable for the typical alluvial biotopes and is naturally regulated by the river arms. The ground water level directly influences the soil moisture, especially in the vegetation period **(Fig. 5.4)**.

The **soil moisture (Fig. 5.1)** is influenced mainly by the water level in the Danube, in river arms, by precipitation and air temperature (**Fig. 5.2**). For each monitoring plot, a map in the scale of 1:10,000 has been elaborated. The equipotential lines represent the ground water levels in the years 1962, 1992 and 1995 (HLAVATÝ, CAMBEL 1995), (**Fig. 5.3**).

In order to emphasise the time and depth relationships of soil moisture, diagrams, in which the abscissa represents time, the ordinate depth, and the humidity levels are expressed by colour, have been elaborated (**Fig. 5.4**). The brown shadows express the moisture deficiency and inaccessibility for the plants; the green and blue colour means sufficient soil moisture; while the violet shadows express high soil moisture and soils fully saturated by water (usually below the ground water level). Ticks at the upper scale of the diagram mark time of measuring. Fluctuation of the ground water level is plotted in the same depth scale. The diagrams show a strong **influence of ground water level fluctuations on the soil moisture**. Besides this, it is possible to recognise impact of precipitation or irrigation, seasons with a high evaporation, and to draw the general conclusions about changes in soil moisture. It can be seen, how the soil moisture reflects the geological profile, structure of sediments and influence of the capillary barrier. The "moisture" measured under the ground water level reflects individual strata porosity and proportion of fine-grained material. Among the data, the dates of the Danube damming, supplying of the Slovak part of the arm system with water and beginning of supplying the Hungarian river arms with water are set off.

Ecological conditions of the floodplains are in addition determined by a sufficient **input of nutrients**. Nitrogen, phosphorus, carbon, hydrogen, oxygen, and sulphur belong to the most significant nutrients for the water and soil organisms. The main role is awarded to phosphorus and nitrogen. Out of these elements, potassium, calcium, magnesium, iron and manganese are necessary for water organisms. Less significant are zinc, copper, cobalt, some organic complexes, vitamins and other substances. Conditions could be evaluated also from the viewpoint of plant and timber production, for which the macronutrients like carbon, hydrogen, nitrogen, phosphor, sulphur, potassium, magnesium and micronutrients like iron, and manganese, zinc, copper, boron and molybdenum are significant. In this connection, the simulated flood creation of quasi-natural conditions is emphasised.

Most elements and compounds are naturally present in the Danube water in sufficient quantities and are not a **limiting factor for survival of water organisms**. The total nutrition value of the water (water nutrition potential) is determined not only by the sufficient quantity of the nutrients, but also by their mutual proportion, mainly by the phosphor/nitrogen ratio.

Fig. 5.5 shows the important **hydrological characteristics;** dynamics of water temperatures and discharges in the Danube; and fluctuation of the water table in the Čunovo Reservoir. **Fig. 5.5a** shows that course of temperatures has a regular sinusoid character (see also **Fig. 5.9**) with maximal temperature in summer and minimal in winter. **Fig. 5.5b** identifies the periods with increased discharges and flood states, or periods of minimal discharges in autumn.

Nutrients in floodwater could be divided in dissolvable nutrients; nutrients in the form of suspended solid materials; nutrients bound to suspended solid materials; and nutrients bound to riverbed sand and gravel.

Floods may influence dissolvable nutrients only if its concentration is diluted (snow thaw) or, in contrast, if they are added to the water during flood (surface flush and run-off after strong rains).

Quantity of **suspended solids** depends on the flow velocity and on the place of their releasing, for example a flushed water reservoir (dams constructed on the Danube in Austria and Germany).

Quantity of **transported gravel and sand** depends on flow velocity and continuity of the river (discontinuity mainly dams, lakes, overflowing dams etc.). As to the content of nutrients, the transported gravel and sand have only a small significance. In this regard, the substances dissolved in water and substances bound to the fine suspended solids have large significance.

Comparison of profiles upstream and downstream of the Čunovo Reservoir shows that passing of the water through **the reservoir does not cause significant changes in dissolvable nutrients, pH and water temperature.**

Concentration of **nitrates** in the flowing Danube water changes in the course of year in dependence on discharge, content of organic substances and biological activity (compare **Fig. 5.6** and **Fig.5.9**). A higher content of nitrates occurs out of the growing season, in winter, and during the spring. The lowest content occurs usually in the late summer and early autumn.

The content of **phosphates** shows similar seasonal fluctuations as the nitrate content. The water in the vicinity of the intake structure of the arm system contained about 0.2 mg/l in 1995 (**Fig. 5.6**). It shows that the phosphate content in the Danube water is mostly sufficient and does not inhibit the biological processes.

The basic scheme of the **carbon** circulation in water ecosystems begins in the atmosphere, from where carbon is taken by the producers, which pass it to the consumers. The carbon passes from these two trophic levels to the destruents. The carbon present in the inorganic form as CO_2 is assimilated by algae. Biochemical oxygen demand (BOD_5) characterises indirectly the content of organic substances, which are subjected to aerobic biochemical decomposition. Values of BOD_5 in the Danube water fluctuate in a long-term scale in a range of 1 - 3 mg O_2/l and are influenced more by momentary discharges than by seasonal influences (**Fig. 5.5 - 5.9**).

The **dissolved oxygen** in the Danube water comes from the atmosphere and from the photosynthetic activity of water plants. Oxygen diffusion from the atmosphere into the water depends mainly on the water temperature (**Fig. 5.7**). The average fluctuation of oxygen concentrations ranges from 8 to 11 mg/l (**Fig. 5.9**).

The electric conductivity of water depends on quantity of dissolved substances dissociated on ions. Together with the index of the **total content of dissolved substances** it represents a group index characterising the content of different substances in the water, without identification of their origin and kind. **Fig. 5.8** shows, that both indices have an expressively seasonal character depending mainly on discharge in the Danube.

The water temperatures have an overall influence on the velocity of metabolic processes. The temperature optimum of most water organisms lies in the range of 10-30°C. Water temperature in the Danube fluctuates up to 20°C (**Fig. 5.5**). As apparent from **Figs. 5.5, 5.7, 4.12, 4.13 and 4.14**, water temperature in the Danube reaches 10°C as late as in March-April. In the Danube arms, the water overheats and, in sunny weather, the temperature of the slowly flowing or stagnant water can reach considerably higher temperatures than in the main stream.

The water **pH** (**Fig. 5.7**) can essentially influence the existence of the water organisms. In flowing arms the water pH corresponds with pH in the Danube, whereas in the arms with small discharge or with stagnant water pH can considerably decline under certain temperatures.

Concentrations of other dissolvable nutrients, i.e., potassium, calcium, magnesium and sulphates, have a similar seasonal dynamics as the concentrations of nitrates and dissolved oxygen. Maximum values occur in winter and in early spring, the minimum in summer.

Content of **nutrients transported in suspended form** are characterised by the total content of insoluble substances (**Fig. 5.8**). Solid substances settled on the bottom or transported by water contain the inorganic and organic fraction representing food for different organisms. In the less populated regions the inorganic fraction predominates, while in the industrial or densely populated regions the proportion of organic substances is higher. The Danube water has a low content of organic substances (**Fig. 5.6, 5.9**). During flood these substances contribute to terrestrialization of the arms with small discharges or stagnant water. As apparent from **Fig. 5.8**, the content of insoluble suspended materials is highest at Bratislava. In the downstream direction their content gradually decreases due to sedimentation of coarse-grained suspended solid materials in the Čunovo Reservoir. In the Čunovo Reservoir. at the profile of Rusovce/Kalinkovo, the content is lower, approximately as high as in the Danube at the Dobrohošť village and at the intake structure in Dobrohošť. Comparison with the **Fig. 5.5** shows that the content of suspended solids at Bratislava, and consequently also in the downstream direction, significantly depends on flow rates in the Danube. Extremely high contents of insoluble substances occur during floods.

Transport of suspended solid materials depends on discharges and thus flow velocity. **Fig. 5.10** shows model distribution of velocities in the Čunovo Reservoir for different discharges measured at Bratislava: a) 1950 m^3/s, b) 3.200 m^3/s, c) 6.200 m^3/s all by discharging 400 m^3/s through the Čunovo weir into the old Danube at the water level of 131.10 m above sea level (KĽÚČOVSKÁ, TOPOĽSKÁ 1995a, 1995b). The figures show conditions for transport of the suspended solid material (sedimentation, erosion/ascending) in the reservoir at different discharges. They also show the influence of the hydraulic guiding structure (shallow dam in reservoir) at Šamorín. The highest flow velocities occur in places of the Danube original riverbed in the navigation canal. **Fig. 5.11** shows modelled change in concentration of suspended solid materials depending on the discharge at Bratislava (KĽÚČOVSKÁ, TOPOĽSKÁ, 1995a, 1995b). The highest concentration of suspended matters occurs at all discharges at Bratislava. At the average discharge of 2,000 m^3/s, the concentration of suspended solid materials at Bratislava is 23 g/m^3 water (23 mg/l) while the concentration in the intake structure into the arm system at Dobrohošť is about 0.8 g/m^3. At the flood discharge of 5,000 m^3/s, the concentration of suspended solids at Bratislava amounts to about 120 g/m^3, while at Dobrohošť it increases to 65 g/m^3. During floods the fine-grained sediments, deposited in the Čunovo Reservoir, release in the places with the higher flow velocities (**Fig. 5.10**).

The model solutions show that flooding of the arms during natural floods offers a larger input of nutrients in the form of suspended solids, because the water contains about 80 times more suspended materials than at average flow rates in the Danube. It would be even higher in the arms reconnected with the old Danube riverbed.

Granulometric characteristic of the suspended solids depends on flow rates in the Danube and in the by-pass canal. At larger discharges, the proportion of the coarse-grained fraction increases at the area of the intake structure at Dobrohošť. Granulometric composition of suspended materials influences sorption processes and bottom permeability after their sedimentation.

Based on the previous analysis it is possible to conclude that:

- The Čunovo Reservoir does not cause significant changes in the level of dissolved nutrients, or in pH and temperature of water flowing via the intake structure into the river arm system.
- The concentrations of dissolved nutrients like nitrates, phosphates, oxygen, sulphates, potassium, calcium and magnesium exhibit strong seasonal fluctuations. The maximal values occur in winter and in early spring, the minimal in summer.

– The increased discharges in the Danube cause an increased transport of the suspended materials from the areas upstream of the Čunovo Reservoir, reduced sedimentation in the reservoir including coarse-gained particles, and partly also erosion of the fine-grained suspended materials from the reservoir bottom. It caused a considerable increase in content of nutrients bound to suspended materials in comparison with states of average discharge. Input of nutrients in the form of suspended materials into the arms through the intake structure at Dobrohošť is 80 times higher during the flood than at average discharges in the Danube. The suspended materials transported during floods considerably contribute to terrestrialization of the blind arms and arms with a limited discharge.

Flora and vegetation

Systematic monitoring of flora and vegetation began by definition of the initial state on established monitoring plots (MP), founded in 1990 (LISICKÝ et al. 1991). Among 24 monitoring plots, the following were situated in the floodplain within-dike zone: MP No. 6 (Dobrohošť), MP No. 7 (Žofín), MP No. 9 (Bodícka Brána), MP No. 10 (Kráľovská Lúka), MP No. 14 (Istragov) a MP No. 15 (Erčed), MP No. 17 (Diely), MP No. 18 (Sporná sihoť) and MP No. 23 (Čičov-Starý les). These Monitoring plots were dispersed on 3,100 ha of floodplain forests. The aim of the botanical monitoring was to obtain basic up-to-date data about the microstructure of vegetation by means of an inventory of flora and vegetation (LISICKÝ et al. 1991). After evaluation of the state before the Danube damming in 1990-1992 the MP No. 7, 17 and 23 were excluded from the monitoring, but majority of parameters were evaluated each year (ROVNÝ et al. 1992, CAMBEL et al. 1993, MATEČNÝ et al. 1994, 1995, 1996, 1997, 1998, 1999, 2000, 2001). Summarized results of the botanical monitoring, inclusive of data on foliage lost and changes in the foliage surface, were published by UHERČÍKOVÁ et al. (1999). In regard to different dynamics of water regime and precipitation in individual years, these results are characterised by a considerable fluctuation in the number of plant species. This fact is not, however, a negative result of the existence and operation of the Gabčíkovo project, but a regular phenomenon characteristic of the floodplains. By means of the indirect monitoring of the flora (only on the monitoring plots, not on the whole area), 760 vascular plants were recorded. However, this number includes the floristic inventory also from the monitoring plots situated outside of the within-dike zone (Podunajské Biskupice, Rusovce, Čičov etc.). Unfortunately, since the founding of the monitoring plots, the overall floristic inventory was not evaluated. The structural changes in vegetation on the monitoring plots, observed in the years 1990-1995, were generalised by UHERČÍKOVÁ (2001) and can be summarised as follows:

- increased spreading of the neophytic plants with a tendency to their naturalisation,
- expressive spreading of the nitrophilous plants,
- absence of the strongly hydrophilous plants,
- impoverishment of the species inventory of most forest communities by 4 - 6 species.

Results of almost all scientific forestry investigations from the floodplain emphasise inevitability of simulated flooding. The floods are important for a sufficient saturation of soil, even on those sites, where the ground water level is sufficiently high, also from the aspect of nutrients input (NEŠTICKÝ et al. 1996, VARGA et al. 1997, NEŠTICKÝ, VARGA 2001). Inevitability of the simulated floods, as a main precondition for natural regeneration of the willow-poplar forests, is also stressed by other authors (ŠOMŠÁK 1998, 1999). The long-term investigation of natural reproduction of willows and poplars (ŠOMŠÁK, 1998, 1999, PIŠÚT, UHERČÍKOVÁ 1995) shows that reproduction of autochtonous trees (*Salix alba, Populus nigra, Populus alba*) from seeds happens only on denuded sediments or on the fluvizem (fluviatile soils) substrates eroded by floods. Reproductions from seed are always spontaneous and show features of fluctuations lasting several years. Reproduction under the maternal stand from seed occurred, and at present also occurs, very sporadically.

Terrestrial fauna

The present state and changes in fauna and animal taxocoenoses are evaluated on the basis of biota monitoring in 1990-1997 (LISICKÝ et al., 1991, ROVNÝ et al., 1992, CAMBEL et al., 1993, MATEČNÝ et al., 1994 - 2001). The initial state is described in the first three reports cited. At the beginning, the fauna was monitored similarly as the flora, on 9 monitoring plots in the floodplain within-dike zone, later on 5 plots. These plots have a very different ground and surface water regime. A wide scale of taxocoenoses of soil, epigeic and planticolous animals was monitored (Mollusca, Oniscidea, Acari, Chilopoda, Collembola, Heteroptera, Coleoptera, Neuroptera, Mecoptera, Lepidoptera, Hymenoptera, Amphibia, Aves, Mammalia, etc.). They relatively sharply reflect changes in communities of terrestrial and semiaquicolous animals

Changes in animal taxocoenoses are to be evaluated from several viewpoints. The **first criterion** is change in species richness. It does not represent, particularly in the floodplain forests, a significant indicative criterion, because in the process of degrading, the disappearing species, characteristic for natural conditions, are replaced by an approximately equal or even higher number of xenocoenous species. Hence, the total number of species does not decrease and may even increase. Sometimes such a state is incorrectly interpreted (also in the case of the Danube inland delta) as improvement of the ecological situation in consequence of antropogenous interventions. **A correct interpretation of changes in species number needs consideration of the ecological requirements (demands for environmental conditions) of individual species.** Particularly significant is the proportion of representation of species of different humidity preference. Its use, however, depends on the degree of knowledge of autecology of the individual species. From the viewpoint of bioindicative use of the animal taxocoenoses in floodplain forests, it represents one of the most significant criteria with a high indicative value. The **second criterion** is the proportion of species requiring permanent shadowing by woody vegetation, and species indifferent to shadowing or preferring ecosystems without shrub and tree stratum. In the floodplain forests this criterion indicates secondary, but synergically acting changes caused primarily by changes in humidity (drying of stands, decline of the number of hygrophilous trees and reduced canopy), influence of abiotic factors (trees uprooted by wind), anthropogenous interventions (silvicultural measures - thinning, selection felling).

The **present structure of taxocoenoses** represents a result of changes that happened before and during construction and after putting the Gabčíkovo project into operation. The draining effect of the Danube worsened ecotopic conditions for the softwood floodplain forests. It is important from the point of fauna that willows in the littoral zone and depressions and river arms earlier filled by water, which does not communicate with the water supplied arms, are drying. In the strip at the old Danube, which width varies according to the configuration of the main arms from 80 to 250 m, the ground water level does not contact the capillary fringe of the tree rhizosphere. It causes an untimely fall of foliage, and semi-natural and economic stands dry out (PIŠÚT 1995). It causes aridisation of the territory and its colonisation by allochtonous or xenocenous faunistic elements (JEDLIČKA et al. 1999).

Among the animal taxocoenoses, these changes are particularly strongly reflected by the taxocoenoses of edaphic and epigeic animals, which are most closely bound to the soil conditions, first of all to soil moisture. The taxocoenoses of animals inhabiting the shrub and tree strata depend more on the climatic conditions (inclusively of microclimate) and vegetation (JEDLIČKA et al. 1999).

The floodplain represents an island partially isolated by the project from the potential immigration sources. In addition, the terrestrial zoocoenoses in the floodplain forests between Bratislava and Dobrohošť are degraded and impoverished to a considerable degree. For example, even the less hygrophilous species abundantly occurring downstream (eastwards) are missing here in **the malacocoenoses,** even in the most humid stands of *Salici-Populetum,* or they occur here in a very low abundance (ŠEVČÍKOVÁ 1997, ČEJKA 1999, JEDLIČKA et all. 1999). In the majority of floodplain forests in the vicinity of Bratislava, they are replaced mainly by forest mesohygrophilous and some other hygrophilous species. In more preserved types of humid forests they are represented first of all by *Clausilia pumila* and *Semilimax semilimax* (rarely also *Vitrea crystallina*), in drier stand types by species of the illyric forest regiotype (mainly *Aegopinella nitens*, than *Petasina unidentata*, *Monachoides incarnatus*, *Cochlodina laminata*) and by some species of the regiotype of old forest settler species (*Alinda biplicata*, but also *Fruticicola fruticum* and on more humid sites also *Arianta arbustorum*). Such structure of the mollusc taxocoenosis is caused by the long-term decline of ground water level resulting from deepening of the Danube bottom. In consequence of this, the polyhygrophilous species disappeared and the possible remainder of populations were not able to regenerate. The potential immigration sources are represented by drifted material, but the potential immigrants probably do not find suitable conditions or there populations are too weak to be able of autonomous development (ČEJKA & FALŤAN 2001). A similar situation also exists in other small remnants of softwood floodplain forests downstream from Bratislava, even in the area influenced by the ground water level increase due to the Čunovo Reservoir in 1992. This area cannot serve as a potential refugee and an immigration source of hygrophilous ecoelements into the by-passed zone. The by-passed zone is isolated from the surroundings by so-called cultural steppe, hence arable land. Only downstream from the tailrace canal it contacts with an ecologically similar area of a small extent. In regard to the generally known relationship of species richness (biodiversity) and area, and the island theory, the mollusc biodiversity cannot be preserved without preservation of the mollusc taxocoenoses of the inland delta in their full extent.

In consequence of low vagility, the malacocoenoses react relatively sensitively to changes in life conditions. After the Danube damming, the largest changes in their structure and disappearance of hygrophilous species were observed in the vicinity of Dobrohošť (MP Dunajské Kriviny), Bodíky (Bodícka Brána) and Gabčíkovo (Istragov). In particular at Dobrohošť, the original malacocoenoses of the softwood floodplain forests dominated by the hygrophilous species turn into the mesohygrophilous coenoses characteristic rather for the transitional to hardwood floodplain forests. At the turn of 1980-ies and 1990-ies, there was a malacocoenosis typical for moderately humid to humid varieties of the softwood floodplain forest with dominance of the polyhygrophilous species *Carychium minimum*, *Zonitoides nitidus* and *Succinea putris*. Analysis of the thanatocoenoses from the soil samples revealed that the wetland species *Vertigo antivertigo* also lived here in the past. This specie has not been recorded in the Danubian area for two decades. After the Danube damming populations of such species gradually disappeared from the monitoring plot at Dobrohošť.

In the area of Bodíky the situation is a little more favourable. After the Danube damming, the habitats are sporadically flooded. In spite of this, we have not, however, recorded restitution of representation of the hygrophilous species (*Carychium minimum*, *Zonitoides nitidus*, *Vitrea crystallina*) to the original pre-dam level. Because of the dominant draining effect of the old riverbed, the short-term simulated floods influence the humidity only for a short time. Therefore we have to state that simulation of floods does not positively influence the structure of malacocoenoses. In the original hygrophilous taxocoenoses, which existed here before the Danube damming, the polyhygrophilous species were replaced by the mesohygrophilous or eurytopic species (*Aegopinella nitens*, *Monachoides incarnatus*, *Alinda biplicata*, *Punctum pygmaeum*). The taxocoenoses on the locality Istragov belonged, until 1992, to the strongly hygrophilous taxocoenoses. This monitoring plot was the only plot where the rare wetland species *Euconulus alderi* occurred in the pre-dam period. After the Danube damming and reduction of flow in the old Danube, the ground water level has declined, the formerly flooded shallow depressions have been reduced, and a xeroseries accompanied by the disappearance of the hygrophilous species (*Carychium minimum*, *Oxyloma elegans*, *Succinea putris*, *Pseudotrichia rubiginosa*) begins in them.

The area of the floodplain forests in the vicinity of the tailrace canal mouthing into the Danube belongs to the last remnants of the inland delta with the occurrence of the humid variety of the softwood floodplain forest of the *Salici-Populetum myosotidentosum* association containing corresponding malacocoenosis. Due to the backwater effect from the tailrace canal, this area is flooded during the growing season, often twice a year. Although the herbage stratum is degraded to some degree (mainly due to presence of the neophytic species *Aster lanceolata* and *novi-belgii* agg.), the malacocoenoses show a structure typical for this type of floodplain forest. The strongly dominant species are autochtonous polyhygrophilous *Zonitoides nitidus*, *Carychium minimum*, *Pseudotrichia rubiginosa*, *Succinea putris* and *Oxyloma elegans*, which often reach the cumulative dominance of 90-95%.

In the downstream stretch not affected by the Gabčíkovo project (Sap - Čičov), the remnants of floodplain forests in the within-dike zone are flooded and sufficiently supplied with seeping ground water. The malacocoenoses are structurally most similar to the original communities of the most humid types of floodplain forests. It is indicated by the predominance of the polyhygrophilous molluscs well adapted to the conditions of cyclical climax. In particular the polyhygrophilous species *Carychium minimum*, *Zonitoides nitidus*, *Succinea putris*, *Oxyloma elegans*, and the forest hygricolous species *Vitrea crystallina*, belong to the typical dominants of the forest malacocoenoses (a typical example is the monitoring plot Čičov - Starý les).

Development of occurrence of **Oniscidae** is documented first of all by the strongly changing dominance proportion of the eurytopic species *Trachelipus rathkei*, which is tolerant to reduced soil moisture, mesohygrophilous species *Hyloniscus riparius* and hygrophilous species *Porcellio scaber* along the moisture gradient. In Dunajské Kriviny, among 7 species recorded during the monitoring (1993-1997), the eudominant species were *T. rathkei* and *H. riparius*, which was mosaic-like distributed in obviously humid places. The species composition of the taxocoenosis itself, however, did not change essentially after the Danube damming.

In Bodícka Brána, 7 Oniscidae species were recorded. Their abundance fluctuated in individual years. *T. rathkei* was eudominant during all years, but in 1997 a sudden decrease of dominance of hygrophilous *P. scaber* was observed. It indicates a shift of the monitoring plot to the drier habitats. This process was doubtless accelerated by clear-cutting of the stand in the immediate vicinity of the place, where the arthropods were sampled in regular intervals.

In Kráľovská Lúka only *H. riparius* and eudominant *T. rathkei* were recorded in the first year of the monitoring. In the next years the species number increased. Dominance of the stenotopic hygrophilous species *Porcellium collicola* increased to 46% in 1997, but dominance of *T. rathkei* suddenly dropped from 98% in 1993 to 13% in 1997. These changes indicate an end of the drying of this locality.

In Istragov in 1993-1996, the taxocoenosis, poor in species number and characterised by predominance of *T. rathkei*, indicated a slow process of drying out. In 1997 the hygrophilous *Porcellium collicola* appeared and showed a high dominance. This change might indicate an increased humidity as a consequence of simulated floods.

In the **Chilopoda** taxocoenosis, the changes caused by the Danube damming were reflected as in qualitative as in quantitative structure. Number of occurring species changed. Except of the xenocenous species, *Clinopodes flavidus*, and *Lithobius microps* disappeared here, whereas the little hygrophilous species *Lithobius lapidicola* and *L. calcaratus* were recorded as new species. Dominance of eurytopic *Lithobius forficatus* increased, probably as a consequence of immigration and subsidence of conditions typical of floodplain forest. Dominance of *Lithobius curtipes*, a mesohygrophilous species characteristic of the Danube floodplain forests, decreased.

In Dunajské Kriviny, in the first year after diverting the Danube, the number of occurring species strongly decreased to the lowest value recorded during the whole monitoring period, and dominance of the eurytopic *L. forficatus* (tolerant to strong fluctuation of soil humidity) suddenly increased from 21% to 49%. A high dominance of this species was maintained also in following years. On the contrary, dominance of mesohygrophilous *L. curtipes* (a species characteristic of the Danube floodplain forests) decreased from 18% to 14% in 1993 and to 3-4% in the following years. *Clinopodes flavidus*, *L. microps*, *L. lucifugus* and *L. cyrtopus* (two former species are xenocoenous for this area) have not been recorded since the Danube damming. On the contrary, after the damming, *Lithobius lapidicola*, *L. pusillus* and *L. calcaratus* belonging to species with limited demands for soil moisture were recorded. In 1995, the number of occurring species increased to 11 and dominance of eurytopic *L. forficatus* decreased to 27%. The simulated summer flood may cause it. Variation of the between-year similarity of Chilopoda taxocoenosis (50-60%) in the period 1993-1997 indicates unstable life conditions in this locality.

In Bodícka Brána, shortly after the Danube damming, number of Chilopoda species decreased to 7, but in the following years it increased to the original level. Eurytopic *L. forficatus* was dominant during the whole period. Dominance of the characteristic species *L. crassipes* and *L. curtipes* fluctuated and *L. crassipes* was not recorded in some years at all. After the damming, dominance of the hypogeic species *Pachymerium ferrugineum* increased to 20-30%. These changes in the Chilopoda taxocoenosis indicate a shift toward habitats with a drier soil surface. This was also confirmed by measuring soil moisture.

In Kráľovská Lúka the Chilopoda taxocoenosis belonged to the richest communities in pre-dam conditions. In the period of 1991-1997, 17 species were recorded here. After the damming this number decreased to 13, among which the ripicolous and hygrophilous species *Lamyctes emarginatus* characteristic of this habitat type, and the hygrophilous species *L. agilis* and *L. microps* were represented. The eudominant species was *L. emarginatus* and dominant were *L. aeruginosus* and *L. curtipes*. After 1993 the polyhygrophilous species *L. agilis* and the forests species *L. cyrtopus* characteristic of higher altitudes were no more recorded. The former species is however xenocenous in floodplain forests and it got here probably during floods. After 1993 *L. micropus* was also absent in the Chilopoda taxocoenosis. The hypogeic species *Geophilus flavus, P. ferrugineum* and *Strigamia acuminata* recorded before the damming disappeared and reappeared as late as in 1997 (probably in consequence of simulated floods). Changes in the Chilopoda taxocoenoses continued also in 1997, when *Lithobius pelidnus* and *Pachymerium tristanicum* were recorded here for the first time. Changes in the species composition of this taxocoenoses indicate unstable conditions in this locality. The eurytopic species *L. forficatus* and mesohygrophilous *L. aeruginosus, L. crassipes* and *L. curtipes* maintained their eudominant to dominant position. Dominance of the ripicolous species *L. emarginatus* decreased in 1993-1995; it increased in 1996 and in 1997 this species was absent. Fluctuation of dominance of this species reflected drying off of the shore zone of the dead arm situated close to the dike. Unstable conditions were reflected, in the full extent, by the Chilopoda taxocoenosis. The lowest similarity of the samples was recorded between the years 1992 and 1993.

In the Chilopoda taxocoenosis in Istragov 15 species were recorded in 1991-1997, among which the eurytopic species *L. forficatus* and *L. mutabilis* were eudominant. The typical mesohygrophilous species *L. aeruginosus, L. crassipes* and *L. curtipes* and the hypogeic species *P. ferrugineum* were represented by a high percentage of individuals. In pre-dam conditions the hygrophilous *L. agilis* was also recorded in 1991 and 1992. Absence of this species in 1993, and increased dominance of the humidity-tolerant species *L. forficatus*, signaled drying of this monitoring plot. The eurytopic species *L. forficatus* and the mesohygrophilous species *L. curtipes* and *L. crassipes* maintained their dominance during the whole monitored period. Increase in dominance of the hypogeic species *P. ferrugineum* (prefers sandy, but not moist or marshy habitats) from 10% to 31% in 1996 also indicated a shift of this locality toward the drier habitats. The most significant differences in the similarity of the one-year samples (33%, 41%) exist between two pre-dam years and the year 1997. They also confirm a slow shifting of this site to the drier habitat types.

Among the **bugs (Heteroptera),** the most significant bio-indicators of habitat state and changes are the species living in litter and soil upper strata. They react sensitively on the changes of floodplain forest character, in particular to humidity, interventions into forests communities, their destruction, clear-cutting and subsequent aridisation and ruderalisation. In the monitoring plots studied, 85 species showed the average abundance (AA) of 6.23 ex.m^{-2} (ŠTEPANOVIČOVÁ & DEGMA 1999). Epigeic heteropteran taxocoenose are characterised by a high degree of heterogeneity indicated by a low number (10) of constant or euconstant species. All other species are accesesoric or accidental elements in these taxocoenoses. The larges number of these species occurred, of course, in the driest variety of the floodplain forests, where many species immigrated for hibernation from near xerothermophilous community of the Crataegetum danubiale. As to the qualitative structure, most similar to these two communities is the bug taxocoenosis in Dunajské Kriviny (AA= 9.33 ex.m^{-2}), where the highest numbers of species occurred, particularly after 1995, as a consequence of ruderalisation. The quantitative representation of bugs in this locality was most similar to that in Bodícka Brána (10.63 ex.m^{-2}). At the same time these two localities showed the highest average abundance of bugs during the whole monitored period. However, only 17 species of all recorded species can be taken as characteristic for the floodplain epigeion (coenobiont and coenophilous species). For indication of changes, only those hygrophilous and mesohygropholious species (*Drymus brunneus, Drymus ryeii, Scolopostethus affinis, Scolopostethus thomsoni* and *Legnotus limbosus*) were used, whose quantitative parameters (AA, dominance, constancy) were bio-indicatively significant. Assessment of changes in taxocoenoses, caused by habitat changes occurring during the construction of the Gabčíkovo project, is based on ecological demands of the recorded species and their relationship to the habitat conditions. Bio-indicative abilities of the characteristic species were manifested particularly in the by-passed area, where their relative representation reached 74.88%. The highest values of dominance of these species were recorded in 1996 and 1997, when the condition in the floodplain forest epigeion had stabilised and the bug taxocoenoses reached a similar state as in 1991.

A strong decrease of dominance of characteristic species was recorded in Dobrohošť in 1993-1995. In that period the negative impact of clear-cutting of a part of floodplain forest and its gradual drying off was visible. In consequence of continuing aridisation and ruderalisation of the floodplain forests, the forest communities began to be penetrated by the euryecious, less hygrophilous bug species from the surrounding biotopes. Their number increased to 15 in 1995 and, at the same time dominance of the characteristic species decreased.

The strong qualitative and quantitative structural differences between the heteropteran taxocoenoses in the monitoring plots Bodícka Brána, Kráľovská Lúka and Istragov were manifested by low values of average abundance (Kráľovská Lúka for the whole period 1.97 ex.m^{-2}, Istragov 3.09 ex.m^{-2}), which were several times lower than in two preceding plots. The 7-year investigation has shown that litter humidity in soil depression exceeded tolerance limits, even of the hygrophilous terrestrial bugs, which occurred here for this reason in a small number of individuals.

The data on occurrence of the characteristic dominant species *D. brunneus* and *L. limbosus*, which shows a good indicative ability and sufficiently large differences in their quantitative representation, appears to be suitable for assessment of differences in humidity of litter in floodplain forests. The different ecological characteristics of both species (*D. brunneus* is a hygrophilous species and a typical inhabitant of litter of floodplain forests; *L. limbosus* is mesophilous) allows, on the base of their occurrence and population density, to characterise permanent and temporary changes in humidity conditions of their biotopes. Maximum abundance of *D. brunneus* in Dobrohošť was 10.50 ex.m^{-2} in 1992 and in Bodícka Brána 7.54 ex.m^{-2} in 1991; i.e., in the pre-dam conditions. The sudden decrease of its abundance in 1993 and several subsequent years was followed by an increase caused by the simulated floods in the later years. *L. limbosus* occurred regularly only in the driest variety of the floodplain forest, in the area outside of the inundation area (Kopáč, Ostrovné Lúčky) and it reached maximum values of its abundance in these localities in 1995. In other monitoring plots, *L. limbosus* occurred sporadically, irregularly, and its low to substandard abundance or even absence are unable to indicate humidity conditions in floodplain forests, particularly decrease of humidity and a visible drying.

Thee differences in values of average abundance of *D. brunneus* and *L. limbosus* are obvious, even after their pooling, according to the three groups of forest communities. In the driest variety of floodplain forests the average abundance of *D. brunneus* was only 0.13 ex.m^{-2} and that of *L. limbosus* 2.60 ex.m^{-2}. In localities in the by-passed area, the average abundance of *D. brunneus* was 2.50 ex.m^{-2}, and that of *L. limbosus* only 0.31 ex.m^{-2}. In the localities downstream of the tailrace canal mouthing into the Danube, the average abundance of *D. brunneus* was 1.72 ex.m^{-2} and that of *L. limbosus* 0.41 ex.m^{-2}. The differences in population density of the above species well indicate floodplain forests and the litter microhabitat with the lowest, highest, and average degree of humidity.

In order to illustrate accurately the impact of the influence of some factors on formation of the bug (Heteroptera) taxocoenosis in the epigeion of floodplain forests, the canonical correspondence analysis was used. It showed (ŠTEPANOVIČOVÁ & DEGMA 1999) that among 9 tested factors only 4 gradient variables have a significance for forming the taxocoenoses of the epigeic bugs, viz., soil and litter humidity, soil pH, content of $CaCo_3$ and average air temperature. The main factor, influencing occurrence of bugs in the floodplain forest epigeion, is a suitable degree of humidity. The closest affinity to this factor exists in the characteristic species *D. brunneus*, *S. affinis*, *S. thomsoni* and three further hygrophilous species, viz. *S. pilosus*, *Holcocranum saturejae* and *Eurygaster testudinarius*.

It has been shown that a sufficient degree of litter humidity, which is the determining factor for existence of the characteristic bug species, also persisted in the last years of monitoring of bugs (1996 and 1997). The 7-year monitoring has also shown that in contrast to the positively acting sufficient litter humidity influenced by the ground water level, the stagnant water, which has the highest level during the floods, causes shorter or larger lasting decrease not only in the qualitative, but also in the quantitative representation of bugs. This is reflected by lower abundance of characteristic species and decrease of species diversity of taxocoenoses of epigeic bugs.

For definition of optimal conditions for existence of populations of autochtonous epigeic bugs in litter and soil surface strata in the Danube floodplain forests, the above data on the qualitative and quantitative structure of their taxocoenoses can be used. They unambiguously show that the deciding factor is soil humidity influenced by ground water level. One evidence of persistence of an optimal state for bugs in the flood plain forests is above all a high density of populations of the characteristic hygrophilous species, whose dominance reached 68% in the entire arc in question and in the by-passed area, where the humidity is more favourable, even 74,88%.

Number of species in the natural or quasi-natural taxocoenoses of **ground beetles (Coleoptera, Carabidae)** in Central European floodplain forests ranges mostly from 22 to 35, exceptionally reaches even 50 species. Number of species lower than 15 can be taken as an attribute of considerably degraded communities (of course if the low number of species dos not result from a sampling error).

In general, the natural Carabidae communities in the ecosystems of the most humid parts of the Danube inland delta existing in conditions of cyclical climate are characterised by cumulative abundance of 80-130 ind./trap/year (the jars with opening diameter of 75 mm served as pitfall traps). Abundance lower than these values (if not caused by a long-termed flooding) can be interpreted as a result of degradation. The lowest limit values (established in other types of ecosystems) characteristic of the extremely degraded taxocoenoses range from 5 to 15 ind./trap/year. Abundance exceeding 130 ind./trap/year has a different interpretation in the cyclic climax flood-plain forests. If they occur unrepeatable and are caused by a sudden increase of abundance of *Pterostichus melanarius* and/or *P. niger*, they can be taken as a mark of temporarily decreased humidity in a site. In contrast, a sudden increase of abundance of *P. niger* accompanies the initial succession stages on the long-termed flooded plots. If the increase in the cumulative abundance results from increased abundance of some of hygrophilous species like *Agonum moestum, Pterostichus anthracinus, P. nigrita, Bembidion männerheimi, B. biguttatum*, it indicates that the ecosystem losses character of the cyclic climax and that the local conditions approximated floodplain forests flooded by stagnant water. In such cases, the cumulative abundance of Carabids ranges between 200-300 ind./trap/year, exceptionally even 400-500 ind./trap/year.

For the bio-indication of changes in the floodplain forests ecosystems, the most significant criterion is change in the representation of ecological groups species; in particular, the changing proportion of representation of species showing different preferences for humidity. In Carabids, the accurate values of hygropreferendum of individual species are not known. However, based on comparisons and field observations, the Central European Carabidae species can be classified into eight groups. Their representation allows quantifying the running changes and can serve for the direct ordination of communities. The second significant criterion is the proportion of species requiring permanent shadowing by tree vegetation, species indifferent to shadowing, and species requiring the non-forest ecosystems. An idealised natural Carabidae taxocoenosis of floodplain forests in conditions of cyclic climax should be characterised by a high proportion of polyhygrophilous species and by absence or low representation of the hygrophilous species like *P. anthracinus, P. nigrita, B. mannerheimi* and *B. biguttatum.*

In Dunajské Kriviny, occurrence of the hygrophilous Carabids strongly dropped in 1993 after the Danube damming. Some species disappeared after 1993, but representation of some more tolerant species, in particular *Carabus granulatus* (1993: 21,59%) and *Pterostichus niger* (1993: 25,52%) increased. Their increased occurrence lasted until 1995, when their abundance decreased again and, in 1997, these species were not recorded. In 1994, invasion of the xenocoenose species *Pseudophonus rufipes* started and culminated in 1995 (17,12% of individuals). This invasion was accompanied with occasional occurrence of several xerophilous species, particularly *Licinus depressus* and representatives of the *Amara* genus. During the whole monitoring, only the tolerant and little hygrophilous species, *Stomis pumicatus* showed a relatively stable occurrence (dominance of about 10%). The course of changes on Carabidae taxocoenosis from the starting point in 1989 to the state of 1997 is characterised by a continuous decrease in values of similarity of the one-year samples from 1990-1997 with the sample from 1989 (from 43-62% to 16-30%). In the whole by-passed stretch, this taxocoenosis was most affected by the post-dam changes.

In 1993 in Bodícka Brána, the abundance and dominance of the more tolerant species, *C. granulatus* (11,11%), *Pterostichus melanarius* (25,90%), *P. niger* (24,26%) a *Stomis pumicatus* (3,89%), suddenly increased. At the same time, representation of all more hygrophilous species decreased. Abundance of all species decreased in 1994-1996. This was reflected by a decrease of the cumulative abundance of Carabids to 1/3-1/2 of values observed in 1993. The most affected were the most hygrophilous species, especially *Platinus assimilis, Clivina fossor, B. dentelum* and *B. sodalis.* Only populations of some less hygrophilous or more tolerant species like *P. strenuus, A. flavipes* and *O. obscurus* remained unaffected. Their abundance, in contrast, moderately increased in individual years. In this species, however, a significant role was also plaid by their small body size. Changes of abundance of some species, that is to say, reflect not only the changes of hydrological regimen, but also changes in food supply. The worst state of the community was observed in 1995. Since 1993, invasion of the euryecious and xenocoenous species *Trechus quadristriatus* started, which can be taken as a significant degradative change. Proportion of representation of individual species in 1997 indicates that a moderate improvement of humidity conditions in this locality happened. This trend is, however, very moderate.

In Kráľovslá Lúka, representation of more tolerant or less hygrophilous species, *C. granulatus* (35,6 a 22,5%), *P. melanarius* (6,5 and 14,2%), *P. niger* (13,5 and 22,3%), increased in 1992 and this trend continued in 1993. The less hygrophilous *Epaphius secalis*, as a new species for this locality, was found in a considerable number. After a decrease in 1991, again increased the abundance of two less tolerant hygrophilous species, *Platynus assimile* and *Patrobus atrorufus*, whose dominance, however, decreased. After restarting of monitoring broken off in 1994 and 1995, a considerable decrease of the number of individuals occurred (from 1648 in 1993 to 636 in 1996, and to 396 in 1997). In 1996 and 1997 in the taxocoenosis only three tolerant species dominated *P. strenuus* (30,1%, resp. 36,36%), *C. granulatus* (16,82%, resp. 19,19%), and *O. obscurus* (3.4% resp. 10,1%). Although representation of several hygrophilous species was low, or such species disappeared, the increased abundance and dominance of these three species contributed to an increase of similarity for the whole-year samples of 1996 and 1997 with the pre-dam sample for 1987. In 1996, an invasion of the xenocoenous *T. quadristriatus* was recorded, but this species retreated partly in 1997. Values of species similarity index of individual one-year samples with the sample from 1987 showed a stable trend. In contrast, values of the proportional similarity index and abundance similarity index strongly dropped in 1989, 1992, and 1993, as a consequence of the described changes. Within this locality, depending on local differences in humidity and small altitudinal differences (in the range of 50-60 cm) the spatial distribution of species strongly varied (ŠUSTEK 1995). After drying of the locality and retreat of polyhygrophilous species, the more tolerant species took their place in depressions, whereas the elevated places were considerably less populated.

In Istragov (the downstream-most situated monitoring plot in the by-passed zone) two small hygrophilous species, *Asaphidion flavipes* (47,7%) and *Bembidion femoratum* (15,36%), strongly predominated in 1989. Other hygrophilous species, *P. assimile* (15,5%), *P. strenuus* (5,7%), *C. granulatus* (3,6%), *P. atrorufus* (2,4%), showed a considerable dominance. From the ecological aspect, presence of polyhygrophilous species, *Europhilus fuliginosus* and *E. micans,* was important. A high dominance of moderately hygrophilous species before substantial changes of the hydrological regimen reflected the presence of sandy soil on the major part of this monitoring plot. In 1990-1992, the cumulative abundance of Carabids decreased to one half. This decrease was caused mainly by the sudden drop of abundance of *A. flavipes* and *B. femoratum,* but abundance of most other species also decreased to 2/3 - 1/2 of the previous state. Already in 1991, the abundance of *P. niger* suddenly increased. Similarly, a sudden increase of abundance of *P. niger* was observed on other monitoring plots two years later. During 1990-1992, a temporarily stabilised state arose, but it lasted only till 1993, when abundance of several moderately hygrophilous species strongly increased (*C. granulatus* from 58 individuals in 1992 to 320 individuals in 1993, *P. atrorufus* from 11 to 211 individuals, and *P. strenuus* from 24 to 222 individuals). In consequence, the cumulative abundance of Carabids increased more then twice, but in 1995 it dropped approximately to the level of 1992. Simultaneously the abundance of *Asaphidion flavipes* again strongly increased, while representation of most other species decreased, except for the moderately hygrophilous and tolerant *E. secalis.* In 1996-1997, the mutual proportion of all species returned to the pre-dam state recorded in 1990-1991, but the cumulative abundance of Carabids was lower and continued to decrease. The flood of 1997 (caused by backwaters in the old river bad) again made the possible occurrence of some polyhygrophilous paludicolous species, like *Agonum moestum, Badister sodalis* and *E micans*).

Ornithocoenoses were originally characterised by a high diversity and density of species. The breeding ortnithocoenosis of the Danube floodplain forests in the pre-dam period consisted of 104 species, among which several significant breeders were represented (*Milvus migrans, Aythya nyroca, Ixobrychus minutus, Ciconia nigra, Pernis apivorus, Alcedo atthis, Dendrocopos medius*). Changes caused in the ortnithocoenosis of the Danube floodplain forests and in the whole Danube inland delta by the Gabčíkovo project were connected with extinction of a part of the arm system and, consequently by rise of a new biotope represented by the Čunovo Reservoir, as well as by adaptation of the persisting ecosystems on the new hydrological regime in the stretch between Dobrohošť and Sap. Processes, which are running in the ortnithocoenosis of the Danube floodplain forests, are essentially influenced by silviculture and technology of felling.

Creation of the Čunovo Reservoir caused destruction and flooding of a complex of Danube floodplain forests, islands and arms at Bratislava, Podunajské Biskupice, Hamuliakovo, Šamorín and Čilistov. The breeding ortnithocoenosis of that area before its deforestation consisted of 77 bird species. Among the more significant species, the black kite (*Milvus migrans*), hobby (*Falco subbuteo*), middle-spotted woodpecker (*Dendrocopos medius*), and barred warbler (*Sylvia nisoria*) are to be mentioned. Construction of the Gabčíkovo power station and tailrace canal caused extinction of the Danube dead arms, whose significance, from the zoological aspect, exceeded the regional scale. The breeding ortnithocoenosis before extinction of these localities consisted of 20 bird species. Some of them represented in Slovak conditions, from the viewpoint of genofond protection, species of all-Slovakian importance, e.g., little crake (*Porzana parva*) and ferruginous duck (*Aythya nyroca*).

After the Danube damming in October 1992, filling of the Čunovo Reservoir situated on the place of the former floodplain forests a new biotope arose – a water table of the surface of 38 km^2. Already during the first years of existence of this new biotope, the reservoir appeared as a locality significant for migration and wintering of waterfowls. The migrating birds are attracted to a longer rest and greater concentration on the extensive water table. During the migration, flocks of cormorants, geese, ducks, divers, grebes, gulls and waders concentrate on the reservoir. Because the water table usually does not freeze during winter, many species of waterfowl hibernate there. For breeding of birds, an artificial island (of 5.5 ha) was built up in the centre of the reservoir, which is inhabited by colonies of black-headed gull (*Larus ridibundus*) and common tern (*Sterna hirundo*). Other expansive species include the tufted duck (*Aythya fuligula*), red-crested pochard (*Netta rufina*), yellow-legged gull (*Larus cachinnans*), and mediterranean gull (*Larus melanocephalus*). A similar process also runs in other localities in Slovakia (for example, the Sĺňava Reservoir near Piešťany).

After putting the Gabčíkovo project into operation, a redistribution of wetland biotopes important for birds started. Some localities (for example Istragov Island near Gabčíkovo) dried out, but in place of the cut-of dead arms, new wetlands arose (for example the Forrás marsh near Bodíky).

After putting the Gabčíkovo project in operation, two bird species ceased occurring as breeders in the arms system – sand martin (*Riparia riparia*) and common sandpipper (*Actitis hypoleucos*). Sand martin nested there in the banks of river arms. After putting the project into operation, the lateral erosion, even in its moderate forms. was stopped. The banks have been grown and became unsuitable for nesting of sand martin. Similarly the nesting biotopes of common sandpipper, which nested on the gravel-sandy banks, have grown and also became unsuitable for its nesting.

The Istragov locality fulfilled an important role as a hunting territory for herons (first of all for great white heron (*Egretta alba*), grey heron (*Ardea cinerea*), and black stork (*Ciconia nigra*)) at the time during chicks fledging and before migration. At low water level the birds used the extensive terrain depression with stagnant shallow water for easy hunting of food. This phenomenon also occurred in other parts of the arms system, but in Istragov it occurred most frequently. In August and September, often 200 herons and some tens (70-80) of black stork hunted there at the same time. After the change of water regimen this phenomenon disappeared in this stretch of the Danube. The Forrás marsh serves, at present, for birds nesting in littoral vegetation, especially reeds (BOHUŠ 1999).

In spite of the changes that have been observed in the ortnithocoenosis, the whole area of the Danube arm system with floodplain forest and a mosaic of marshy biotopes, represents, from the ornithological viewpoint. even at present, an area exceeding the regional significance. It is desirable to begin its re-naturalization.

The species composition of the **mammal fauna (Mammalia)** did not change essentially after construction of the Gabčíkovo project, but changes in its structure appeared. Taxocoenosis of small terrestrial mammals consists of *Sorex araneus, Apodemus flavicollis, Clethrionomys glareolus, Sorex minutus, Crocidura leucodon, Crocidura suaveolens, Microtus arvalis, Microtus oeconomus, Pitymys subterraneus, Apodemus sylvaticus, and Micromys minutus*. The anthropogenous factors support spreading of *Microtus arvalis* and *M. musculus*, which are unoriginal there.

The basis of small mammal taxocoenosis consists of four species, *Apodemus flavicollis, Sorex araneus, Clethrionomys glareolus,* and *Apodemus sylvaticus*, among which the tree first universally forest species strongly predominate. The flood or their absence has a determining influence on the dominance structure of this synusy dominance structure changes particularly along the humidity gradients. The most flood-resistant species is *A. flavicollis*, but populations of *S. araneus* and *C. glareolus* also quickly regenerate after floods. In the absence of floods, *C. glareolus* becomes the absolutely dominant species whereas dominance of *S. araneus* and to certain degree also of *A. flavicollis* declines. Decreased ground water level results in reduced trophicity of biotopes and, as a consequence, in reduced cumulative abundance and biomass of small mammals.

It is obvious that mammalian taxocoenoses in the within-dike zone survive the long-termed stress manifested by a long-termed autodominance of the single species *C. glareolus*. Ten years after the Danube damming, the population of *C. glareolus* considerably increased to the detriment of *A. flavicollis*, which together with *S. araneus* and *C. glareolus* represented 80-90% of biomass of micromamalia. In the pre-dam conditions, the floods reduced the population of C. glareolus, because its ability to save from floods by ascending wooden plants is much smaller than in *A. flavicollis*, which predominated there in the past. This state is also undesirable for the reason that *C. glareolus* is a serious competitor for the space and food resources for the relict and endangered species *Microtus oeconomus*, whose population size decreased so critically after putting the Gabčíkovo project in operation that its survival in Slovakia is put into question. *A. flavocollis* was not such a serious competitor for *M. oeconomus*, because it eats mainly various seeds. From this reason, in the past *M. oeconomus* occurred, although not abundantly, in all suitable habitats in the entire within-dike zone and its population very quickly regenerated after the floods.

In the situation, where floods elevating the water level by 30-40 cm for a short time are simulated in an improper time (and do not fulfil other functions, especially input of nutrients), they can damage the most valuable and sensible elements of the small mammal fauna for which it would be more desirable to maintain a stable water table during the whole year. Flooding does not have a negative impact on small mammals in autumn (but at that time the floods are untypical) when they cannot damage the nests of the relict and critically endangered *M. oeconomus* with litter. Its abundance strongly decreases in the localities in the within-dike zone and, at present, *M. oeconomus* no longer occurs in most localities. The primary cause of this was the drying of the whole arms system in winter 1992-1993, when even the last bodies of stagnant water froze to bottom. Similarly, the porous sandy soil with the not deeply constructed nests of *M. oeconomus* also froze. In these places, *M. oeconomus* never could construct deep holes because of a high level of ground water, which however helped to maintain the soil temperature above the ice point. Due to frost and low ground water level, the nests of small mammals, particularly of *M. oeconomus*, on the margins of surface waters and their inhabitants froze. The competitors, *Apodemus flavicollis*, but mainly *Clethrionomys glareolus* were not affected in this way, because the major part of their populations had nests in drier and higher situated places and successfully hibernated. In the next growing season, *C. glareolus*, having successfully hibernated and having born a new generation began to spread into the places originally inhabited by *M. oeconomus*, where it forced out the last hibernated individuals. Later, no more floods came, which helped to reduce the population of *C. glareolus*. The third factor contributing to reduction of the already decimated populations of *M. oeconomus* was simulating of floods in the spring. Increase of the water table in the arms affected only the species reproducing in vicinity of the water bodies, especially *M. oeconomus*.

Another change in the present-day within-dike zone is absence of *S. araneus*, the third most abundant species of floodplain forests.

The arm system represents in its present state an ideal habitat for **beavers**. The Čunovo Reservoir is, however an invincible barrier for beavers. Therefore the beavers cannot colonise the ideal biotopes in the arm system, though the population in Borská nížina lowland increases every year. In 2002, only 3-4 territories inhabited by beaver were recorded in the arm system, a reproducing pair inhabited one of them. We presuppose that these beavers immigrated there through Little Carpathians and then downwards along brooks and further via Dudváh, Čierna Voda and Vážsky Dunaj rivers, and finally, in the upstream direction, penetrated the arm system (two another beaver territories were also recorded at the Malý Danube).

It can be concluded that the most serious changes in the terrestrial fauna were recorded in the monitoring plot Dunajské Kriviny near Dobrohošť, situated close to the beginning of the by-pass canal. Draining effect, loss of the original hydrological regime and absence of floods caused profound changes in its ecosystem. The water level in the upstream-most part of the water supply canal, supplying floodplain, is too low and insufficient for the correct function of the watering and flooding of this monitoring plot. The last flood in pre-dam conditions, which influenced a major part of this monitoring plot, was in 1991. The first flood after damming the Danube was in 2002. The underwater weir in the old Danube riverbed at Dunakiliti, which could improve this situation, was finally constructed 2 km upstream, at Dunakiliti. Originally, a typical Ulmeto-Fraxinetum Populetum association covered this monitoring plot. The upper layers of soil profile consisted of thick layers of deposited sands. Soil moisture ranged from 15%-25%. After 1992, the draining effect of the old Danube caused a loss of surface waters, a decrease of ground water level, and a decrease in soil moisture to 0-20%. Since 1992, the ground water level has stabilized, with minimal fluctuations at a depth of 4,2 m (2.5-3.3 m in 1992). Conditions for a hardwood forests arose. In general, the proportion of hygrophilous and typical species decreased. On the contrary, the xenocoenous invaded this locality. A moderate increase in soil moisture after simulated flooding positively influenced the communities of edaphic animals (Acari, Onisceidea, Chilopoda) and, to limited degree, of taxocoenoses of epigeic organisms (Coleoptera, Heteroptera). The small terrestrial mammals also indicated an improvement of soil moisture. The existing data do not allow saying whether the moderated aridisation observed in the last years of the monitoring represents a permanent trend or a climatically caused fluctuation swing. At present the terrestrial communities in this monitoring plot belong to the most degraded in the whole area monitored. The adaptive process towards a hard-wood floodplain forest move forward only slowly.

The monitoring plot Bodícka Brána situated in the downstream part of the by-passed area represents an elm-ash stand with admixed poplars and willows, with a higher soil moisture (25-35%) and ground water level at the depth of 2 –2.5 m. Clear-cutting of a part of the poplar cultivars stand caused an undesirable opening of this stand. This resulted in changes in composition of the herbage and shrub layer and, subsequently, in communities of terrestrial animals (penetration of the open-landscape species, decrease of occurrence of hygrophilous species and increase of mesohygrophilous and euryecious species). Many of the hygrophilous species (Coleoptera, Mollusca) occur close to the threshold of their observation possibility. Decrease of occurrence of a part of species stopped or even reverted in the last year of the monitoring and abundance of some hygrophilous species (Coleoptera, Lepidoptera, Oniscidea, Chilopoda) increased again. The euryvalent and moderately hygrophilous species of butterflies (Lepidoptera) maintain their high dominance. In spite of the observed changes, the state of the communities can be still taken as reversible (re-increase of abundance of some hygrophilous species). It seems that during the last two years of the monitoring the structure of the communities returned into the state, that arose immediately after diversion of the Danube. Durability of this trend is, however, hardly predictable and it depends on interaction of soil moisture, timber exploitation and fluctuation of climatic factors.

The monitoring plot Bodíly – Kráľovská Lúka has, in the by-passed zone, the largest distance from the flowing arms. It was regularly flooded each year (sometimes even twice a year) and until 1992 it fully depended an the floodwater. Until 1997, decrease of the ground water level and drying of the marshy shore zone were observed in dry years. The plesiopotamal in the core of this plot separates the obviously drier habitat situated closer to the dike and grown by a poplar monoculture from a humid softwood floodplain forest (*Salici-Populetum*). Changes in species composition signalise instability of conditions. However, the general trend of decreasing species diversity (Oniscidea, Coleoptera) and the increase of dominance of mesohygrophilous, tolerant and xenocoenous species (Mollusca, Coleoptera) continues in spite of the fact that this trend slackened or even stopped in some taxocoenoses (Chilopoda, Lepidoptera). It signals slackening or even stopping of the negative succession trends in general. It is, however, obvious that this slowing down is a consequence of two more humid growing seasons in the last years. In addition, a long-term flood occurred in the growing season of 1997. In general, the succession of taxocoenoses runs in the direction toward the communities being characteristic of drier types of softwood floodplain forests. Within the framework of locality, the spatial distribution of species strongly changed depending on moderate variations of surface altitude (about 50-60 cm). After the drying and retreat of the polyhygrophilous species, the more tolerant species replaced them in the depressions, while the more elevated places became less inhabited. The changes in the ortnithocoenosis do not result only from operation of the Gabčíkovo project, but they were also caused by another significant factor – the system of silviculture.

The locality Istragov, situated in the downstream-most part of the by-passed area, belonged until 1992 to strongly hygric biotopes of the softwood floodplain forests (*Salici-Populetum myosotidetosum* JURKO, 1958) with more patches grown by alders. Close to the old Danube, the poplar monocultures were situated. These were gradually clear-cut during the time of monitoring. A layer of alluvial sand covered the locality. After the Danube damming and decrease of discharge in the old riverbed, the ground water level sunk, the soil moisture in the surface layer decreased by about 15%, extent of shallow flooded depressions was reduced, and a xeroseries began to develop (LISICKÝ 1995, ŠEVČÍKOVÁ 1997). Even in the lowest places, the secondary succession runs to the drier variety of the flood-plain forests community (*Salici-Populetum typicum*). The large scale cutting of poplars and opening of the stands contributed to drying of the locality. Retreat of the species indicating marshy habitats or polyhygrophilous species (Mollusca, Coleoptera) was recorded in the taxocoenoses of terrestrial animals. They were replaced by moderately hygrophilous forest species. It indicates the drying trend on the locality. These changes were connected with massive felling to clear-cutting of the stand and subsequent changes in other layers of ecosystems. The trend of a strong retreat of polyhygrophilous species and aridisation, however, slowed down in some animal groups (Mollusca, Lepidoptera) in 1996, and the adaptive succession changes (Mollusca, Chilopoda) are slower in comparison with the vegetation. From the representation of individual ecological groups of species the ecosystem in Istragov seems to be less affected among the other monitored localities.

Aquatic fauna, eupotamon (taxocoenoses of the Danube old riverbed)

In the **potamoplankton** of the old Danube, the average proportion of euplanktonic Crustaceans decreased to a certain degree. This is a result of reduced reproduction of planktonic Crustaceans in the arm system and, thus the reduced drifting into the old riverbed. In the first two post-dam years the euplanktonic species more (Cladocera) or less (Copepoda) retreated in the old Danube in the annual averages, whereas the quantitative proportion of tychoplanktonic (benthic and littoral) species remained unchanged or increased (ILLYOVÁ, 1996, VRANOVSKÝ, ILLYOVÁ 1999). Among the Cladocera, these were the species *Alona quadrangularis, A. affinis, A. rectangula, Macrothrix hirsuticornis* and *Chydorus sphaericus;* and among the *Copepoda Nitocra hibernica* and *Eucyclops serrulatus*. Quantitative proportion of pseudoplankton was (similarly as before the Danube damming) larger in the profile at Dunajské Kriviny than in the profile at Gabčíkovo. It is, however, to be noted that in individual samples the quantitative proportion of both compared ecological groups fluctuated and the proportion of the true plankton in the old riverbed depended on their drifting from the arms of the parapotamal or plesiopotamal type situated upstream of the monitored profile (VRANOVSKÝ, ILLYOVÁ 1999).

Influence of the Danube damming was reflected by an intense change in the taxocoenoses of the **micro- and macrozoobenthos** (MATIS, TIRJAKOVÁ 1995 a, b). First of all, the proportion of the terrestrial species (of the genus *Colpoda*) increased. They get into the river by drifting after terrain preparation of the Čunovo Reservoir. The strongly reduced discharge and the lowered water table in the old Danube, and filling of the Čunovo Reservoir with water resulted in forming of taxocoenoses characteristic for waters in which decaying processes, bound with a sudden development of bacteria, are running. It was reflected by increased abundance and diversity of Infusoria and Flagellata. In consequence of these changes, the character of biotopes changed. The flow velocity decreased and some river stretches were isolated and changed into stagnant water bodies in which typical taxocoenoses began to be formed. In the through flowing arms the species diversity and abundance enriches particularly by Flagellata and Infusoria. The stretch upstream of the damming (locality Kopáč) does not change apparently, and the number of species and low abundance characterize the original river conditions. In this first period after creation of the reservoir, some rare species appeared, among which some species (*Stentor multiformis, Balantidioides bivacuolata*) were recorded in Slovakia for the first time. In the old Danube species diversity and abundance of some monitored groups increased, particularly of Mastigophora. It was caused by decrease of the flow velocity and increased sedimentation. The increase in the number of terrestrial species (*Colpoda cucullus, C. inflata, Leptopharynx costatus, Colpoda steinii*) is also striking. It indicates that the river brings a lot of sediments, and its bottom is silted. After the Danube damming, stabilisation of taxocoenoses showing high diversity and abundance started. These taxocoenoses become more similar to those of permanently discharging arms. The species diversity and abundance decrease in the direction from Dobrohošť to Istragov (KRNO et al. 1999) due to changes in the bottom substrate. In the locality Kľúčovec, in pre-dam conditions, the abundance of Infusoria remained on a low level all year. The influence of damming was recorded after the year 1993 when a striking increase of abundance was recorded. A high abundance was also observed in the following years due to more stable riverbed.

Among the **macrozoobenthos**, the representatives of permanent fauna and Chironomidae predominate at the expense of other temporal fauna. Change in hydrological regime caused differentiation of the original bottom into two stretches. In the upstream stretch, to which the profile at Dunajské Kriviny belongs, the decrease of flow velocity caused stabilisation of the originally moveable bottom. The changed abiotic factors allowed the algae to form the rich growths on the stable gravely bottom. In the downstream stretch, at Istragov, where the backwaters reach, or at Sporná Sihoť, where the regular daily fluctuations of the water level occur, the benthic communities changed profoundly. After the changes of the bottom substrate and hydrological regime (strong decrease of discharge and flow velocity), the original benthic community was destroyed. In the first years nearly no zoobenthos occurred on the bottom. Only later a new benthic community started to be formed (KRNO at al., 1999). After the decrease in the water level of the old Danube we observed a mass occurrence of dying benthic macro fauna of the bare riverbanks.

The monitoring of the **permanent fauna** (KOŠEL, 1995b; KRNO at al., 1999) showed that abundance of Gastropoda increased in the upstream stretch (Dunajské Kriviny – Gabčíkovo) (KOŠEL, 1995a). The highest increase was observed in all previously dominant species *Ancylus fluviatilis, Lymnaea ovata* and *Bithynia tentaculata*. The following new species were recorded there: *Nais christinae* (Naididae), *Limnodrilus hoffmeisteri, Potamothrix vejdovskyi* (Tubificidae), *Gammarus roeseli* and *Chaetogammarus tenellus* (Amphipoda). Decrease was observed in *Dendrocoelum lacteum* (Hirundinea) and *Dikerogammarus haemobaphes* (Crustacea). After 1995, the species diversity of the permanent fauna increased. The mollusc *Lithoglyphus naticoides* spread in the Danube. At the same period, a striking shift in the proportion of food gilds from filtrators to scraptors (algophages) was recorded. This indicates a high increase of periphyton in the river and transition of the flow metabolism from heterotrophy to autotrophy. Abundance and biomass of the pontocaspic crustacean species also increased (*Jaera istri, Corophium curvispinum* and *Dikerogammarus villosus*). The Tibificidae family increased among Oligochaeta. The scraptors *Dikerogammarus haemobaphes, Dikerogammarus villosus* and *Corophium curvispinum* (Amphipoda), eaters of fibrous algae (*Jaera istri* - Isopoda) and representatives of the Naididae family living on algal growths became dominant. The fine sediment between the gravel becomes a suitable biotope for the species of the Tubificidae family (*Limnodrilus spp., Potamothrix sp.*) inhabiting the muddy substrates. Due to the increased food supply, abundance and biomass of the above groups increased several times.

In the Danube downstream part at Istragov the species diversity of the **permanent benthic fauna** decreased. Some previously dominant species disappeared and some new species of Oligochaeta, (species of the *Limnodrilus* genus bound to muddy substrate) began to occur and their abundance gradually increased. The stagnophilous species, *Asellus aquaticus* and *Limnomysis benedeni* (Crustacea), appeared as new species. After 1995 previously dominant Cladocerans disappeared and some new representatives of Oligochaeta appeared which did nor occur at all or occurred only in a limited extent, for example the *Limnodrilus* species bound to muddy substrate. Their abundance gradually increased. After the complete change of substrate character and water regime (decreased flow rate and velocity), the original benthic community was destroyed. In the first years after changes the bottom remained without zoobenthos. Only later a new benthic community began to be formed. This was characterised by an absolute predominance of Oligochaeta and species *Limnodrilus claparedeanus* and *Limnodrilus hoffmeisteri*, which are not original in this type of biotope.

In the second half of 1995 a considerable decrease of abundance of the macrozoobenthos permanent fauna was recorded in the Danube stretch Dunajské Kriviny – Gabčíkovo. These changes are connected with construction of the submersible weir in the Danube at Dunakiliti, which caused a strong water turbidity and covering of the bottom with fine sediments. In 1996, fluctuation of water level in the riverbed caused denudation and flooding of the ripal depending on supplying the arms on the Hungarian side with water. Because the flood waves lasted shortly, the benthic fauna in the ripal zone was relatively poor.

Similarly to the regulated downstream of Rhôna (FRUGET, 1991), except from Chironomidae, the species *Baetis fuscatus, Caenis luctuosa* (Ephemeroptera), *Psychomyia pusilla, Hydropsyche modesta* and *Ceraclea dissimilis* (Trichoptera) (**Tab. 5.8**) predominate in the Danube temporary fauna after 1992. Later, for instance in Rhein (TITTIZER et al., 1989), more substantial changes in the macrozoobenthos did not occur in spite of improvement of water quality. Similarly, as in the Danube, it is connected with reduced geomorphologic diversity of the river and its contact with the arm system. This is also reflected in the considerably reduced heterogeneity of hydro systems (FRUGET, 1992), and impairment of functional integrity in linking of the river with the river arm system. Since 1993 the taxocoenoses of Ephemenoptera have been strongly, qualitatively and quantitatively, impoverished in the old Danube, where only two eurytopic species, *Baetis fuscatus* and *Caenis luctuosa* (rarely *C. macrura*), continued to occur. Both these species have replaced the species *Caenis pseudorivulorum* in the old Danube between Dobrohošť and mouthing of the tailrace canal into the Danube at Sap village. The fauna of caddisflies consisted of representatives of two genera - *Hydropsyche* and *Psychomyia* – similarly as in regulated European big rivers Rhôna (BOURNAUD et al., 1990) and Rhein. Proportion of algophages (*Psychomyia*) increased on detriment of filtrators (*Hydropsyche*). At the same time, the species *Hydropsyche contubernalis* and *H. bulgaroromanum* were replaced by the species *H. pellucidula* and *H. modesta* (KRNO et a., 1999). Later the species *Rhyacophila dorsalis* also appeared. The former species are typical of smaller water flows, as the old Danube has become. Stabilization of the bottom and a better trophicity in 1994 and in the first half of 1995 made possible a considerable increase of mayflies and particularly caddisflies.

The Danube damming caused a strong increase in the number of recorded **chironomid** species after 1992 (KRNO et al., 1999). While in 1990-1992 we recorded 6 species, in 1993-1995 their number increased to 18, which was caused by changed hydrologic conditions. In consequence of reduced discharge and decline of flow velocity, the bottom was stabilised to certain degree. It made possible colonisation of several new species, for which the previous extremely lotic conditions were unfavourable. Abundance of originally predominating species *Chironomus* gr. *fluviatilis* moderately decreased, whereas abundance of some originally rare species increased considerably (*Microtendipes* gr. *chloris, Chironomus* gr. *reductus* and *Chironomus* sp.). The species *Cryptochironomus* gr. *defectus* and *Dicrotendipes nervosus* belong to species, which have preserved their original frequency and abundance. Decline of flow velocity in old Danube caused settling of a 0.5 m thick layer of clay-sandy sediments, which were not inhabited by aquatic insects, except for chironomids (*Chironomus* gr. *fluviatilis, Chironomus* gr. *reductus, Cryptochironomus* gr. *defectus, Endochironomus sp., Polypedilum* gr. *nubeculosum*) and the stagnicolous and psamophilous species *Ephemera vulgata* (Ephemeroptera).

While in the pre-dam Danube the temporary fauna formed, in annual average, about 30% of the cumulative abundance of macrozoobenthos, in the old Danube this value decreases under 10% (years 1998-2001), which is an analogy with its natural representation of the Danube arms. In autumn 2001 the simulated flood very positively influenced the caddisfly fauna. The genus *Hydropsyche* represented by *H. incognita* and several other species have reappeared (**Tab. 5.1**).

From the viewpoint of occurrence of **fish** it is important that putting of the Gabčíkovo project in operation caused a considerable reduction of flow rate in the old riverbed, slowing down of the flow velocity, shift of bank line into middle of the old riverbed, shallowing of the littoral, and, at Istragov, covering of riverbed by muddy sediments. In consequence of this the littoral zone does not more offer natural covers to the fish. These changes are reflected in a reduction of the abundance and species diversity of the ichtyocoenosis. The species number decreased from 19 species recorded in 1991-1992 to 7 species in 1993. Lack of cover and covering of the littoral by muddy sediments and the littoral monotony caused that this locality is not searched by the rheophilous species, but the eurytopic species. Among the species, which were not recorded after 1993, 9 species were rheophilous (*L. lota, G. baloni, B. barbus, C. gobio, L. cephalus, L. idus, G. kessleri, G. albipinnatus L. leuciscus, L. idus* and *B. barbatulus*), and 8 eurytopic (*A. alburnus, A. bjoerkna, C. auratus, C. carpio, E. lucius, S. lucioperca* and *P. fluviatilis, P. marmoratus* [ČERNÝ (1999)].

It is to be stressed that the critically endangered species, requiring attention, have disappeared the *Gobio kessleri* and the wild form of *Cyprinus carpio*, endangered *Gymnocephalus baloni* and the species *L. idus* and *L. lota*. Reduction of population size of *Chondrostoma nasus* and *Stizostedion lucioperca* is also a warning.

Parapotamon (communities of the parapotamal type river arms)

After putting the project in operation, the hydrological regime in the floodplain river arms, situated upstream of the port of Gabčíkovo (they belong to system of Vojka, Šuľany, Bodíky and Baka) is considerably different from the regime in the arms situated downstream from the Gabčíkovo port towards village Sap. While the arms upstream became supplied with water from the intake structure near Dobrohošť, the arms downstream are not artificially supplied with water. But the downstream arms are relatively intensively influenced by the backwater from the confluence of the old Danube with the Gabčíkovo tailrace canal. Since putting the water supply into operation, this difference is also reflected in the composition of the planktonic crustaceans. In the upstream arms the true plankton abundance of the planktonic crustaceans retread and the entire zooplankton decreased, while the percentage of tychoplanktonic species increased (among cladocerans mainly *Alona guttata A. rectangula*, *Chydorus sphaericus* and *Disparalona rostrata*, among copepods *Nitocra hibernica*). In 1995 low abundance of euplanctonic crustaceans and mostly also dominance of tychoplanktonic forms continued to persist (VRANOVSKÝ, ILLYOVÁ 1999).

In the Istragovské Rameno arm, not artificially supplied with water, a quantitatively rich crustaceoplankton with a strong representation of euplanktonic species, above all the copepods, survived. Among the euplanktonic cladocerans the dominant species were *Bosmina longirostris* or *Diaphanosoma orghidani*, among copepods mostly *Cyclops vicinus*, *Acanthocyclops robustus* or *Thermocyclops oithonoides*. It was caused by sporadic flow in the arm, which was mostly filled by stagnant water with the water level fluctuation dependent on of the backwater level fluctuation. Increased proportion of the tychoplanktonic forms, in comparison with the past, results, according to our opinion, from the accelerating terrestrialization, shallowing and overgrowing of the arms.

In the arms of the parapotamal-type (former dead arms) between Dobrohošť and Gabčíkovo (river km 1840-1820), the average abundance and biomass of the zooplankton, particularly of the planktonic crustaceans, considerably decreased after the Danube damming. Percentage of euplanktonic crustaceans considerably declined and the tychoplanktonic (littoral and benthic) species became dominant. These changes result from the transformation of the periodically discharged arms, which were favourable for existence of planktonic crustaceans, into the permanently discharged arms, which offer considerably worse conditions for zooplankton, particularly for the planktonic crustaceans. Such a situation also persisted in the arms of the system of Vojka and Šuľany in 1995 and in the next years. Some increase of abundance and biomass of the zooplankton, particularly the planktonic crustaceans, in the downstream part of the former system of Baka indicated light improvement of abiotic condition for the zooplankton in the downstream part of the flowing arms (VRANOVSKÝ, ILLYOVÁ, 1999).

The conditions in the arms of the parapotamal type in the stretch between Gabčíkovo and Sap are similar to the pre-dam state in spite of the fact that they are situated in the by-passed area. Due to it they are more favourable for development of euplanktonic crustaceans. The euplanktonic species mostly continue to predominate over the tychoplanktonic species.

In the upstream part of the Danube arm system (Bodícka Brána) supplying with water from the reservoir created rheophile conditions, which reduced species diversity of the micro- and macrozoobenthos. The communities reacted to the change of the arm character by destabilised structure (KRNO at al., 1999). The communities of the macro- and microzoobenthos in the discharged arms not supplied artificially with water (Istragov) are characterised by the typical inhabitants of sapropel and muddy substrate, which predominates in this locality (KRNO at al., 1999). In the permanent fauna inhabiting gravel-sandy littoral of the upstream part of the arms with flowing water, representation of Oligochaeta considerably decreased in the turn of 1992 and 1993. At that time Tubificid species and *Hypania invalida* (Polychaeta) disappeared. Among the Oligochata, only species of the Naididae family, inhabiting perifyton and showing ability of a quick recolonisation and some amphibiotic species, survived. Recolonisations of other components of the permanent fauna run by means of drift. Recolonisation was relatively quick as indicated by the species diversity, which increased almost twice within two months. Representation of the higher crustaceans (Amphipoda, Mysidacea) was considerably lower. Among the Oligochaeta, the species of the Naididae family predominated in the spring sample, similarly as in the old Danube. In 1995, the dominant were Amphibiotic species, moveable Amphipods and among Oligochaeta the species of the Naididae family with a short live cycle. Later, the Amphipods took the dominant position in the permanent fauna on the gravely substrate. In 1997 the species diversity increased. The Amphipods showed a high abundance in summer and autumn. Also *Jaera istri* (Isopoda) reached a high abundance.

After 1992 the permanent water flow in the arm system of Bodíky, supplied with water, made possible occurrence of the rheophilous species of the temporary fauna (**Tab. 5.1**). The frequent denudation of the littoral zone in the arms, caused by fluctuation of water level, was reflected by changes of inhabiting aquatic fauna (KRNO et al., 1999). Under the new rheophilous conditions the typically stagnicolous mayfly *Caenis horaria* is gradually replaced by *C. luctuosa*. The more regular occurrence of mayflies *Baëtis fuscatus*, *Caenis luctuosa* and caddisflies *Athripsodes cinereus*, *A. albifrons*, *Oecetis furva* and *Anabolia* spp. indicate the permanent water supply of arms, belonging originally to the plesiopotamal type, supplied by the surface and ground water. On the contrary, the stagnicolous taxa like *Caenis simile* (Ephemeroptera) and Cyrnus spp., *Oligotrichia* spp. and *Mystacides azurea* (Trichoptera) retreat. Among the dragonflies, the pioneer species *Anax imperator* and *Libellula quadrimaculata* were recorded in 1993. In the years 1994-1995, both the rheophilous (*Calopteryx splendens*, *Platycnemis pennipes*) and stagnophilous species (*Enallagma cyathigerum*, *Coenagrion puella*) occurred in the locality. Structure of the Chironomid taxocoenosis changed in comparison with the year 1992. The species *Potthastia longimana*, *Paracladius conversus*, *Endochironomus* gr. *signaticornis*, *Endochironomus* sp., *Glyptotendipes* gr., *Polypedilum convictum* and *Micropsectra junci* appeared here. On the contrary we did not record the species *Macropelopia nebulosa*, *Chironomus* gr. *fluviatilis*, *Ch.* gr. *salinarius*, *Dicrotendipes* sp., *Paratendipes intermedius*, *Stictochironomus* sp., *Paratanytarsus* gr. *lauterborni* and *Tanytarsus* sp. In 1994, a strong invasion of phytophilous species *Glyptotendipes* sp. and *Polypedilum exectum* continued. These species found suitable life conditions on the algal growths on the gravely substrate and they became most abundant there. In 1995, the species composition of chironomid taxocoenoses also indicated seasonal changes of hydrologic conditions: in spring, the rheophilous conditions (more water flows into the arm system) were indicated by occurrence of *Cricotopus bicinctus,* while in autumn (less water) presence of *Microtendipes chloris, Glyptotendipes gripekoveni* a *Chironomus* gr. *thumi* indicated hydrological conditions similar to the stagnant waters, which are preferred by these species. After 1995 more rheophilous species of the temporary fauna (rheophilous Danube species *Heptagenia sulphurea, Serratella ignita* and *Psychomyia pusilla* typical particularly of the eupotamal) began to occur in the through-flowing arms. The caddisfly *Ecnomus tenellus* strongly retreated in all arms supplied with water. After 1995, the rheophilous species dominated in the chironomid taxocoenoses: in spring *Orthocladius thienemenni, Cricotopus bicinctus, Rheotanytarsus* sp., and *Pottastia gaedii,* while in the second half of the year *Microtendipes chloris, Glyptotendipes pallens* and *G. gripekoveni,* which prefer the stagnant waters (KRNO et al., 1999).

Similarly as in the Danube old riverbed, significant changes in structure of the aquatic fauna also occurred in the river arms, which were not artificially supplied with water (Istragov) or whose water supply has not been solved yet. In the arm in Istragov, which was through flowing in the past and was without macro-vegetation, the submersion vegetation (*Potamogeton pectinatus)* began to occur sporadically. This is caused by the fact that (similarly as in the arm in Sporná Sihoť) the water can flow into the arm only through its downstream mouthing into the old Danube at times of higher backwater. Therefore there is no significant flow in the arms, which could inhibit development of macro-vegetation. The gravely bottom is covered by muddy-sandy-clayey sediment with organic detritus.

In the permanent fauna of the arms in Istragov, the representatives of the Tubificidae family (*Limnodrilus hoffmeisteri, L. claparedeanus*) take a dominant position and reach a high abundance and biomass. In summer 1997, after high discharges, Amphipoda represented by the species *Dikerogammarus bispinosus* and *Corophium curvispinum* appeared in the old river bad, but they were not recorded in the autumn. It confirms that under the existing hydrological regime in the arms they do not find suitable life conditions.

Temporary fauna (**Tab. 5.2**) was represented in the Istragov area mainly by the chironomid larvae represented mostly by four species of the genus *Glyptotendipes* and by *Chironomus* gr. *fluviatilis*, *Procladius* sp., *and Cladotatytarsus* gr. *mancus.* Abundance of individual chironomid species radically decreased in 1995. The species of the genus *Glyptotendipes* disappeared, and the species of the genus *Chironomus* occurred only sporadically. Only species of the genera *Cricotopus* and *Procladius*, *Cladotatytarsus mancus* (in spring), *Cryptochironomus defectus* and *Chironomus* gr. *semireductus* continue to occur there. Also the number of species of dragonfly larvae decreased. After 1996 only moderate changes occurred. The three disappeared species of chironomids (*Cricotopus* sp., *Chironomus* gr. *thumi* and *Cryptochironomus* gr. *defectus*) were replaced by 2 new species (*Endochironomus* gr. *nymphoides* and *Paratanytarsus* gr. *lauterborni*). When compared with the year1992, an increase of abundance was recorded in the species *Chironomus* gr. *plumosus, Polypedilum* gr. *pedestre* and particularly in the predaceous species *Tanypus kraatzi.* In the following years the chironomid community stabilised and the accessory species *Eukieferiella devonica, Brillia modesta* and *Rheotanytarsus exiguus* also occurred. The species diversity of the dragonflies was low. Among the original number of 3 species, only the eurytopic subspecies *Ischnura elegans elegans* continued to occur there. From the viewpoint of neuston (HALGOŠ 1999), this biotope seems to be little favourable. During the years mentioned, only several individuals of *Aëdes vexans* and *Aëdes sticticus* occurred sporadically. An interesting finding was made in September 1998 (KRNO et al., 1999). After a strong decrease of water level in the arm and subsequent quick development of aquatic vegetation, a mass occurrence of *Anopheles maculipennis* s.l and sporadic occurrence of *Culex hortensis* and *Culex pipiens* was recorded. This indicates stabilisation of life conditions.

In the arm near Bodícka Brána, we registered the quantitative changes in ichtyocoenosis structure, namely in the decrease of proportion of economically valuable species, particularly of the predators. Out of impact of the Gabčíkovo project it is explained mainly by illegal fishing. The illegal fishing, which decimated the ichtyocoenosis of the arms of the system of Bodíky, was realised mainly in autumn 1992, at the time of very low water levels and after putting the Gabčíkovo project into operation. The observed changes were moderated by the supply of water from the by-pass canal. Decrease of abundance and species diversity of fish (from 19 species in 1990 to 8 species in 1994) was recorded at the time of the Danube damming when a substantial part of ichtyocoenosis emigrated at low water levels and the remnant was caught by poachers. After construction of culverts (cascades) in the arm system, the re-immigration of fish from the old Danube was inhibited, but after beginning to supply the arms with water from the by-pass canal, the composition of ichtyocoenosis stabilised to certain degree (ČERNÝ 1999).

Plesiopotamon (communities of arms of the plesiopotamal type)

In the medial zone of the plesiopotamal type arms predominated in the **Copepod** taxocoenoses the euplanktonic species (mainly *Eudiaptomus gracilis, Cyclops vicinus, Acanthocyclops robustus*). In the **Cladocera** taxocoenoses the littoral, i.e., tychoplanktonic forms (mainly *Chydorus sphaericus* and *Simocephalus vetulus*) predominated in the first period after damming the Danube. Later, the percentage of tychoplanktonic forms continued to increase not only in the Cladocera, but also in Copepoda. In 1996-1997, the tychoplanktonic Cladoceran species *Chydorus sphaericus* and euplanktonic species *Bosmina longirostris* dominated there. Among copepods, *Thermocyclops oithonoides* dominated in 1996, similarly as in the previous period. In 1997 more euplanktonic species occurred. The littoral species *Eucyclops serrulatus* was also dominant (VRANOVSKÝ, ILLYOVÁ 1999).

In the former arms of the plesiopotamal type in the by-passed stretch, if they have not been dried off in consequence of decrease of the ground water level in pre-dam conditions, a rich-in-species taxocoenosis of planktonic **Crustaceans** survives. In this taxocoenosis the proportion of tychoplanktonic species increases and contributes to an increase of the overall species diversity. This is a consequence of the natural process of ageing, overgrowing, and terrestrialization of these water bodies. This process is, however, accelerated by simulated floods, which have a lower periodicity and intensity than natural floods. In the arms on the south-eastern margin of Bratislava and immediately downstream from Bratislava (on both sides of the Čunovo Reservoir), in which a quick terrestrialization was to be expected, the water table was stabilised due to an increase of the ground water level and, in this way, conditions for revitalisation of hydrocoenoses, inclusive of zooplankton, have been created. Remnants of the plesiopotamal type arms, which are situated downstream from the by-passed stretch, maintain a hydrological regime similar to the pre-dam conditions. Species diversity of the planktonic crustaceans is here high and tends to increase. At present, however, these shallow water bodies are subject to terrestrialization, overgrowing and further shallowing (VRANOVSKÝ, ILLYOVÁ 1999).

Although, the arm at Kráľovská Lúka is situated in the within-dike zone, it is not connected with other arms. It is supplied only by ground water. Overgrowing of this arm by macro-vegetation continues, particularly after 1997. Its overgrowing by submerged macro-vegetation, shallowing, and terrestrialization accelerates. From January to September 1993, a low water level (0.3 m on the water gauge) persisted in the arm, and it increased only in October 1993. In the period of the low water level, the water temperature reached as high as 33°C (9 June 1993).

Micro- and meiofauna in this type of arm continues to stabilise. Increasing species diversity also manifests itself. Among the sporadically occurring species the following were recorded: *Histiobalantium natans, Tintinnopsis cylindrica, Ophrydium crassicaule, Frontonia ambigua, Holosticha grisea, Strombidium turbo, S. velox, Frontonia ambigua, Holosticha grisea* etc. (KRNO et al., 1999).

Typical representatives of the permanent fauna were *Asellus aquaticus* (Isopoda) and *Limnomysis benedeni* (Mysidacea). New species in this locality were *Psammoryctides albicola* and *Gammarus roeselii*. In 1995, *Rhynchelmis limosella, Dero digitata* and *Nais* spp. (Oligochaeta) belonged to the dominant species. Abundance of *Plumatella fungosa* and *P. repens* increased significantly. Their cover reached about 50% of the surface of the solid substrate. In 1994, after a one-year absence, some species (leech *Erpobdella octoculata*, bivalviates *Planorbis planorbis* and *Bithynia tentaculata*), occurring here before 1992, re-appeared. Gastropods *Physella acuta* and *Hippeutis complanatus* were recorded as new species, and abundance of some surviving gastropods, (*Lymnaea auricularia, L. stagnalis* and *Gyraulus albus*) increased. In 1995, the water level moderately increased in comparison with the previous year. The submerged growths of *Batrachium* sp. dominated on the water surface in spring, while those of *Ceratophylum* sp. and *Myriophylum* sp. in summer. The gastropode *Anisus vortex* was recorded as a new species in this locality. Three new species for this locality were recorded in 1996, viz., *Dugesia lugubris* (Turbellaria), *Glossiphonia complanata* (Hirudinea) and *Armiger crista* (Gastropoda) and in 1997 additional six new species: *Chaetogaster langi* and *Pristina longiseta* (new for the fauna of Slovakia) and leeches *Glossiphonia concolor, Theromyzon tessulatum* and *Erpobdella testacea.*

In the temporary fauna (**Tab. 5.2**), the species composition of mayflies changes. *Caenis robusta* replaces, in these arms, the species *C. horaria* and *C. luctuosa*. Among the dragonflies only stagnophilous species (*Ischnura elegans, Coenagrion puella, C. pulchellum, Enallagma cyathigerum,* and *Erythromma* spp.) dominated in 1995. Increased water heating and eutrophisation was confirmed by the thermophilous species *Crocothemis erythraea* and *Sympetrum meridionale.* In general, increasing the proportion of stagnophilous dragonfly species and predomination over the eurytopic species was observed. Chironomids were represented by a taxocoenosis characteristic of the arms with stagnant water, rich macro-vegetation and rich algal cover on sand-gravel substrate (*Procladius* sp., *Paracladius conversus, Endochironomus gr. nymphoides, Glyptotendipes* sp. and *Polypedilum convictum*). An increased abundance was recorded in the species *Microtendipes chloris* and *Polypedilum pedestre.* New species found here after 1995 were *Ablabesmyia monilis, Polypedilum* gr. *nubeculosum, Cladotanytarsus* gr. *mancus, Tanytarsus* gr. *obatifrons, Tanytarsus* gr. *macrosandalum, Paratanytarsus* gr. *lauterborni, Endochironomus* gr. *tendens* and the abundance of the *Glyptotendipes* species strongly increased. After 1996, the proportion of the stagnophilous dragonflies increased, which predominated over the eurytopic dragonfly species. The strong increase of abundance of phytophilous and pelophilous chironomids *Glyptotendipes gripekoveni, Einfeldia* gr. *pectoralis, Einfeldia* gr. *pagana, Tanytarsus* gr. *macrosandalum* and *Dicrotendipes nervosus* reflected the continuing overgrowing of the arm by macro-vegetation.

The state of aquatic biota considerably worsened after 1999. There were periods in which the epifauna did not occur at al, particularly after the winter (the strong outbreak of macrophytes and their subsequent decaying caused an almost anoxic environment in the arms of this type). The short floods in June 2001 slowed down this unfavourable trend.

Among the representatives of neuston the mosquitoes predominated in these arms (BULÁNKOVÁ, HALGOŠ, 1995), viz. *Anopheles maculipennis* s.l., *Culiseta annulata, Aëdes vexans, Aë. sticticus, Aë. cinereus, Aë. dorsalis, Aë. cantans, Aë. leucomelas, Aë. communis, Aë. flavescens, Culex pipiens, C. territans, C. modestus.*

In the years 1981-1990, the arm at Kráľovská Lúka was characterised by a high abundance of ichtyocoenosis. However, in 1991 it was found out that the water level fluctuations considerably delayed after the fluctuations of the water level in the Danube main stream. This delaying supported the process of ageing and terrestrialization of these arms. After the Danube damming, this process was accelerated by the low discharge in the old Danube. The arm was no more supplied with water. On the contrary, the old river drained the area. The water level in the arm declined so far, that the shallow parts covered by *Nuphar luteum* a *Trapa natans* dried off. In the case of Kráľovská Lúka, the process of ageing is also accelerated by the facts that the arm belongs during the major part of year to the plesio-palaeopotamal type and is situated on the margin of the widest stretch of the Slovak side of the flood plain within-dike zone. These factors, together with the intensive fishing, particularly of predators and economically valuable species, reduced the species diversity in this arm. Abundance of ecologically plastic, eurytopic species (*Rutilus rutilus*), introduced species (*Lepomis gibbosus*), and expansive species (*Carassius gibelio*) increased in the ichtyocoenosis. On the contrary, relative abundance of endangered species, belonging in the past to receding species, decreased, and during 1992 these species disappeared. Extensive fishing caused this state in common carp (*Cyprinus carpio*) and Volga sander (*Sander volgense*), while absence of communication with other water bodies caused it in the endangered species, like yellow pope (*Gymnocephalus schraetser*) or rare species (*Abramis sapa*), (ČERNÝ 1999).

Small lakes in floodplain

Changes caused by the Danube damming were strongly reflected in the qualitative and quantitative representation of individual mosquito species (neuston) in the floodplain small lakes. A common feature of the whole monitored area is a strong decrease of occurrence of the spring species of mosquitoes, particularly of the genus *Aëdes* (*A. vexans* and *A. sticticus*) (BULÁNKOVÁ, HALGOŠ, 1995; HALGOŠ, PETRUS, 1995), caused by absence of spring floods. Until putting the project into operation, there was a sufficiency of ground water, which was reflected in seasonal structural changes of the mosquito fauna. The regular three-peak flood curves, which were characteristic of the past, were replaced by one-peak curves. After putting the Gabčíkovo project in operation, a strong decrease of ground water level was recorded after 1993 and the mass outbreaks of mosquito stopped.

The inundation small lakes have the largest significance for developments of praeimaginal stages of insects, particularly of the calamity species of mosquitoes (HALGOŠ, 1995). These lakes are represented by natural or man-made depressions, which are strongly waterlogged or flooded by seeping of ground water at the time of high water levels in the Danube. In the monitoring plot Bodícka Brána, the species of the genus *Aëdes* predominated (*Aë. vexans*, *Aë. sticticus*, *Aë. cinereus*) in 1991. In 1992 we recorded occurrence of the species *Culex pipiens*, *Culex territans* and *Anopheles maculipennis* s.l. In the next years, the biotope began to dry out. In 1995, due to the simulated flooding, this biotope became favourable for development of mosquito. Very interestingly, very rare species, e.g. *Culex territans, Culex hortensis, Culiseta ochroptera,* were recorded here. In 1996, the seeping of ground water was observed in the late autumnal months caused by the increased water level in the Danube. Due to the simulated floods in 1995-1997 (KRNO et al., 1999), as well as due to favourable hydrologic conditions in the old Danube investigated biotopes were flooded by seeping ground water. This was manifested by occurrence of the praeimaginal staged of mosquito, particularly of the spring species *Aëdes cantans, Aë des communis* and *Aëdes leucomelas.* Unfortunately, the clear-cutting of the floodplain forests and total destruction of biotopes under monitoring eliminated the positive effect of the simulated floods.

Periodic water bodies

In the monitoring plot Dunajské Kriviny in 1991 a relatively rich occurrence of larvae of *Anopheles maculipennis* s.l. was observed in a puddle (water hole) arisen in a forest road after a rain (HALGOŠ, 1995). Occurrence of this species in such biotopes is relatively sporadic and its occurrence in periodic puddles was no more recorded. In 1991 other periodic puddles, dependent on rain precipitation, were chosen in Istragov. In late June, a rich occurrence of larvae and pupae of *Aedes vexans* was recorded here. In the next years, the rain puddles quickly dried off as a consequence of decreased ground water level and were unsuitable for development of mosquito.

In the periodic water bodies in the area of Istragov an intensive development of the calamity mosquito species was observed in 1991-1992. Since 1993, a decrease of ground water level and degradation of this biotope started. The small depressions were filled by water only at the time of the atypically increased water level in the old Danube, for example in 1996-1997 and were not inhabited by praeimaginal stages of mosquito. At present, this biotope is overgrown by shrubs and partly filled by felling debris.

6 HITHERTO DONE

The basic concept of arrangements in the flood plain within-dike zone was to assure such a level of ground water, which in the pre-dam conditions (1985-1989) approximately corresponded to the discharge of 1,300 m^3/s in the Danube. Such water level was able to supply the root system of tress in floodplain forests with moisture. In addition, the basic concept required re-supply to the arms system on both sides of the Danube with such amounts of water. to ensure permanent flow in the main arms

After previous changes and diversion of a part of the Danube discharge into the by-pass canal, the ecosystem in the inundation between Čunovo and Sap is in a functional provisory, which is unsuitable, at least from the viewpoint of preservation of ecological values of the original inland delta. Biota is subjected to adaptive changes, which are leading to its gradual degradation (LISICKÝ et al., 1997). Efforts to improve this state were limited. up to present time, to manipulation with water in the left-side part of the flood plain within-dike zone. Its possibilities have not been fully used yet. The simulated floods only improve the condition of the ecosystem, but are not able to substitute the missing disturbances typical for the Danube floodplain forests and other typical communities, because they considerably differ from the natural floods by smaller dynamics and efficacy (volume of the overspill discharge, size of flooded area), water quality (a part of nutrients bound to suspended solids remains in the Čunovo Reservoir), and are without connectivity between the river and its arms (the water is led from the by-pass canal, not from the river) (LISICKÝ, 2001). The recently proposed water management measures solve only to increase the ground water level and re-connection of the water bodies by means of rising water table in the old Danube, but do not consider restitution of autoregulation processes of the Danube ecosystem. According to the hydrobiological typology, the former main stream (eupotamal) has turned into a side arm type (parapotamal). However, the rise of water the table at small discharges would transform the so far persisting lotic system into an almost lentic one. Impoundment of the water level in the old Danube riverbed is acceptable, from the ecosozological viewpoint, only for the mutual reconnection of the arms and as a provisory stage until the time in which the eupotamal of the main arms will have become functioning.

On the Hungarian side, the arm system was adapted already before 1992 for up to 80% for water supply by means of the intake structure in the Dunakiliti weir. The system of water distribution is projected in such a way that a canal partially including the old river arms, constructed along the old riverbed, is able to supply the side arms with water. The water level is regulated by a system of overflow dams and spillways in the canal and arm system. At present, the arm system on the Hungarian side is supplied by means of three openings in the riverbank using water from impounded old Danube upstream from an overflowing weir at Dunakiliti and the water levels are regulated by Dunakiliti weir.

In May 1993, an autonomous system of supplying the floodplain within-dike zone with water was put in operation on the Slovak side. The intake structure takes the water from the by-pass canal near the Dobrohošť village. Its capacity is, according to the project, 234 m^3/s. It supplies the river arm system and makes possible to regulate the water level for the needs of silviculture and from the ecological viewpoint. In addition it is able to simulate floods in the flood plain, clean the arms from organic sediments, etc. Discharge and water level in the within dike zone are regulated by means of water cascades with sluices and shallow spillways (**Fig. 2.1**). In this way, 7 sections in the flood plain were created with gradually controllable water levels. Water level difference between dams - cascades at low discharges reaches 0.6-1.2 m, at higher discharges decreases. The first simulated flood in the within-dike zone lasted from 19 July to 18 August 1995. The hydrological analysis showed that it duration and intensity corresponded to the pre-dam Danube discharges of 3000 - 4500 m^3/s.

Simulating floods allows inundating 60-70% of the floodplain. The sections can be inundated differently, all together, or some of them can be inundated while the others cannot. The dams - cascades are situated perpendicularly to the Danube. Each of them lies in the area bordered by the original left-side flood protection dike and, at the old riverbed, by a risen riverbank. These cascades are inconspicuously placed in the terrain, and fastened forest roads form most of them. The main goal of this solution was to assure a permanent discharge in the main river arms in the within-dike zone and to increase ground water level, soil moisture and make possible simulation of floods. The projected permanent (minimal) supplying discharge was 20 - 30 m^3/s. It was envisaged to connect individual sections with the old Danube by means of fish ways, or directly, according the level of water in the old Danube. It was also presupposed to construct direct connections between sections or to connect them by fish ladders. The expected number of floods was 2-5 a year. In autumn, a flushing of main arms was also expected. However, the floods were simulated with different frequency (**Fig. 6.1**). From the technical viewpoint it is possible to improve furthermore the existing state and to use the existing devices or to construct new ones, for example the underwater weirs (overflowed dams), fish ladders, interconnections of arms with the old Danube, redirection of water flow in arms, etc.

In the area of the arm system a permanent intake of water is guaranteed. It is controllable within the limits of the intake structure capacity. Its full capacity never has been used up to the present time; the largest discharge tested did not exceed 140 m^3/s. In comparison with the pre-dam state the permanent surface of the water table considerably increased, the water level is higher and the water quality in the arm system has improved and corresponds to the quality of the Danubian water. At present, there is a great variability of discharge with different flow velocities and depth in different places, from 1 m/s to stagnant water in the old arms of the pleisopotamal, now filled by the ground water. The danger of rising of anaerobic conditions, occurring in the pre-dam period, as well as drying off of the main arms has vanished. Excessive eutrophisation can occur in the dead arms, but it will be within the original natural range.

Planned, but not realised measures in the Danube old riverbed (the water level was not raised to the state corresponding to the pre-dam discharges of about 1300 m^3/s) has emphasised the breaking of the connection between the Danube and its arms. In addition, in the littoral strip along the Danube old riverbed, in particular in the locality of Dunajské Kriviny, and in the area of Istragov, the levels of ground water and of water table in the arm have decreased still more, with all negative consequences.

On the basis of the Hungarian data, it can be concluded that the ground water level increased after realisation of measures agreed to in the Agreement 1995 in the entire area of the Szigetköz Island, from the arm system to the Mosonyi Duna. The ground water levels are higher than in 1991 at low and average discharges in the Danube, and considerably higher than just after the Danube damming at the equal discharges. It means that the ground water level in the major part of the Szigetköz Island is, after realisation of the agreed measures, higher than at the average pre-dam discharges in the Danube.

In spite of many efforts at creation of a suitable regime and moisture conditions in the within-dike-zone and in spite of many measures realised, monitoring of the natural environment shows shortcomings and possibilities of a better use of existing devices for control of the hydrological regime, as well as some shortcomings arisen in the last time.

In this place we state the principal shortcomings, from the viewpoint of water regimen, which are to be solved in next steps. They are the following:

- definition of flood protection measures, choice of meadows, mown meadows, definition of their water management and role during the flood;
- definition of arrangement, care and maintenance of the Danube old river bed in regard to conveyance of flood water and other uses, for instance water sports and yachting, technical navigation, etc.;
- connection of the Danube with the arm system in several places;
- making possible fluctuation of water levels in the Danube old riverbed, and in the arms system, which would be correlated with discharge in the Danube at Bratislava and, as a consequence, a wider fluctuation of ground water levels;
- making possible a quasi-natural simulation of floods in correlation with flood discharges in the Danube;
- support of at least partial meandering of the arms in the within-dike zone;
- increase in water level in the old Danube and, as a result of this, increase in ground water levels in the bank zone along the old riverbed;
- adjustment of ground water levels to the natural state, rise of the sunk level of ground water in the area of Dunajské Kriviny, Istragov, possibly in the upstream part of this area (lines A - C), in the downstream part at mouthing of the arms into the old Danube river bed, Kráľovská Lúka and, possibly, also on other places;
- providing a better connection and possibilities for migration of organisms through the lines (cascades) (putting the fish ways in function, direct connecting of arms);
- definition of biocorridors, in particular along the riverbank lines and restitution of biocentres, as well as definition of areas of economic forest stands;
- definition of touristic or otherwise used parts of the within-dike flood plain zone;
- demands on water manipulation in the right-side seepage canal;
- demands on levels of surface and ground waters in the within-dike flood plain zone; and
- possibly other measures, also out of the within-dike flood plain zone.

In the first place, it is necessary to pay attention to flood protection and uses of the flood plain within-dike zone for conveying the floodwaters. This function must be defined from the ecological viewpoint so that the within-dike zone has a nature-close character and fulfils its natural function (for example the meadows and mown meadows are to be placed so to they support the flood protection measures). It is obvious that the non-realises measured and the existing hydrological measures cause the original requirements of the project to be not satisfied (e.g., water level in the old riverbed, hydrological regimen of Istragov, etc.). On the contrary, some realised measures do not fill the aims that were to be achieved (water supply for Dunajské Kriviny). Other realised measures fulfil the aims only partly or are not used optimally (e. g. fluctuation of water levels). Monitoring of biota has disclosed some other requirements for further improvements (e.g. moisture conditions), or some new requirement have arisen (mainly in consequence of changed social requirements to use of the territory).

All these facts are reasons why different scenarios are proposed. By means of a comparison of the scenarios it is possible to choose a scenario or select some of its elements, which seem to be optimal from different aspects and according to different priorities. Out of the shortcomings caused by unrealised original goals (e.g. rise of water level in old riverbed), the main reason for proposing new scenarios is the fact that monitoring of the environment begins to fulfil its task of enlarging knowledge about the area in question and its biotopes. It presents new facts helping us to decide, better and more concretely, what is desirable to be achieved from the biological, ecological and nature close viewpoint. On other hand, there are available devices (improvement of their use) making it possible to fulfil these goals, or new devices can be gradually provided without enormous cost.

This study is not a project or a ready project proposal. It is a study of how to solve the problems from different positions (ownership - environment - recreation - economy). Doubtless, there exist not only compromise solutions, but also solutions expressing symbiosis of different viewpoints, for example the function of the floodplain and the aims to achieve a nature close state in this area.

The aim of future management is **to restore the ecosystem integrity** in the floodplain between the original flood protection dikes. From this viewpoint, it is necessary to concentrate on the **support of decisive ecological processes.** This includes not only provision of the optimal life conditions for as large a number of species as possible, but also **preservation of the natural biodiversity, maintaining amplitude and frequency of changes (dynamic balance) and preservation of the reparation and regeneration processes**.

Optimisation should lead to a **return to naturalness** (not originality), i.e., to providing or creating of conditions for the **natural application of ecological rules and autoregulation of the entire ecosystem** as a complex of azonal ecosystems. If we start from the basic concept of the inland delta consisting of a community catena ranging from the aquatic communities (eupotamal to pleisopotamal) through the semiaquatic littoral and transitional communities to the terrestrial communities with decisive humidity gradient, corresponding ground water level and cyclic disturbances in the form of flood, then our **aim should be to achieve a state in which the artificially created conditions open a way to autoregulative functioning and, in a certain sense, to secondary succession of those communities, which have deviated from the natural state in consequence of various interventions**. It is obvious that **such a development also can locally result in changes or even extinction of existing communities. However, the starting conditions should be set so that these communities could arise in other suitable places by the natural succession** (with possibility of control of ecosystem development in the first stage). At the consequent realisation of this concept **we must also accept the possibility of rising of communities from the drier part of the humidity gradient** (hard-wood floodplain forests, Danubian forest steppe), which begin to form in the drained part of the within-dike floodplain zone at the old Danube.

The potential state of the communities cannot be understood as a static state, but as dynamic oscillations between two idealised natural states (extremely moist whith repeated strong disturbances and relatively drier and more stabilised). Such a potential state cannot be taken as an invariable characteristic of a concrete site, but only as a set of limit, which the state of a concrete community should not pass for a long time. This means that the **system can be dynamically transformed not only in time, but also in space.**

This state must not automatically means preservation of all species occurring there at present, hence preservation of the complete species diversity of the present time, which is formed by many ecologically invasive species with a wide ecological tolerance, whose secondary invasion was made possible by the changed conditions. A possibility to control the running renaturation is inevitable for suppression of the invasion plant species, until the time in which this task will be overtaken by the autoregulation. This control requires a special monitoring and methods of its evaluation.

7 SOLUTION SCENARIOS FOR FUTURE

Flooding of the within-dike zone should simulate the original state, i.e., floods in spring and summer. An optimal state for ichtyocoenosis occurs when both floods cover the floodplain up to the flood protection dikes (HOLČÍK, 2001). Beginning, culmination, and fading away of the flood should have a similar character as before the Danube damming (see **Fig. 4.8b**).

It is important to maintain the course of filling end emptying of the flooded territory (Fig. 4.9). The curve of filling can be steeper; i.e. the filling can be shorter. On the contrary, the curve of emptying must be flatter and continuous, i.e. the emptying of the flooded area must last longer so that it makes possible hatching of the laid spawn and floating of the young fish from the inundated area. The concrete date about the term of beginning and lasting of floods should be harmonised with the temperature regimen in the floodplain (**Fig. 4.14**):

- spring flood, filling at the temperature of the inflow water of 4°C, start of emptying after the water temperature in inundation has reached 15°C;
- summer flood: filling at the temperature of the inflow water of 15°C, start of emptying after the water temperature in inundation has reached 20°C.

The temperature and time limits should be verified and modified in regard to the changes that arose after the Danube damming and other measures. It is also obvious that the optimal flood will not occur every year.

Natural habitats in this study have the priority. It is obvious from the environmental viewpoint of preservation of values and specific features of the within-dike floodplain that the basic priority is the functioning floodplain from the viewpoint of flood protection. Without a functioning floodplain there cannot be preservation of the nature close biodiversity and ecological processes, which are typical in the territory defined as inundation, with respect to the specific hydrologic and ecologic features of this Danube stretch. For this reason, all other interests must be subjected to the fact that this territory is and will be irregularly inundated, and they must to contribute to the preservation of the nature close biodiversity and ecological processes when using this territory.

Optimisation of hydrological regime should approximate the natural state. When optimising the hydrological regime, we prefer to create a new eupotamal. Realisation of such a proposal would create conditions best approximating the natural state (Fig. 2.2). It is necessary to consider that previous straightening of the Danube and concentration of discharges into one fortified riverbed caused irreversible changes. Construction of the Gabčíkovo project made possible at least approximation of nature close state in the within-dike floodplain.

In regard to the historical development of the arms system, it is necessary to focus on the within-dike zone with a risk that communication of the water level in the Danube old riverbed with the arm system will not be reached. The deepened bottom of the Danube riverbed does not allow the water, without a sufficient impoundment, to escape from the riverbed and to inundate the within-dike zone at discharges as earlier. Because the water level in the old riverbed is lower than in the arm system, the riverbed acts as a drain draining water from the arm system. In the present situation there exists a possibility to use the original main arms of individual arm systems to overtake function of the main stream. It is desirable to obtain the optimal state with the minimal interventions and minimal manipulation with the water management facilities.

If the concept of a new complex and bilateral eupotamal is not accepted, optimisation of the hydrological regime will be problematic, in particular in the area of Istragov. Supplying of the arms with water has been not yet technically resolved. At present, the water gets into this system of aquatic biotopes through their downstream mouthing as a result of the backwater, caused by the confluence of the tailrace canal with the original riverbed. The arms in the vicinity of the tailrace canal, for instance, the Išpánsky Dunaj arm, are obviously supplied with the seeping ground water. However, the bottom downstream of the tailrace canal mouthing into the original riverbed is deepening. Therefore it can be expected that the backwater level in the old Danube will decline in the close future and communication of the water in the arms with the Danube will be reduced. This danger is rather serious because there are very valuable biotopes; shallow "lakes" and "lagunes" overgrown with reed (*Phragmites*) and reed-mace (*Typha*), which represented rich aquatic biotopes showing a high production and diversity, before the Danube damming.

Optimisation of the water regime could be realised by construction of a submerged weir (dam) in the old Danube, similar to that at Dunakiliti, at the level of the upstream gate of the Istragovské Rameno arm. This would raise water level and increase discharge into the Istragovské Rameno and Foki arms. The lower gate of the Istragovské Rameno arm could be closed. If the hydrologic conditions do not allow constructing the submerged dam in the proposed place, it could be shifted upstream, under the mouthing of the peripheral arm in Istragov. The preserved riverbeds of the connected arms would also make it possible to fill the Išpánsky Dunaj arm with water. This arm is mounting at the confluence of the tailrace canal into the Danube. The risen water level in the old Danube would allow filling the peripheral arm in Istragov and filling of the internal lagoons mentioned above.

Complex of measures in floodplain within-dike zone includes the following main parts:
- Interconnection of individual arm systems in the floodplain so that a **new stream** will be created. It would allow preserving the heterogeneous water formations (arms, inundations lakes, lakelets, inundation puddles etc.) in the within-dike zone.
- Supply of the water for **the new stream** from the by-pass canal and/or from the Danube old riverbed upstream of Dobrohošť, for example by an submerged dam similar to that at Dunakiliti).
- Ensuring of the **heterogeneous hydrologic conditions in these new stream formations,** obtaining of a wide scale of flow velocity in individual types of arms **by means of remediation of already vanished mouthings of mutually connected arms.**
- Ensuring of the **water level fluctuation** in water formation, from the temporary denudation of some parts of the bottom to flooding of the floodplain within-dike zone.
- Providing of the **coordination of the water level fluctuations with fluctuations of discharge** in the Danube upstream of Bratislava.
- **Connection of the** ends of the arms (in several places) **with the old Danube riverbed.**
- To create conditions for reaching of high water flow velocities in the new main stream and its arms during the flood situations. This would **flush the water bodies,** would support **erosion and sedimentation processes and transform the river arm banks** in the within-dike zone and lower its terrestrisation as a consequence of the natural succession.
- If the aims mentioned above are to be achieved, it is necessary **to set unambiguous priorities** and to define basic limits resulting from these priorities for management of this territory (**manipulation rules**). (Priorities can be named, for example, in the following order: flood protection of the territory outside of the within-dike zone, natural functioning of ecosystem and nature protection, silviculture, recreation, etc., in the floodplain inside the within-dike zone).
- In reality, **this territory is hydrologically a functioning floodplain**. Therefore it is obvious that at high flood discharges in the Danube, it will be always naturally flooded. It is necessary to introduce and provide a regimen for the flooded area. This means, among other things, to inform all users that this area is flooded and the term of floods will not be set administratively, but it will correlated at each flood with the discharges of the Danube. The increase of water levels and some flooding of the area are always to be expected in this territory when the discharge in the Danube at Bratislava will exceed 4,500 m^3/s.

The overriding and most important function of the old Danube riverbed are to lead discharges, which cannot flow through the by-pass canal, arms (including the new stream) and floodplain surface in the within-dike zone during the increased and flood discharges. Outside of flood situations the old riverbed should not drain the ground waters in its vicinity, but just on the contrary, it should support the optimal ground waters level and its fluctuation. The old Danube can fulfil this task only if its water levels will be higher than the present ones and if they will sufficiently oscillate approximately at the level corresponding to discharges of 1300 m^3/s in pre-dam conditions (1985-1989). The cheapest and most satisfying solution seems to be the submerged dams, which could be destroyed, to a certain degree and under defined conditions, by the extreme high floodwater. Their disadvantage would be the necessity to be reconstructed after larger floods. Under the presumption of leading a discharge of 4,000 m^3/s through the by-pass canal it can be estimated that such a reconstruction would be necessary once every 15-50 years, according to the construction and the mode of management of the Danube riverbed. During the non-flood state, the sanitary, but variable discharge supporting (depending on arrangement of the arm system and its supply with water) fluctuations of groundwater table, would flow in the old riverbed.

There were several proposals. One of the acceptable proposals are shallow submerged dams in the form of a wide letter "V", with a very small slope on the downstream side, completed with the existing and new groynes between them. Other solutions can be the some fortification of natural fords, low inflatable weirs, river meanders and other arrangement of the riverbed, or their combination.

The basic criterion for measures in the old Danube riverbed is obtaining of such water level, which could be considered as satisfying. Such a water level corresponded before the Danube damming, according to Slovak Environment Commission, to the discharge of 1,300 m^3/s. It was a level, which was able to provide the groundwater table on a level supplying sufficient soil moisture for the root system of the forests trees in the within-dike zone. In regard to this requirement, there are several Slovak or Hungarian proposals for maintaining the water table in the old Danube. One of such proposals is also the proposal given in the „Report on Temporary Water Management Regime" of the Working Group of Monitoring and Water Management Experts for the Gabčíkovo System of Locks" (CEC, December 1, 1993). This proposal presents a solution consisting of 8 submerged dams (over flown dams) downstream of the Dunakiliti weir. These dams are given in the **Table 7.1** and **Fig. 7.1**. Besides this, in order to ensure connectivity, the fish ladders are proposed between the Danube and arm system, **Table 7.2** and **Fig. 7.1**.

From this proposal only the simplified and incorrectly formed submerged dam at Dunakiliti was realised in accordance with the Agreement 1995 in the river km 1841, hence by 2 km more upstream than originally projected.

The Hungarian proposal given in the report elaborated at the Office of Premier Minister, Bureau of the Government Agent for the Danube called: Task of Analysis of Impacts for the Danube" presented to the Slovak side in December 1999 (OFFICE OF PREMIER MINISTER OF THE HUNGARIAN REPUBLIC 1999) is also similar. This proposal is in **Table 7.3.**

Principally both proposals are identical and have the same aim – to connect the old Danube with the main arm and ensure that a part of water from the Danube flows into the arm, flow through this arm and then the water mouth back into the Danube and then again flow into an other arm, for example on the other side etc.

In both cases, the water table level would be regulated by discharge and an adequate shape of the submerged dams, according to the required fluctuation of water table and discharges. Principally it should have a "V" shape to enable sufficient fluctuation of water levels. The submerged dams should have a moderate slope (1 : 50) on the downstream side and should be constructed so that an extraordinary flood, exceeding some critical values would destroy such a dam or at least a part of it. The old riverbed should be permanently discharged and should be managed so that it can lead the required flood discharge. The arm systems should not be regulated except for the requirements of flood protection. It means a defined discharge and protection of the banks in meanders in the vicinity of the flood protection dikes and in the exactly defined places. It is necessary to calculate with flooding of the within-dike zone and with flowing of the water on the surface of this territory. Such a state is considered to be natural and to correspond with the basic functions of the floodplain.

Proposals to create a new eupotamal (partial or complete leaving of the old riverbed) and the shifting of the eupotamal function into one or more existing side arms had appeared already before finishing the Gabčíkovo project (LISICKÝ, 1992). They were justified by the necessity to preserve the lotic conditions in the main stream of the Danube. Already after two first years of the Gabčíkovo project operation the monitoring of biota showed that the fear from the low ecological efficacy of function of the proposed puffer measures (see **Chapter 6**) were well-founded and confirmed the necessity of an essential alternative (LISICKÝ, 1994, LISICKÝ, 1995).

In the present situation, there is a possibility to use the original main river arms of the flood plain so that they simulate one of the Danube branches. In the past, before the water was concentrated into the one stream, the Danube water branched in this stretch into many arms and, in this way, the discharge was divided into several parallel flowing streams. The proposed solution would represent one of the branches of the main stream with adequately smaller discharge. From the viewpoint of the hydrobiological terminology, it would mean a shift by one order, when the former parapotamal-type arms would become the main stream (eupotamal). Subsequently the qualitative shift would also happen in other types of arms. The important factor in the flow created in this way would be providing of hydrological conditions ensuring that the discharge in the "new stream" will fluctuate in accordance with water table in a flow only slightly influenced by man. It means that the water table of the "new stream" would be manipulated by means of a new intake structure in correlation with the water discharge at a water gauge (for. example at the Devín village). At the highest discharges the water should spill and fill the adjacent water bodies, possibly also with the help of regulation of water level by means of cascades.

There is a tendency to obtain the optimal state by means of minimal interventions and minimal manipulation with water management facilities. In the initial stage, it would be necessary to deepen silted mouths of some arms to support their communication with the "new stream".

LISICKÝ (2001) proposes to use the former side arms at restitution of meandering river pattern and a strong support of anastomoses. According to his proposal, the new eupotamal would cross the old riverbed at 4-10 places. It would allow leading larger discharges through the within-dike zone without dredging one dominant meandering riverbed. An argument for this (for the future) open solution is the fact, that we are not able to foresee unambiguously the character of the riverbed-forming activity of the river under the present local anthropogenous limits. Therefore it is not desirable to define a priori, how and where the new eupotamal should arise and how it should appear. It is probable that the water will use the existing well discharging arms in the initial stage, but later it will begin to re-model partly the floodplain at the flood discharges.

At such and similar solutions it is inevitable to propose and gradually realise the necessary technical measures in the old Danube. However, there is a question, to what degree such a scenario would be optimal for ensuring of leading the flood discharges and ice. The less radical solutions of this group are represented by the proposals to strengthen two parallel eupotamals in the main arms on both the Slovak and Hungarian sides without connection crossing the old riverbed (ŠPORKA, 2001). This solution is also recommended by LISICKÝ (2001) as a temporary acceptable alternative. However, the reasons for such function limits are not of the ecological nature, but of the political nature (existing state border and potentially different opinions of the Slovak and Hungarian sides about such solutions). But, even at such solutions the necessary technical measures in the Danube old riverbed are to be proposed and gradually realised.

Requirements to scenarios of optimal hydrologic regime solution with respect to the ecological demands

The arm system should have, first of all, the permanently flowing water in the main arms. The main arms should be connected with the old riverbed so that water flows into the arms in some places and flows out at other places in relation to the discharges in the Danube. Inlets and outlets should be at the places of backwaters in the old riverbed so that water flows several times into the arms and at the same time across the Danube old riverbed. It is also possible to form separately meandering arms on one ore both sides of the within-dike zone. The proportion of water flow between the old Danube and the meandering arm can be different (it was very different also at the beginning of the 20th century). The discharge in the main arm also depends on the aim we want to reach. The more water will flow in arms and the flow velocity will be higher, the higher will be erosion and sedimentation processes, the faster will be the process of moving of meanders, process of erosion, and forming of new riverbanks, the higher will be also demands for management of river arms in the vicinity of the flood protection dikes.

From the viewpoint of connection of arms, the fish ways, ladders, boulder passes, bypasses and other types of connection come into consideration. From the viewpoint of water table levels, the system of cascades able to provide flood simulation should be preserved or possibly modified. By means of closing and opening of culverts it is possible to regulate the processes of erosion and sedimentation.

The basic concept of arrangement of the **within-dike zone**, whose part is also the old Danube, follows from necessity **to maintain the priority function of the floodplain to lead and temporarily retain the flood discharges. From this function the basic ecological concept to preserve the natural values of such functioning floodplain is also derived, of course, under the presumption that suitable conditions will be created for it from the viewpoint of hydrological regimen. Unlike the hydraulic structures in Austria and Germany, which were built up in the middle of the former floodplain and the water in the most arms flows slowly with small amplitude of water levels fluctuation, the floodplain at the Gabčíkovo structures has preserved its original function, as it had in the first half of 20th century. In this sense, the Gabčíkovo project is unique. Preservation of biotopes of such floodplain seems to be overriding from the ecological and practical viewpoint. It is realisable under the existing water management and technical conditions and construction of the Gabčíkovo project**. Besides this it is possible to create, to a certain degree, hydrological conditions for disturbance and restoration of the autoregulative system in a part of the floodplain. This means mainly **increase in spill out process, support of sedimentation processes and riverbed-forming potential**, connection of the main riverbed with arms, making possible meandering of main arms, increase of ground water levels of the drained zone along the old Danube, support of fluctuations of discharges and water levels in the floodplain within-dike zone in correlation with discharges in the Danube, use of the intake structure at Dobrohošť, connection of the arms with the old Danube, etc. **From the viewpoint of groundwater, it is desirable to increase fluctuation of the groundwater level, what can not be realised in the permeable alluvial gravel otherwise then by fluctuation of water table also in the old Danube riverbed**. Therefore, the submerged dams (but also other technical facilities) must be formed so that they make possible, or create, such a fluctuation. The submerged dam at Dunakiliti serves as an example, which inhibits such a fluctuation.

It is evident, that such modifications of water regime, which are based on the dynamics of discharges and water levels, on support of erosion and sedimentation processes, and which result in the creation of conditions supporting disturbance and autoregulation of the system, need **specific and accurately defined monitoring, monitoring criteria for evaluation of its results, and need an instrument** (for example a permanently working mathematical model) **for the water-management regulation of the hydrological regime dynamics.** Subsequently, water-management, ecological, and other measures, inclusively of management of commercial forests should be carried out.

The floodplain within-dike zone should be able to lead and retain a part of floodwater and should be able to realise the natural and simulated flood. From this viewpoint it does not need any terrain rearrangements. The terrain works will be potentially necessary for flooding this area or for connection of the terrain depressions with the adjacent arms. If the Danube old river bed's capacity to transfer the flood discharges will be curtailed, this function must be overtaken by the branch system and mainly the within-dike zone. This requires its maintenance and possibly creation of deforested corridors (meadows).

8 GENERAL CONCLUSIONS, RECOMMENDATIONS AND PROPOSALS

Optimisation of water regime should approximate the natural state before closing and separating the Danube river arms from the main stream. From the ecological viewpoint it is desirable to create a new main riverbed/arm of eupotamal. Theoretically there are several alternatives, viz. creation of the eupotamal by connecting the Slovak and Hungarian systems of arms, creation of the new eupotamal only on the Slovak territory or creation of two eutopamals separately on the Slovak and Hungarian territory. In the case that creation of the new eupotamal by connection of the Slovak and Hungarian systems of arms (possibly using sections of the old riverbed) will appear as not real from any reason, then it is possible to consider creation of the new eupotamal only on the Slovak territory, according to proposal of ŠPORKA (2001) or of two parallel ("national") eupotamals (LISICKÝ, 2001). It would result in the relatively most natural state, close to the state before the beginning of construction of the Gabčíkovo project and before closing and separating the Danube River arms from the main stream. It is necessary to take into consideration that the previous works in the Danube riverbed made in connection with navigation, viz., straightening of its riverbed, fortification of river banks, concentration of discharges into the straightened riverbed, have caused changes which inhibit return to the original natural state, state when the Danube meandered freely nor, at least, to state from the middle of 20th century. Significant changes also have arisen due to construction of the Gabčíkovo project, but some possibilities to approximate the natural state in the floodplain arose too.

In respect to the historical development of the arm systems it is necessary to focus on the within-dike zone considering the risk that communication of the water table in the former arm systems will be reached only in some places or that the direct communication will not be reached at all. The deepened bottom of the old Danube riverbed and intake of water into the by-pass canal do not allow natural spilling of water into the inundation and it's flooding, as extreme floods with discharges exceeding 8000 m^3/s are an exception. However, the situation can be improved by means of technical measures.

From the viewpoint of the aims defined it is necessary first of all:

- To provide creation of the "new stream" by means of connection of main arms of individual arm systems. It would allow preserving diverse water bodies (arms, lakes, flood lakelets, flood puddles etc.) in the floodplain within-dike zone.
- To restore already vanished mouthings of mutually connected arms (anastomoses) in order to obtain wide scale of flow velocities and diversified hydrologic conditions in these water bodies.
- To allow fluctuations of water table in the water bodies, from temporary denuding a part of the bottom to the flooding of these bodies at high water levels.
- To ensure the fluctuations of discharges and water level in the arms corresponding to the fluctuation of water level (discharge) in the Danube at Devín.
- To allow the water in the new main stream to reach high flow velocities in order to flush the riverbeds and, in this way, to inhibit their excessive terrestrisation resulting from the natural succession.
- In respect to the aims defined above, it is necessary to set the unambiguous priorities of management for this territory (its use for flood protection - leading of discharges, function of a polder, nature protection, silviculture, recreation etc.) and, on this principle, to elaborate manipulation rules of the integrated water management of the floodplain within-dike zone.

A precondition for preservation of the communities close to the natural state (communities of natural character) and converging to the original state of the floodplain forests, as well as for reaching an acceptable state, is ensuring of flooding of a major part of the forest stands by the water from remnants of the arm system. This flooding must have a larger extent and duration than the hitherto practised simulated floods.

Therefore it is necessary to ensure floods in the entire area of interest, at which the water will flow (not only stagnate!) through the major part of forests at least for several days a year. For formation of the natural communities it is much more important to ensure more or less regular fluctuation of the ground and flood water in a relatively wide amplitude than to ensure a stable level of water table. For preservation of ripicolous and littoral communities it is also inevitable to ensure fluctuation of water table in the arms themselves, so that a part of their bottom and moderately declining banks is denuded for a longer time.

The discharge and water table in the main arms of the original arm system should be variable and must be correlated with the discharges in the Danube upstream of Bratislava. The water table in the lateral arms should be also variable. A stable high water level should not be maintained in them as it is practised at present over the major part of year. Diversity of water bodies (arms, meanders, depressions) also must ensure low water levels and allow water to heat and create conditions for balanced representation of fauna and aquatic vegetation of water table and shores. Most characteristic species of such communities do not tolerate a permanently high water level resulting in lower temperatures of water in the arms.

According to LISICKÝ (2001), the old Danube is too capacious (and has heavy fortified banks) to the hitherto considered discharges (250, but also-600 m^3/s at Čunovo), to be sufficient for the further forming of the entire riverbed. According to the hydrological typology, the main stream (eupotamal) has changed, as a matter of fact, on a side arm (parapotamal). Damming of the old riverbed and rising of its water table is necessary for reduction of its draining effect. From the ecosozological viewpoint it is acceptable only as a transition stage, until the time at which the eupotamal in the main arms of the original arm system starts to function. A functioning solution close to the natural state can be reached only by a gradual diversion of the present discharge from the old riverbed into the original arm system adapted for larger discharges. In such a state, the old riverbed would serve for leading flood discharges. It means restoring the anastoming and meandering river pattern in the new eupotamal, which existed here in the past and gradual leaving of the straightened and in the 20th century rearranged main riverbed with fortified banks. By means of a controlled succession, an autoregulative ecosystem could be naturally restored, which would correspond, in relation to the considerably lower discharge (for example according to Agreement 1995), to the Danube stretch upstream of Bratislava. At the same time it is necessary to refrain from the requirement of navigation in the Danube old riverbed, which is not ensured in any other hydraulic structure on the Danube (For the present moment the navigation is technically possible between Čunovo and Dunakiliti with possible passing downstream of the Dunakiliti weir and from Sap upstream up to the port of Gabčíkovo). After providing a sufficient discharge in the new riverbeds, it will be possible to allow for the gradual terrestrisation of the not functioning stretches of the old riverbed, under condition of preservation of its function for leading large flood waters.

The hydrologic regimen itself is not sufficient for return to the natural state. It represents only an inevitable precondition. Out of modification of the management of the hydrologic regime, it is necessary to change essentially the approach of silviculture and local population to the landscape use. First of all it is necessary to prevent the gradual urbanisation of this territory and its fragmentation by a network of forest roads, intensively used plots, recreation facilities etc. A pre-requisition of this is maintaining of an intern regime of naturally or artificially flooded area and a regime corresponding to the Protected landscape area, in some places a regime of Nature reserves or at least of the special purpose forests. Without this, the realisation of the water management measures will be effective, but its effect will be devaluated by other human activities. Also for this reason, it is necessary to strictly insist on elimination of any activities, which are in contradiction to the character of a floodplain.

The basic scenario

For the more detailed final discussion and realisation of modelling of the scenarios of further policy we recommend the proposals belonging to the "new eupotamal" group. They are most promising from the viewpoint of restoration of the natural processes and autoregulation of the ecosystem. Therefore only individual varieties of this group of scenarios are to be completed and their suitability is to bee evaluated. For their realisation they need, as the first step, to rise of the water table in the old Danube by means of submerged dams or damming the riverbed on several places and construction of hydraulic guide structures across the old Danube. The proposal to dredge one dominant side arm, which also belongs to this group, is laborious, expensive and problematic from the view of flood protection, extent of earthworks and maintaining of the riverbed in the floodplain. In addition, it contradicts to the concept of supporting the natural riverbed-forming activity of the chosen arms and of inhibiting excessive facing of their banks. From the discussion about individual scenarios it follows that the solutions presuming creation of a new eupotamal, as schematically proposed in **Fig. 8.1**, are most functional and optimal from the view of ecology and ecosozology. The complex Slovak-Hungarian solution, which would restore a unique system in this stretch of the Danube, is preferred. In the case that modelling or other reasons (i.e. other than ecological reasons) would show its unreality, the second preferred solution is creation of two parallel eupotamals along the both sides of the old Danube. From the practical aspect of leading of flood discharges, the most acceptable way seems to be creation of a new eupotamal using temporarily submerged weirs in the places where the new eupotamal should cross the old Danube. Such solution preserves the function of leading of flood discharges, reduces draining effect of the old riverbed, and will work with a small (variable) discharge in the old riverbed until the new eupotamal in the main arms of the original arm system will have started its work. The new eupotamal should be created so that it does not need maintaining of its riverbed and fortification of banks.

If we accept the principle that arrangements should be non-violent, carried out on the limited areas in the within-dike zone, inexpensive, requiring only limited earthworks, and that they should converge to natural processes, then there exists a combination of proposals and sequence of works. An advantage of this sequence is also a chance to correct the course of works on the base of environment monitoring. The sequence of the works would be arranged as follows:

- construction of several low overflowing dams (similar to the one at Dunakiliti) making possible to connect the arm system with the old Danube at several places;
- providing of a natural dividing of water between the old Danube riverbed and the connected arms;
- optimisation of discharges in the arms in relation to dams and water dynamics in the arms;
- rearrangements leading to restoration of the natural processes in an autoregulative system, inclusively of the dynamics of discharges and levels of the surface and ground water, erosion and sedimentation, meandering in the within-dike zone and mutual connection of arms; and
- monitoring of functionality of several, at the beginning 2-3, low overflow dams constructed in the old Danube and on the base of its result proposing further arrangements, for example fortifying of fords, connections between arms, changes in water levels, etc., gradual building of further overflowing dams in the Danube.

In respect to the unsatisfying quality of the necessary historical data and lack of experience with rehabilitation, up to restoration of a river in a similar scale and in a comparable environment there exists a question of preliminary modelling of expected processes (erosion, sedimentation, water quality, influence on ground waters etc.). In regard to a great heterogeneity of parent rocks, sediments and geomorphology, creating of a reliable model would be probably expensive. On the other hand, there is some experience with modelling of the processes in the Čunovo Reservoir and in its vicinity, experience from other countries as well as new investigative methods, which can make the modelling process considerably easier. It will be desirable to model mainly those parts of the new solution, which require some technical measures, for example verification of passing of floods and ice and, step by step, also of the entire large area experiment. It is also possible to model the erosion-sedimentation phenomena. Results of such model are quite well. There is only the question whether they will apply in praxis, where the situation depends on real discharges and time frequency of floods. Modelling is a process, which, based on the monitoring, models the proposals and contributes to the decisions and realisation of the proposals. The monitoring continues, the results are compared with the model, the model is corrected and a new phase begins – correction of the proposals. It is an iterative process, which can be used in the course of works. One of main lessons from the Austrian stretch of the Danube is the fact that the modelling is not able to offer the final solution already in the initial phases and to foresee the concrete events. Because the modelling is a process, it is necessary to divide the proposal into subsequent steps, to model them and to monitor the results and by means of the gradual steps to refine and correct the proposal. It can be stated that some failures of the modelling do not result from the modelling method, but from the insufficient knowledge of parameters input in the models.

From this reason the experts, who compiled this study, endorse the idea of **gradually controlled (by means of the technical measures and water management) releasing of the river dynamics in the area of interest according to the scenario proposed in the conclusion, and endorse the principle of gradual adaptive decision-making oriented to the gradual optimisation of the hydrological regimen in the next decades. The basic concepts of this optimisation are expressed in the previous chapters. At the same time they recommend to realise as few technical measures as possible in the arm system and to allow nature and natural processes to create the new eupotamal.**

The available water sources

The previous considerations show that there are principally two water sources:

1. Water from the Čunovo Reservoir:
   - On the left side of the Danube old riverbed (the Slovak part of the arm system) it is the water from the by-pass canal inflowing into the arm system through the intake structure at Dobrohošť. Its amount can be regulated in a wide range of 0 to 240 m^3/s.
   - On the Danube right side (the Hungarian part of the arm system) it is the water from the Čunovo Reservoir from the intake structure leading water into the Mosonyi Duna with the capacity up to 40 m^3/s and water from the seepage canal.
2. Water from the old Danube, whose total quantity ranges, according to the "Agreement" from 1995, from 250 to 600 m^3/s. During the flood discharges, its amount can be much larger, theoretically more than 10,000 m^3/s. According to the proposal of the Hungarian side from 1999 (OFFICE OF THE PREMIER MINISTER OF THE HUNGARIAN REPUBLIC 1999) based on the opinion of five Hungarian institutions, which defines the ecological-technical concept, the explicitly defined ecological minimum of the discharges in the old Danube in the growing season is 400 m^3/s, while in winter 20-40 m^3/s. Water sources are:
   - On the Hungarian side the water from the old Danube is connected with arm system directly by inlets situated upstream of the Dunakiliti weir. In summer 100-300 m^3/s water flows into the arms.
   - A overflow dam, similar to that on the river km 1843 at Dunakiliti, constructed at Dobrohošť would make possible to supply analogically the Slovakian arm system directly from the old Danube.

It is evident that both the basic water source, the water from the Čunovo Reservoir and the by-pass canal and the water from the Danube old riverbed, are available and can be mutually combined.

The solution presumes several varieties. The optimal and most functional variety, from the viewpoint of ecology and ecosozology, seems to be the solution presuming creation of the new eupotamal in the main arms of the present floodplain. We prefer the complex Slovak-Hungarian solution, which would restore the unique ecosystem in this stretch of the Danube. The second preferred solution is creation of two parallel eupotamals on both sides of the old riverbed.

These two varieties presume to connect the water of arms with the old riverbed downstream of the Dunakiliti weir, for example by means of submerged dams. Furthermore they presume two alternatives – one common Slovak-Hungarian eupotamal crossing the old riverbed in several places or two separate eupotamals, each on one side of the Danube, not crossing the old riverbed. Decision about one of these alternatives does not exclude accepting later another alternative or to solve the situation on one side of the Danube only.

Beside this, the intake structures for Mosonyi Duna at Čunovo and for the Slovak arm system at Dobrohošť will remain functional. In the Slovak side it will be possible to reduce the water amount inlet through this intake structure and to use it for a complementary control of discharges in the arms and for the simulation of floods.

The old river bed, obviously in a rearranged form, will retain its function of leading the flood discharges, hence leading of those discharges which can not flow through the by-pass canal, arm systems and, at higher discharges, through the entire floodplain zone. In the non-flood situations it will lead the sanitary discharges or it will be changed into a riverbed with low submerged weirs and impounded sections. These intermittently flowing and stagnant sections may be used e.g. for sports navigation. In any case it is necessary to calculate, and maintain its flood protections function.

The main kind of arrangements in arm systems is their transformation to discharging arms of the eupotamal type, which will form a new river. One of the possible proposals, for example, is represented in **Fig. 8.1**. Of course, the scheme can look otherwise. Principally it is a functional solution close to the natural state, which will be obtained by the gradual diversion of the discharge from the old riverbed into the original arm system, adapted step by step for the required discharges. It means restoration of the anastoming and meandering river pattern, which existed here in the past, and the gradual leaving of the canalised old riverbed of the Danube whose transformation was finished in the past century.

Sequence of works

In regard to the existing experience and information from Austria, all realisation steps should be modelled in advance, step-by-step realised, and, at the same time, step-by-step monitored. One of the possible alternatives is, for example the following:

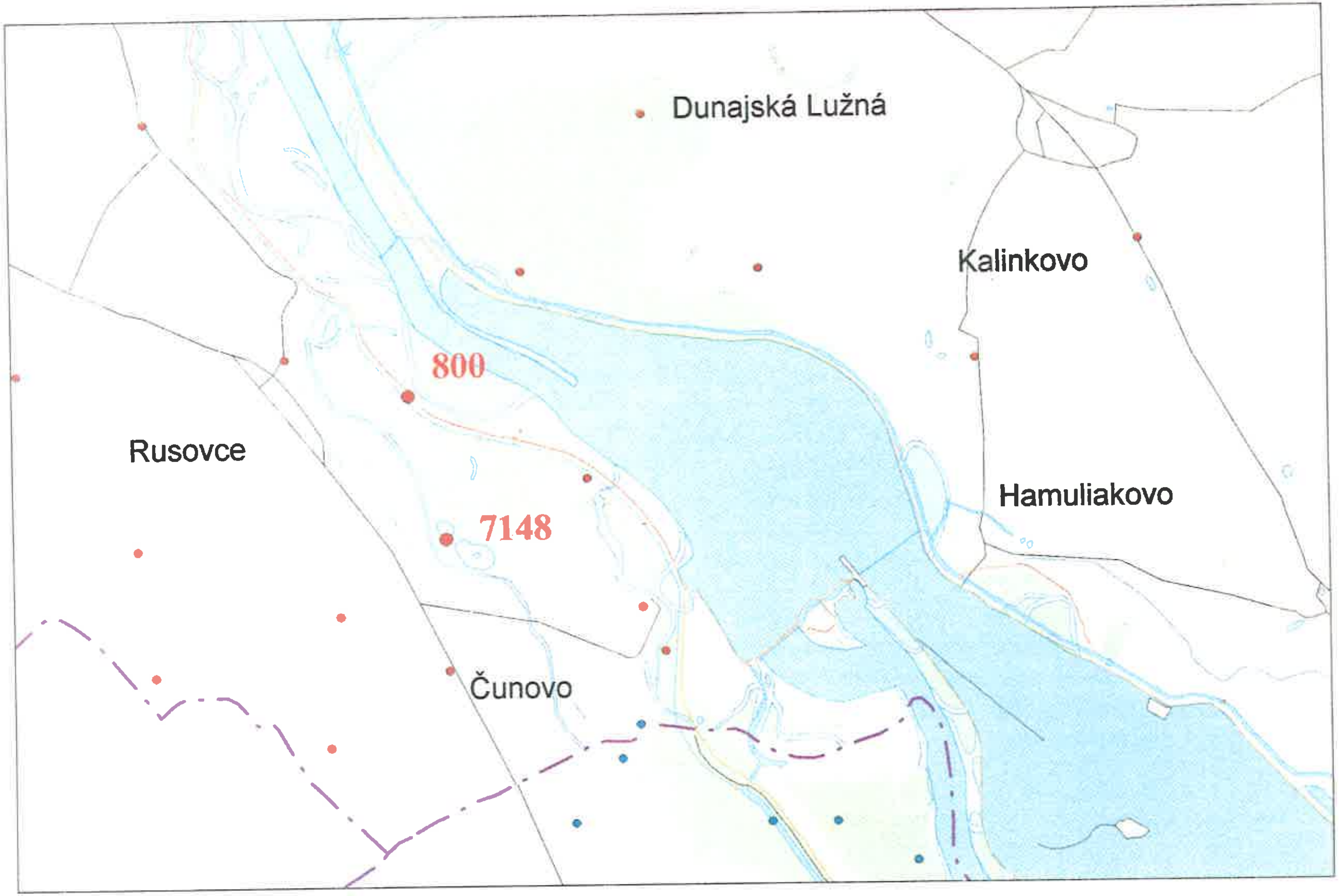
- Elaboration of the proposal for connection of the old riverbed with the future arm of the eupotamal type, verifying the solution by means of modelling and elaboration of the project,
- Construction of the submerged dam somewhere between the river km 1838 (Vojka) and 1840 (Dobrohošť),
- Construction of a sill and groyne in the inlet canal at the sluice at Dunajské Kriviny.
- Connecting the Vojčianske Rameno arm by means of an inlet (opening) in the banks with the backwater in the Danube old riverbed.
- Construction of a dam in the river km 1830 at Bodícka Brána (or r. km 1828.35 downstream of the present line E or in r. km 1831.70 downstream of the present line C or in the r. km 1834.90 downstream of the present line B) upstream of which the new eupotamal could cross the Danube old riverbed and conceivably intake there more water from the old riverbed.
- Monitoring of the changes arising after the construction of dam and processes in the arm, mainly the relation between erosion and sedimentation, transformation of banks, etc.
- To leave the sanitary discharge in the old riverbed and to adjust it for transferring the flood discharges.
- Evaluation of changes and processes, implementation of the results into the model, repeating of the models.
- Evaluation of results of previous works and proposal of further course of the works.

9 EPILOGUE

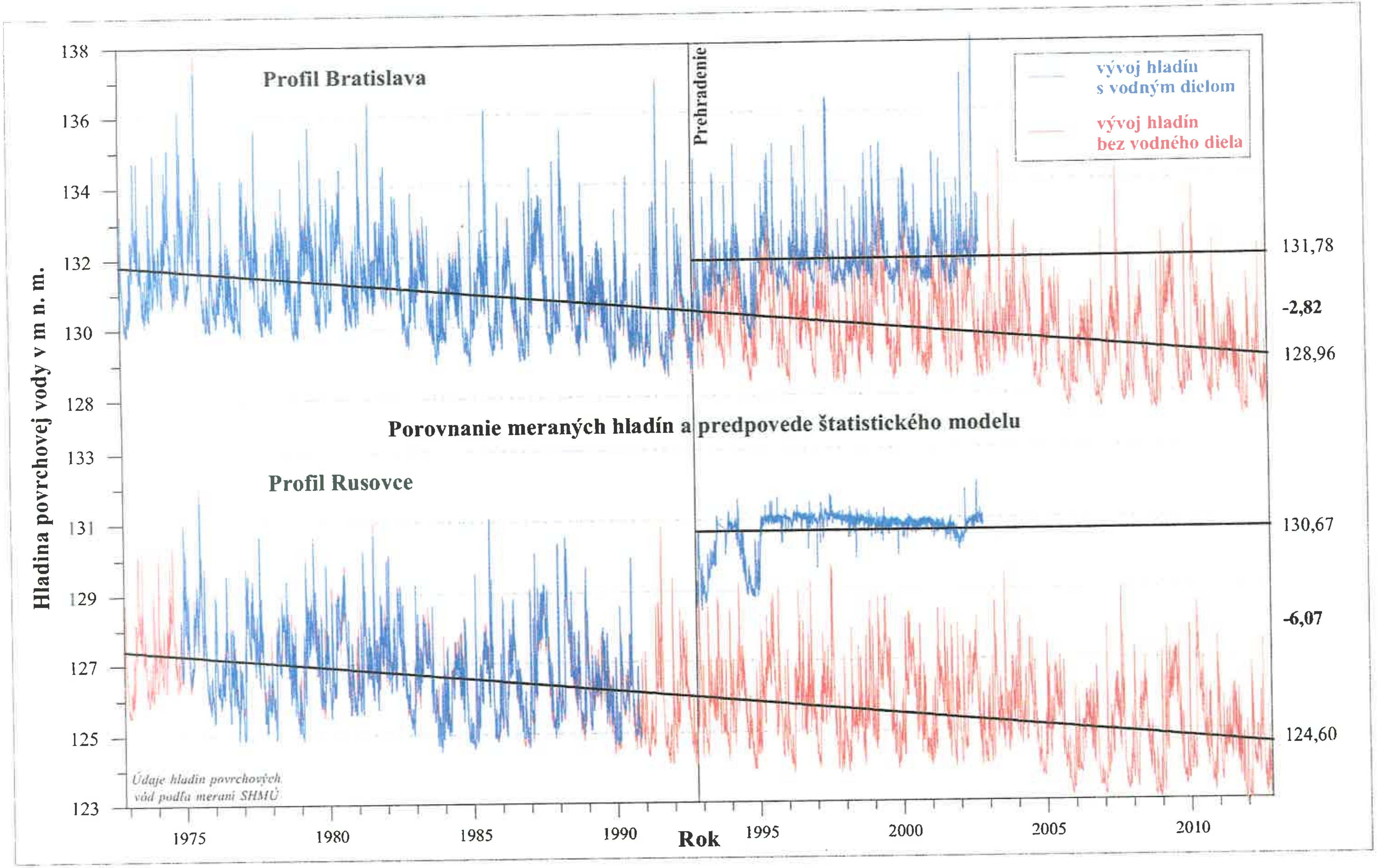
In this study, which provides qualitative and logic-based analysis of complex environmental assessment of problems, goals and possibilities, we tried to present a vision of how the floodplain between the flood protection dikes of the Danube old riverbed in the stretch between the Dobrohošť and Sap villages should look from the viewpoint of flood protection and natural functions. This vision is based on the knowledge of a large group of experts. Their ideas are presented, cited and summarised in the vision. They represent a scientific background of opinions and interpretation of monitoring of natural environment.

It is evident that the proposed state cannot be obtained, at once and quickly. Gradual steps are presumed, with minimal technical interventions and minimal regulation works. The results of this effort do not depend only on water management measures, but also on different decisions of different levels, from the international negotiations to the local authorities and individuals. However these aspects are not the topic of our study. The study does not insist on the strict respecting of all opinions, but it proposes an aim, which can be reached just by the gradual steps, discussion and application of monitoring and interpretation of its results. The authors expect that all proposals and projects will be first professionally discussed, modelled, and after their realisation monitored, evaluated and gradually completed so that they lead to the filling of the vision proposed.

OBRÁZKY - FIGURES

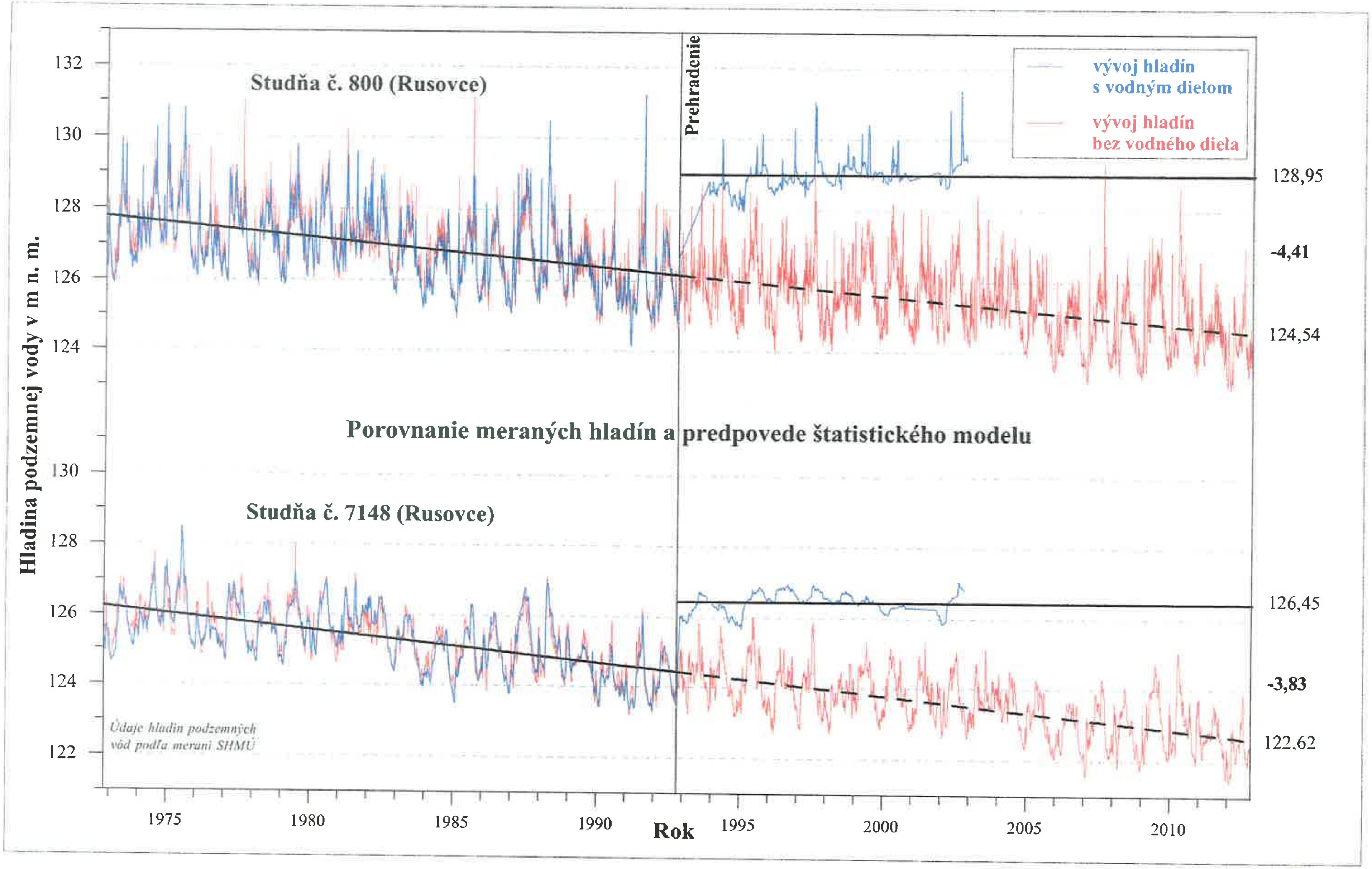


Obr. 0.1 Monitorovanie hladiny podzemnej vody v oblasti Rusovce - Čunovo
Fig. 0.1 Monitoring of the ground water level in the area of Rusovce - Čunovo villages



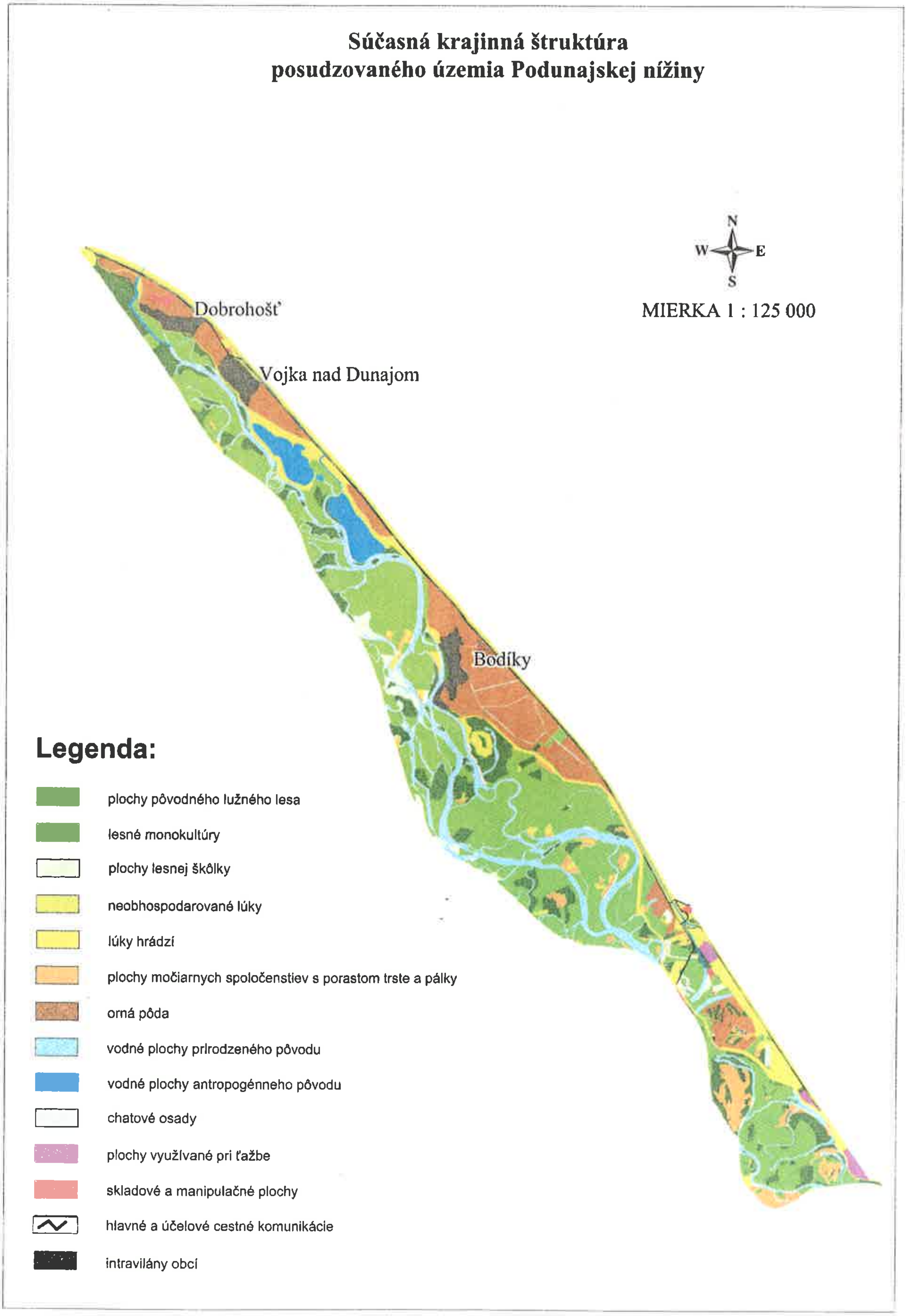
Obr. 0.2 Hladiny vody v Dunaji v Bratislave a Rusovciach
(modré - monitorované hodnoty; červené - vypočítané štatistickým modelom a predpovedané po prehradení Dunaja)

Fig. 0.2 Water table in the Danube at Bratislava and Rusovce
(blue colour - measured data, red colour - calculated by statistical model and forecasted after damming the Danube)



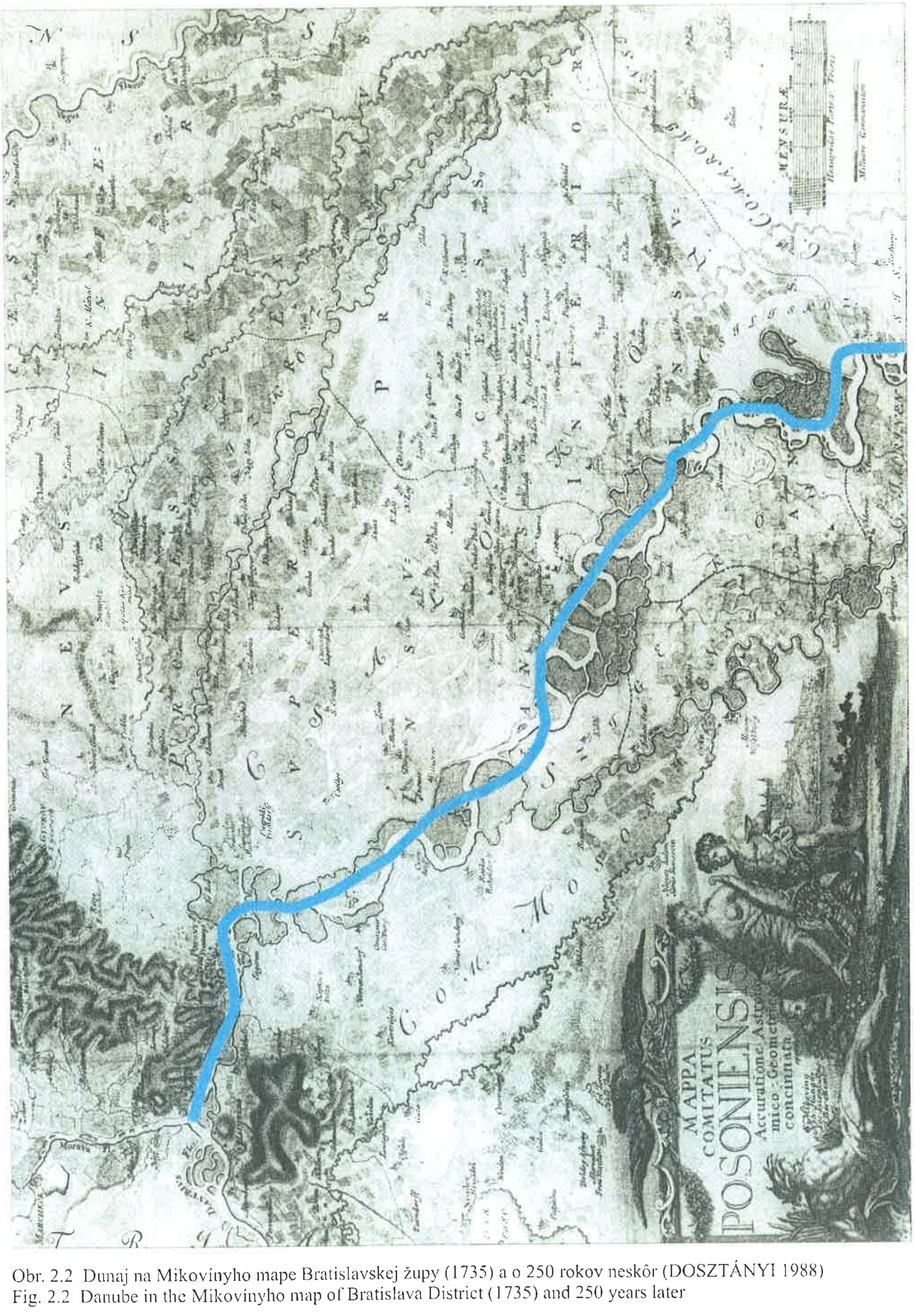
Obr. 0.3 Hladiny podzemnej vody
(modré - monitorované hodnoty; červené - vypočítané štatistickým modelom a predpovedané po prehradení Dunaja)

Fig. 0.3 Ground water level
(blue colour - measured data; red colour - calculated by statistical model and forecasted after damming the Danube)

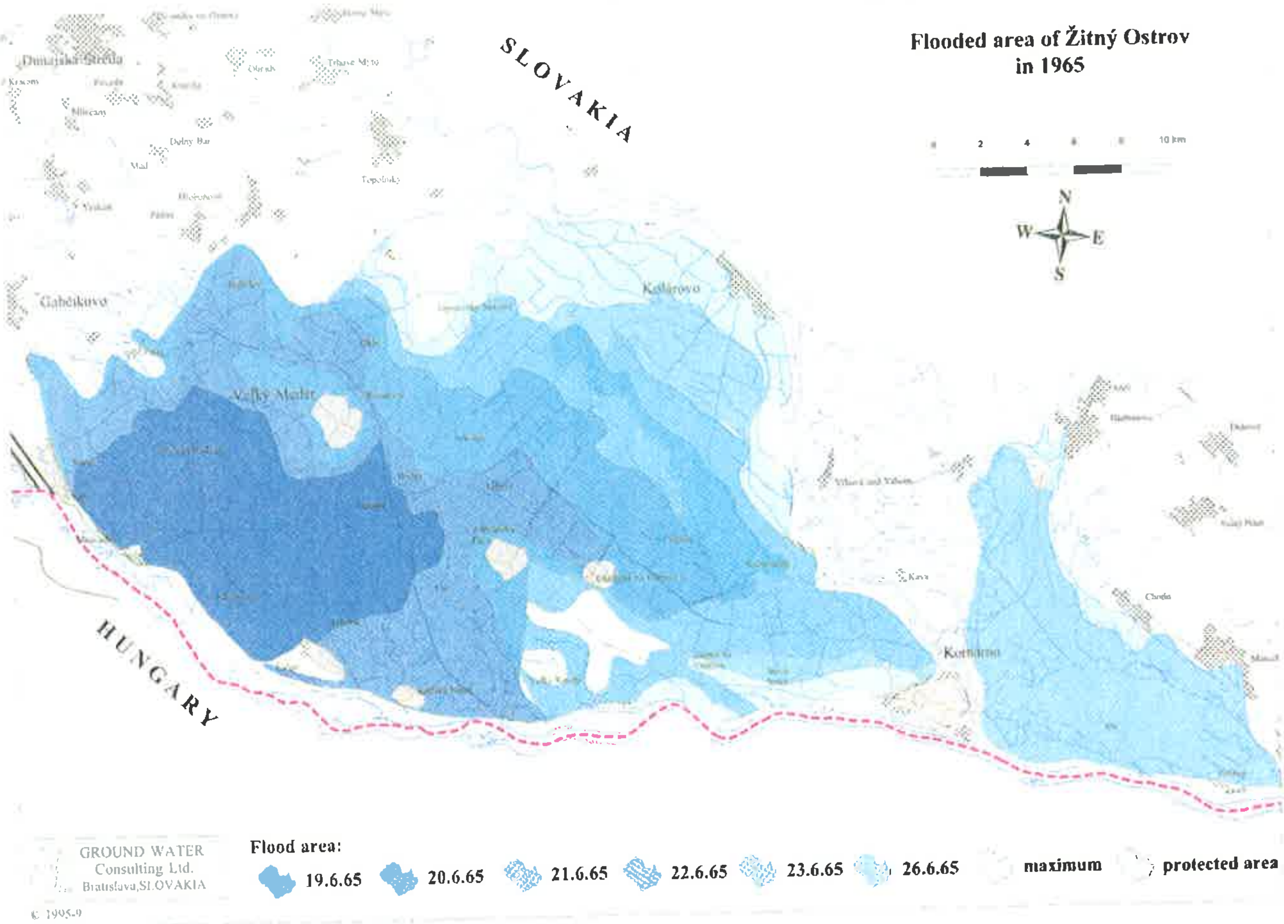


Obr. 1.1 Prehľad o súčasnej krajinnej štruktúre podľa Kozovej a kol.
Fig. 1.1 General view of landscape structure according to Kozová et al.

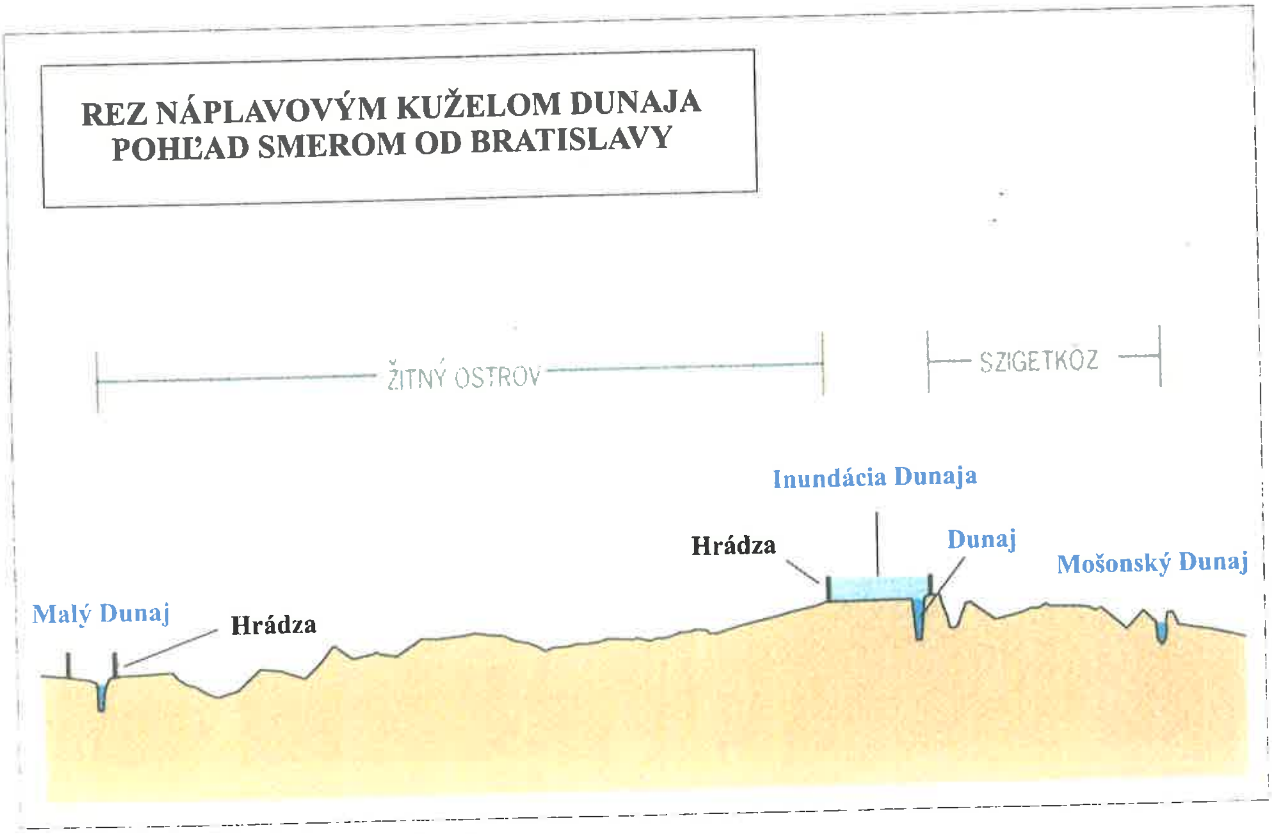
Obr. 2.1 Inundačné územie s ramennou sústavou
Fig. 2.1 Floodplain with the Danube branches



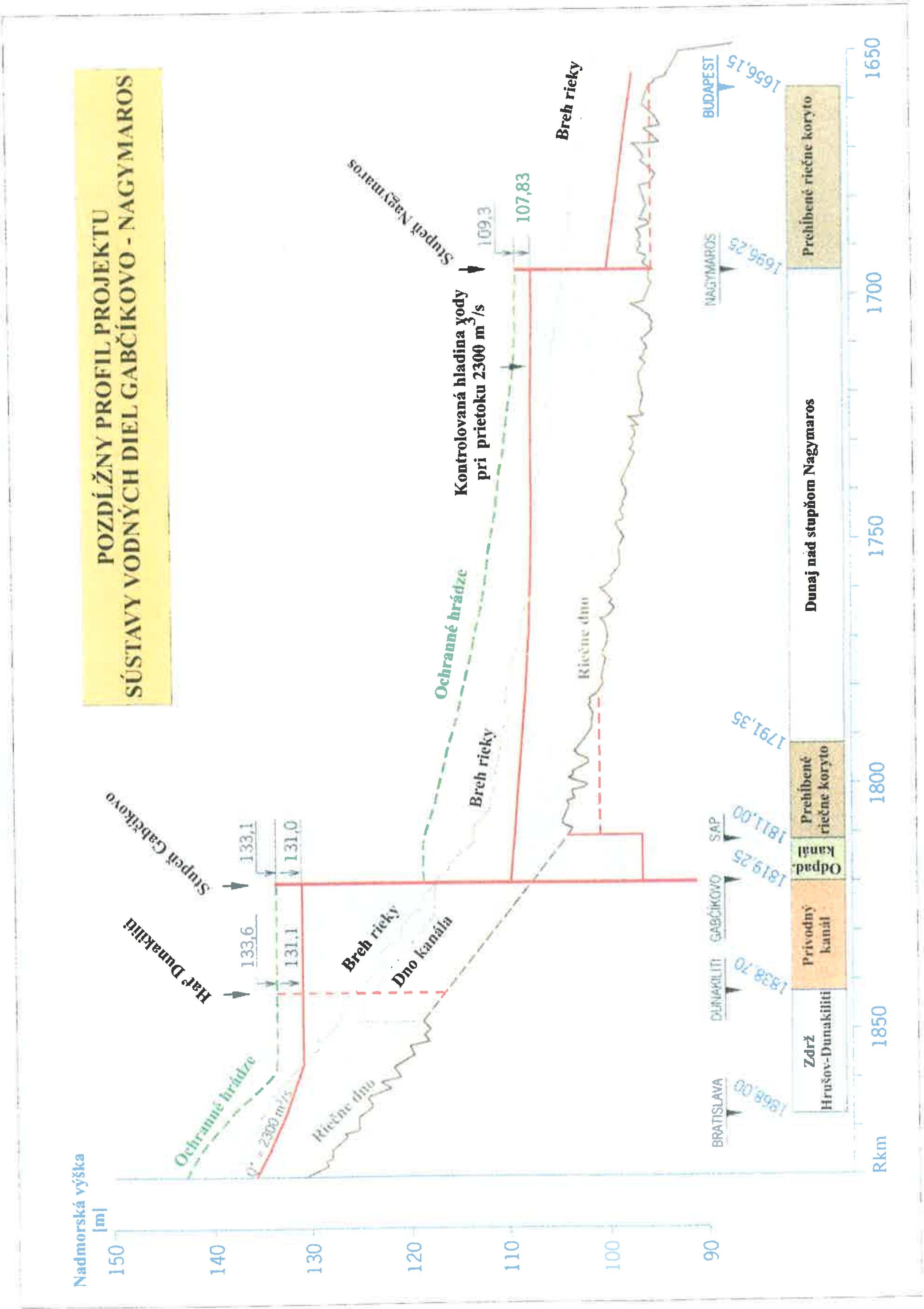
Obr. 2.2 Dunaj na Mikovínyho mape Bratislavskej župy (1735) a o 250 rokov neskôr (DOSZTÁNYI 1988)
Fig. 2.2 Danube in the Mikovínyho map of Bratislava District (1735) and 250 years later



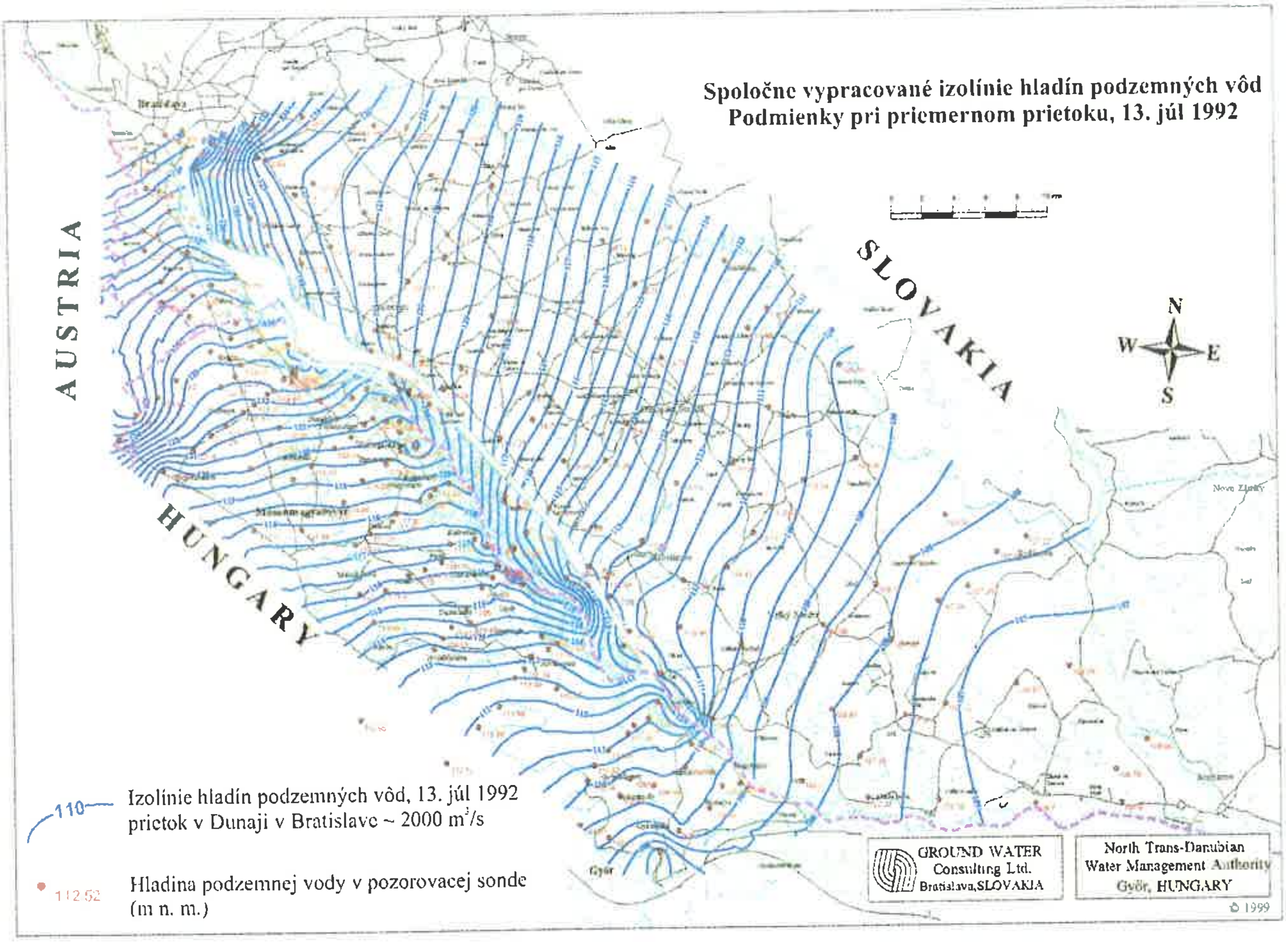
Obr. 2.3 Zaplavené územie Žitného ostrova v roku 1965
Fig. 2.3 Flooded area of Žitný ostrov in 1965

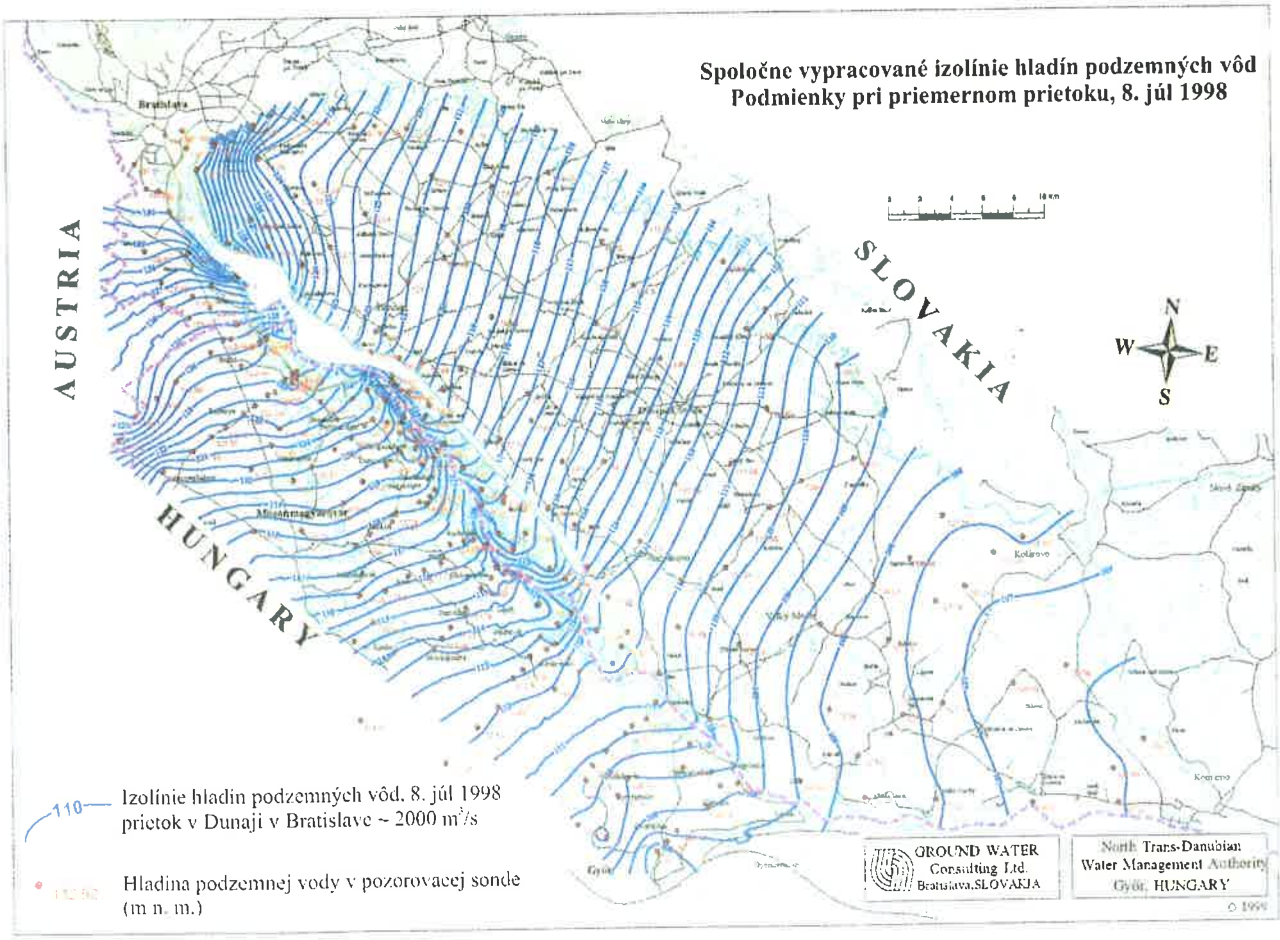


Obr. 2.4 Rez náplavovým kužeľom Dunaja
Fig. 2.4 Cross-section through the Danube alluvial fan

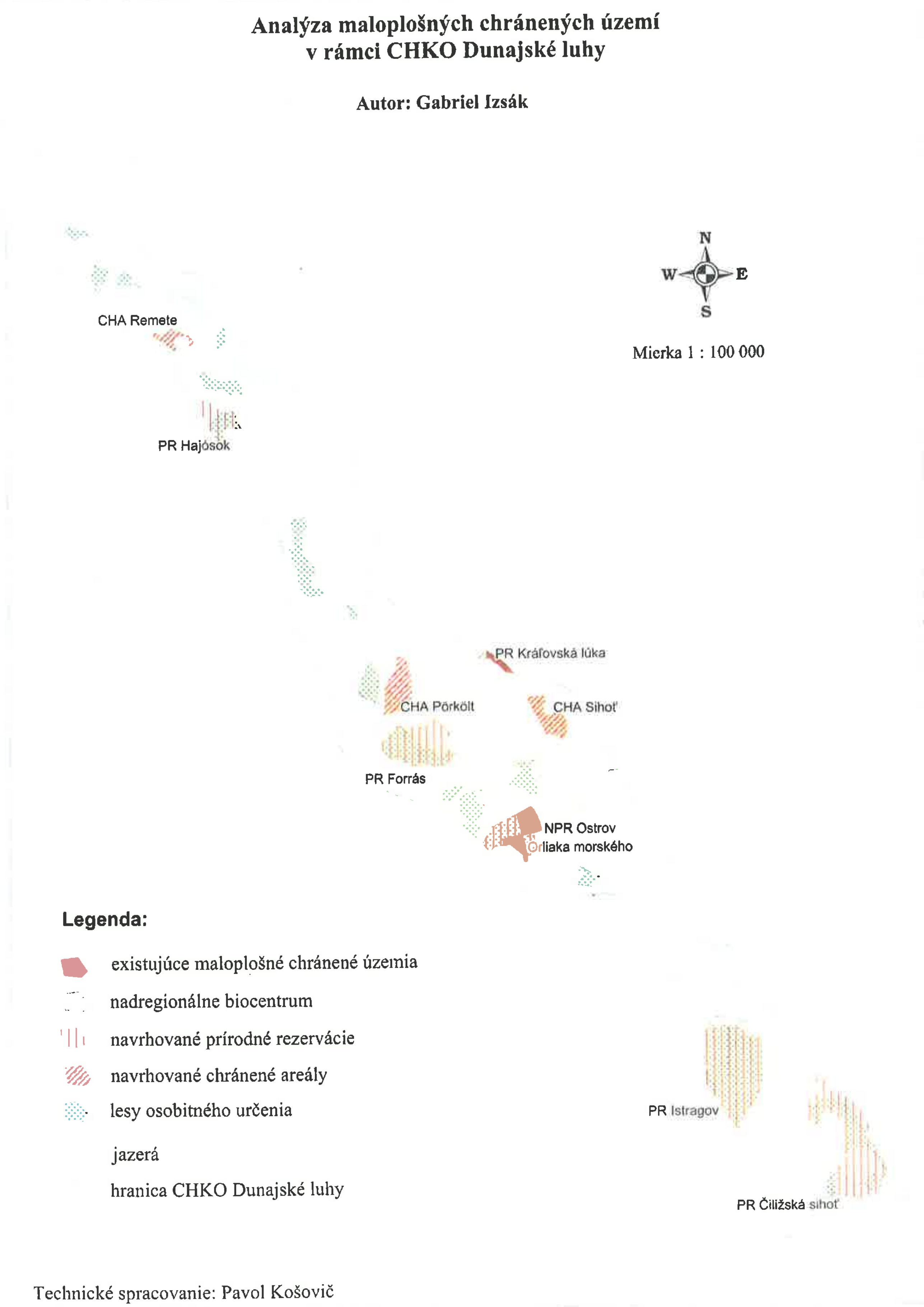


Obr. 2.5 Pozdĺžny profil projektu Sústavy vodných diel Gabčíkovo - Nagymaros
Fig. 2.5 Lengthwise profile of the system of Gabčíkovo-Nagymaros Project





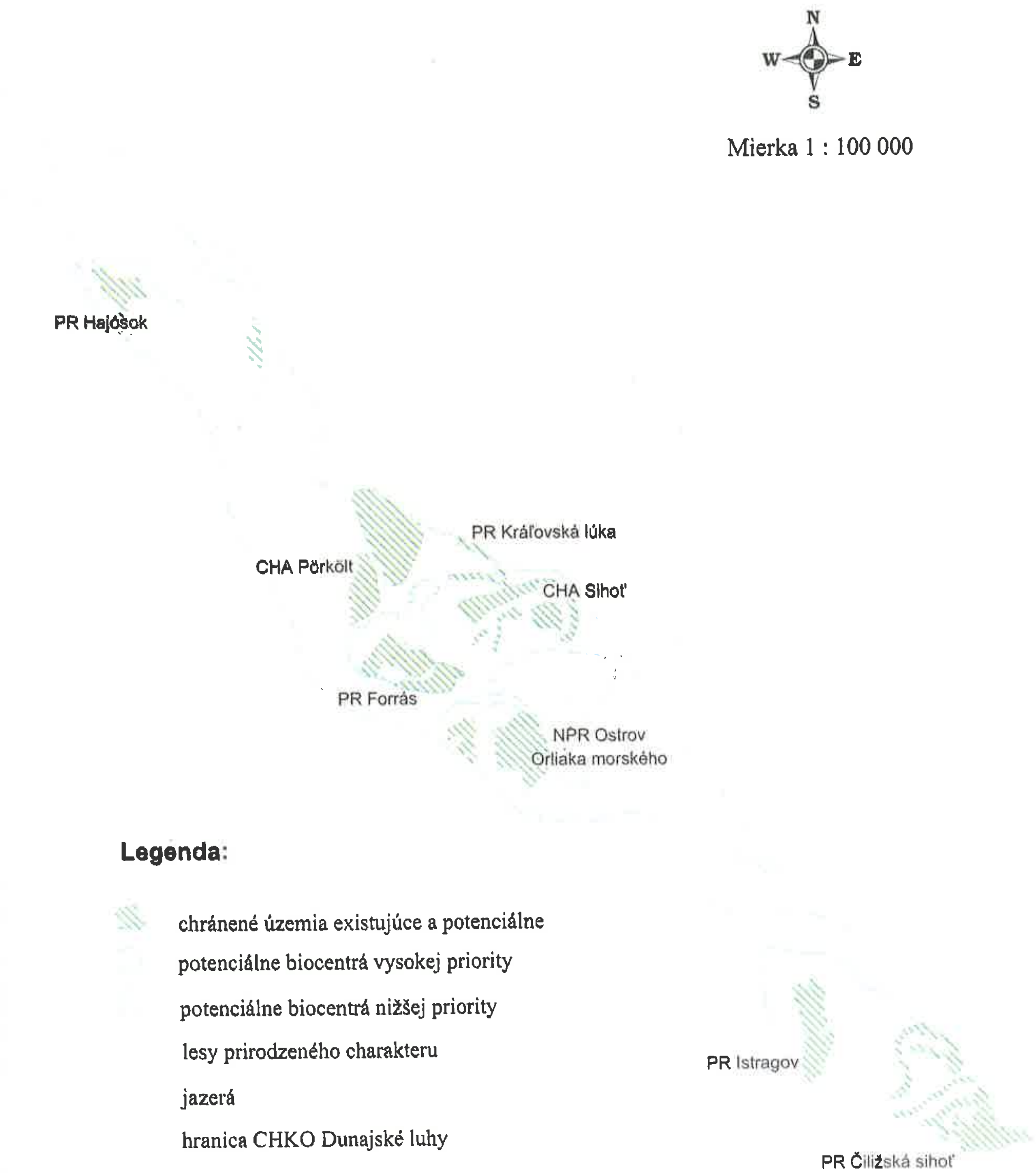
Obr. 2.6 Izolínie hladiny podzemnej vody pred a po prehradení Dunaja
Fig. 2.6 Contour lines of the ground water level before and after putting the Project into operation



Obr. 3.1a Súčasný stav biocentier, existujúcich a navrhovaných chránených území podľa Izsáka
Fig. 3.1a Present stay of bio-centres, existing and proposed protected areas, according to Izsák

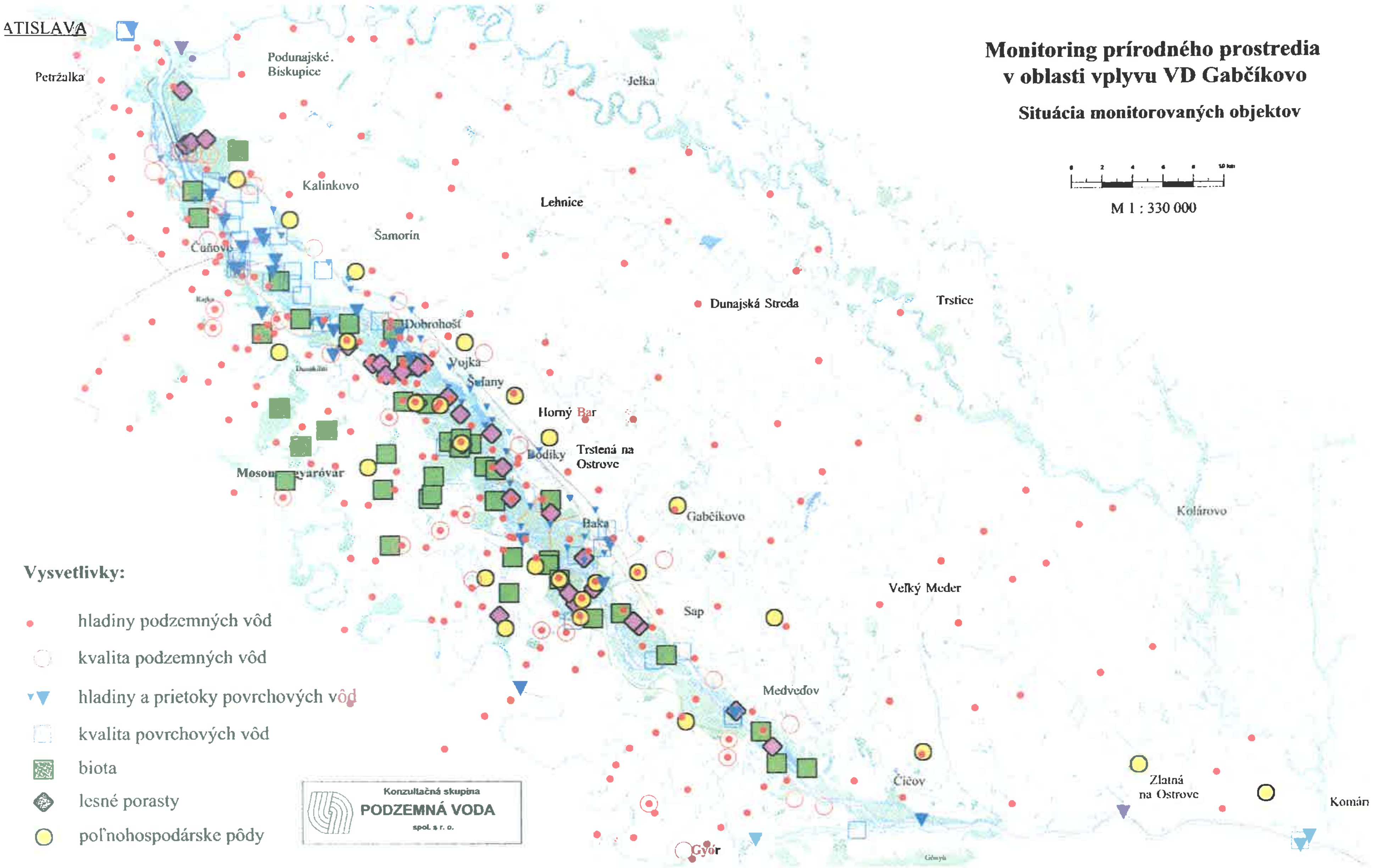
Alternatívne riešenie návrhu malopošných chránených území v rámci CHKO Dunajské luhy

Autor: Mirko Bohuš



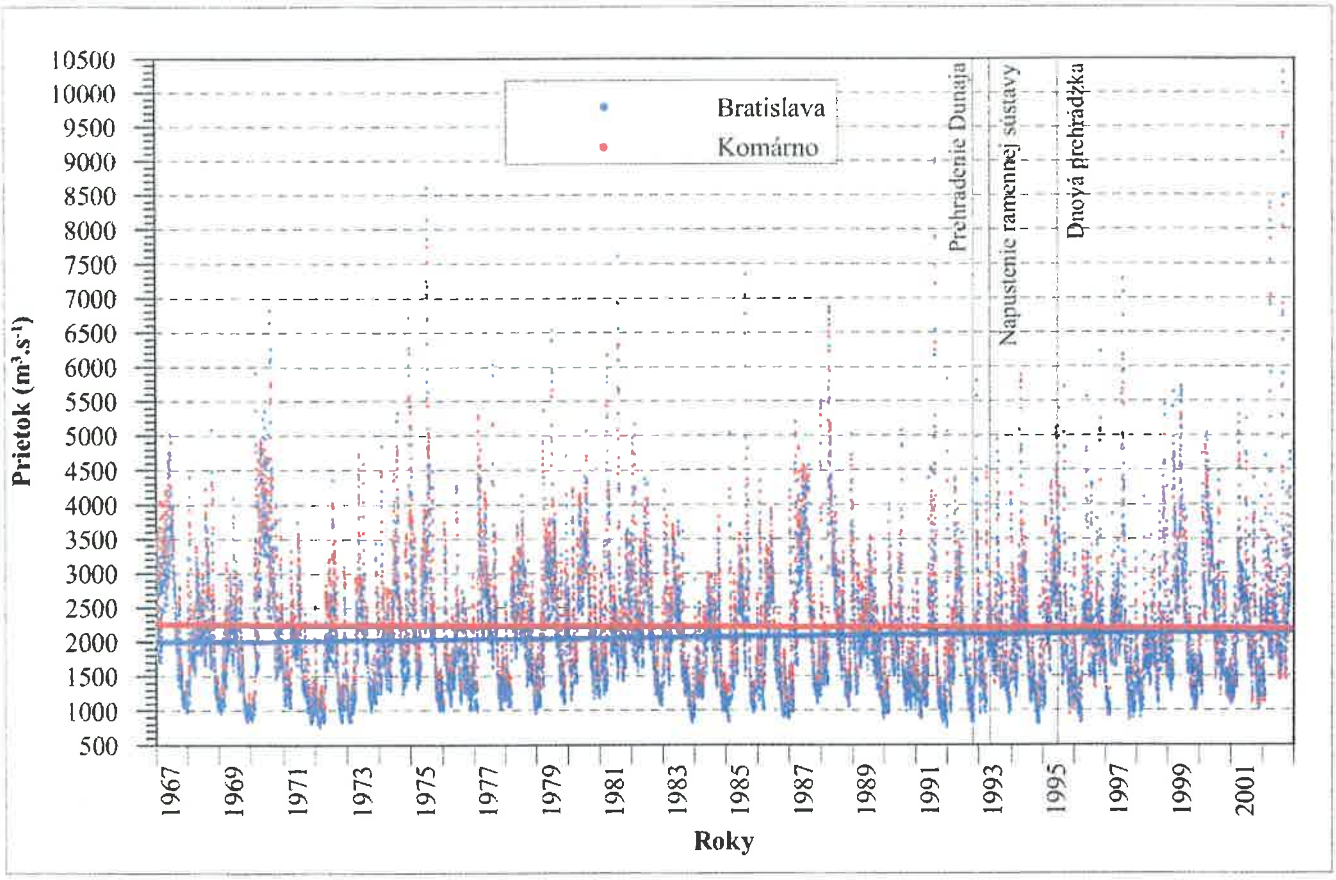
Technické spracovanie: Pavol Košovič

Obr. 3.1b Súčasný stav biocentier, existujúcich a navrhovaných chránených území podľa Bohuša
Fig. 3.1b Present stay of bio-centres, existing and proposed protected areas, according to Bohuš

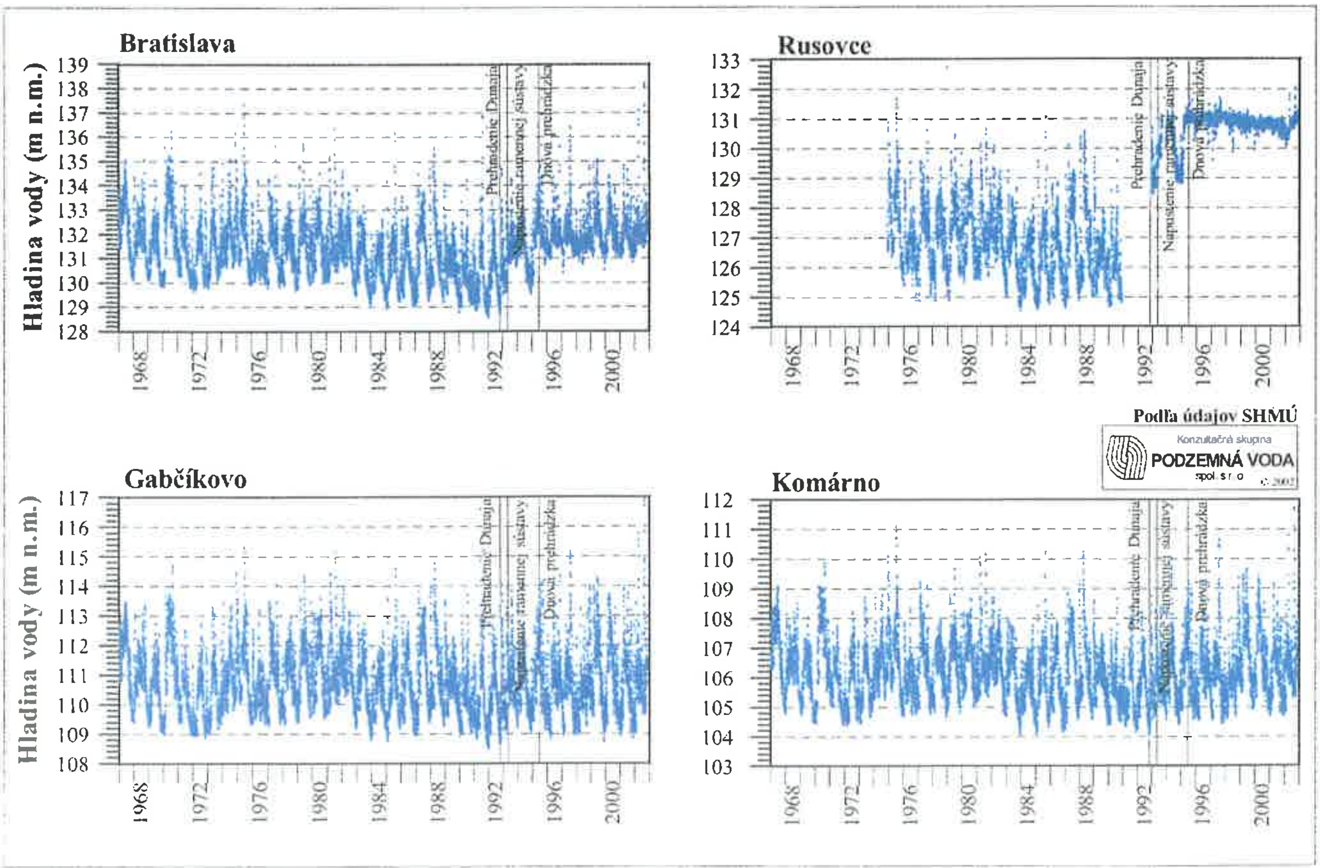


Obr. 4.1 Monitoring prírodného prostredia v oblasti vplyvu VD Gabčíkovo

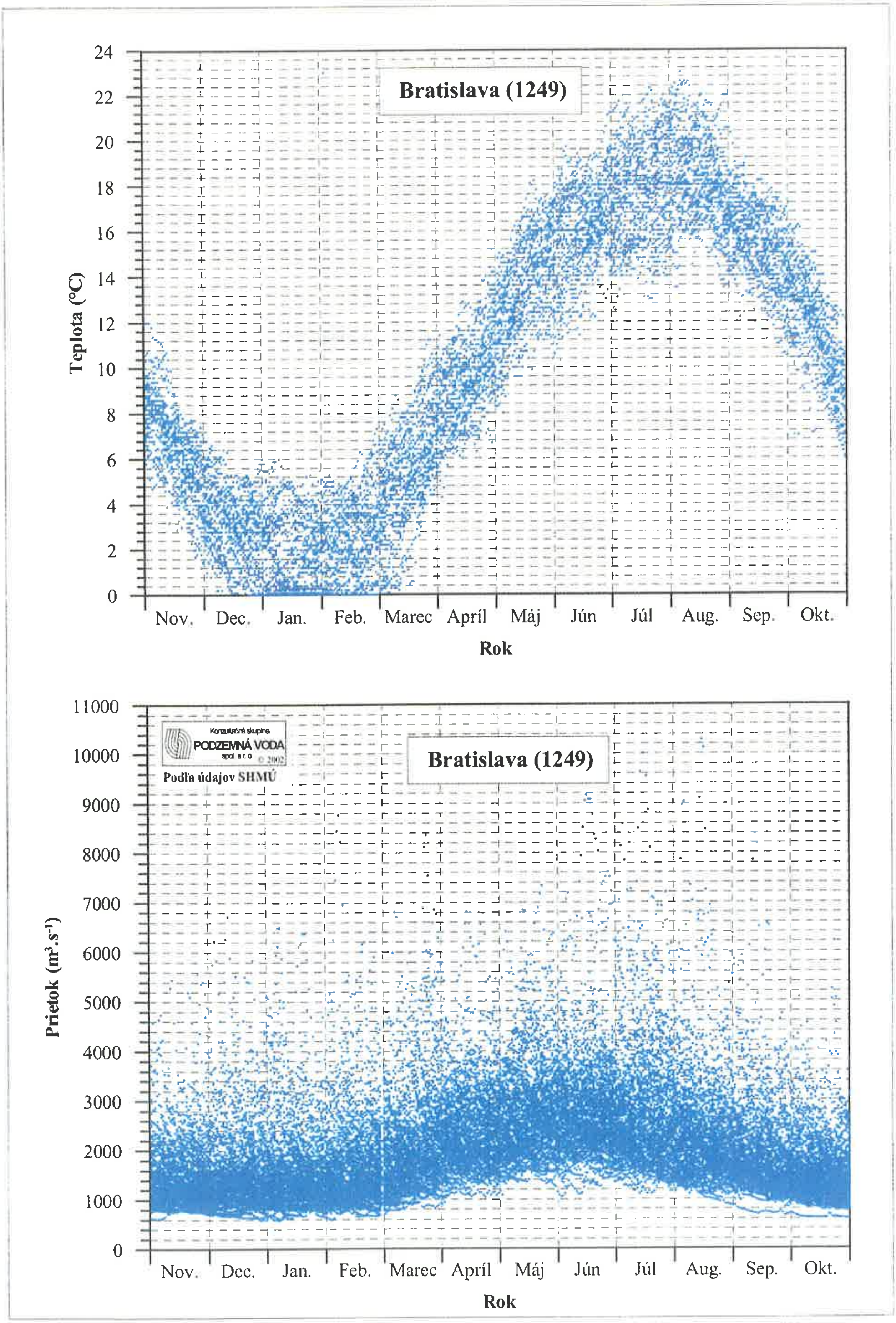
Fig. 4.1 Monitoring of natural environment in the area influenced by the Gabčíkovo hydroelectric power project



Obr. 4.2 Kolísanie prietokov v Dunaji v r. 1967-2002
Fig. 4.2 Fluctuation of discharges in the Danube from 1967-2002

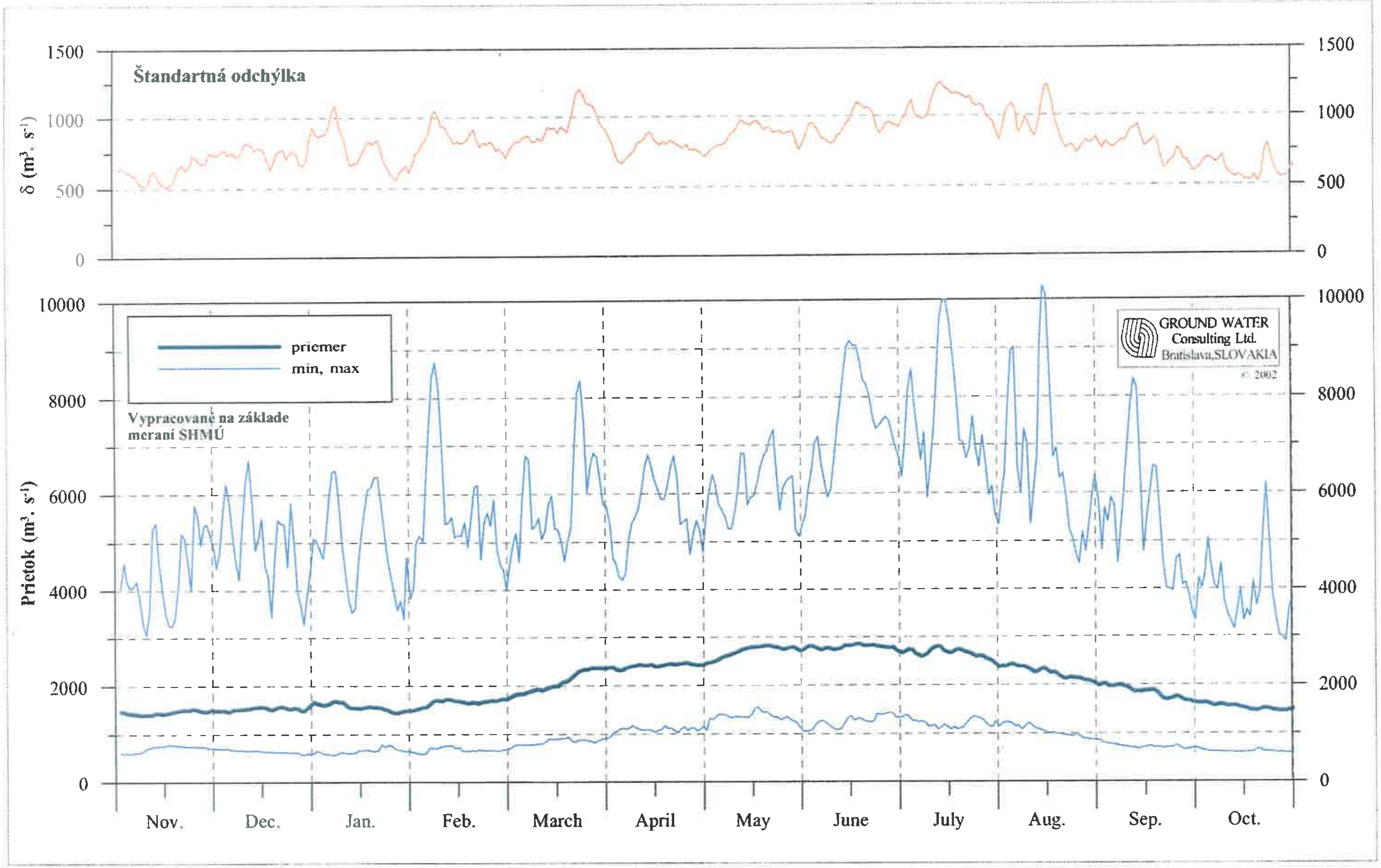


Obr. 4.3 Hladiny vody Dunaja v Bratislave, Rusovciach, Gabčíkove a Komárne v r. 1967-2002
Fig. 4.3 Water levels in the Danube at Bratislava, Rusovce, Gabčíkovo and Komárno from 1967 to 2002



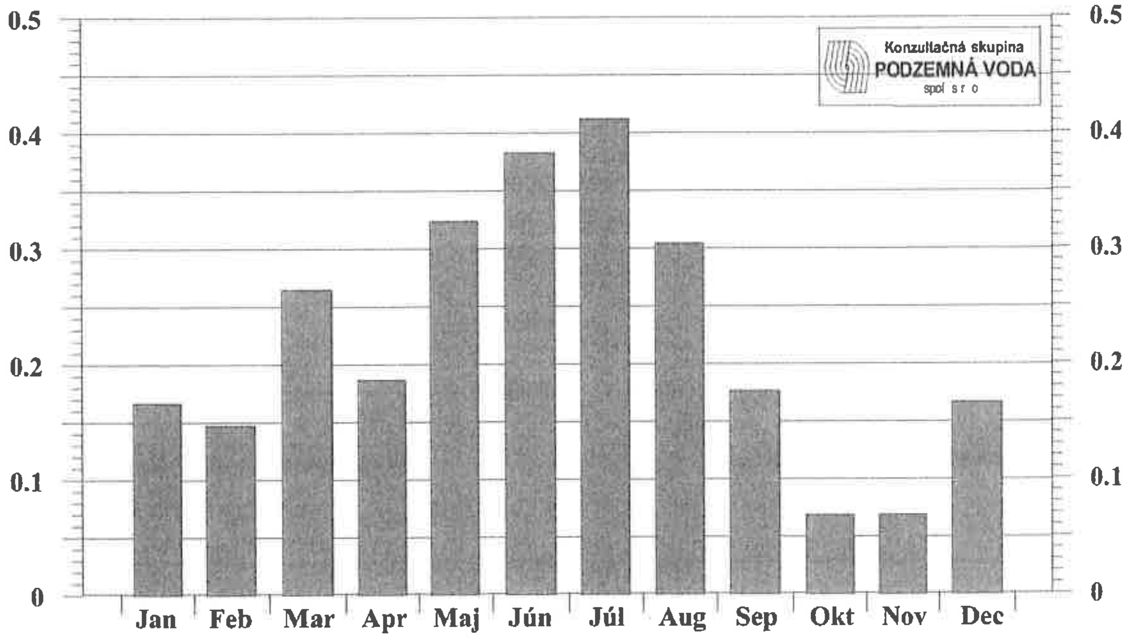
Obr. 4.4 Dlhodobé denné kolísanie teploty a prietoku v Dunaji v Bratislave

Fig. 4.4 Long-term fluctuation of water temperature and discharges in the Danube at Bratislava

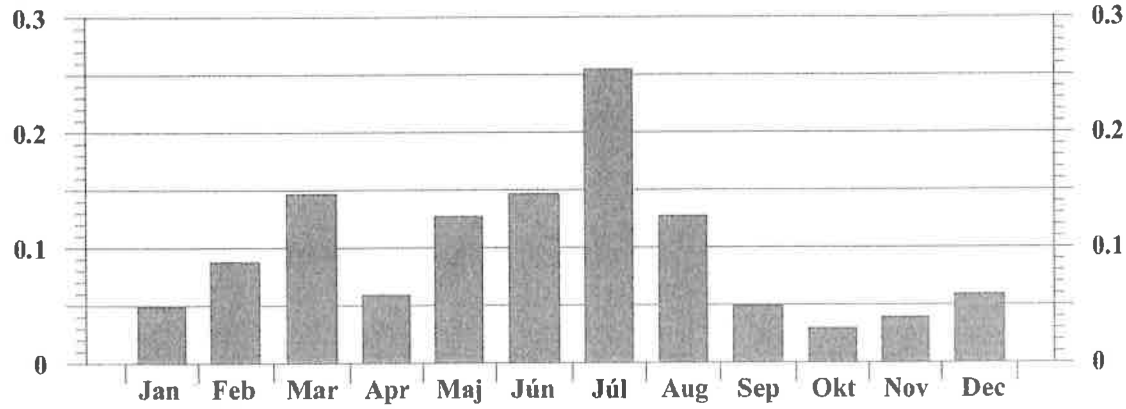


Obr. 4.5 Dlhodobé denné kolísanie prietoku vody Dunaja v Bratislave
Fig. 4.5 Long-term fluctuation of discharges in the Danube at Bratislava

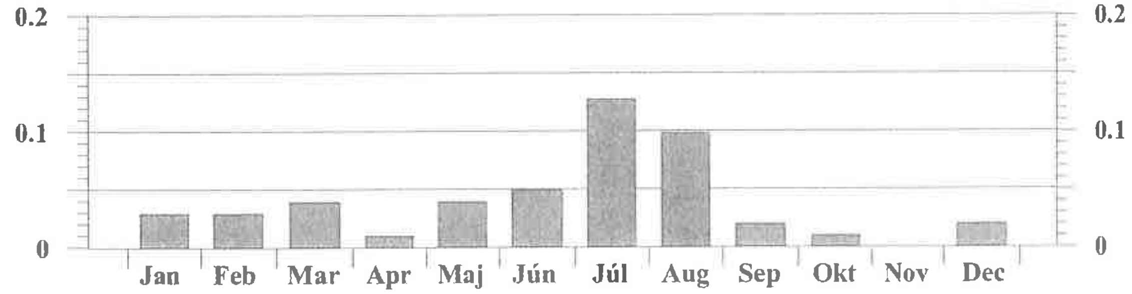
Dunaj - profil Bratislava / Devín
(1901 až 2002)



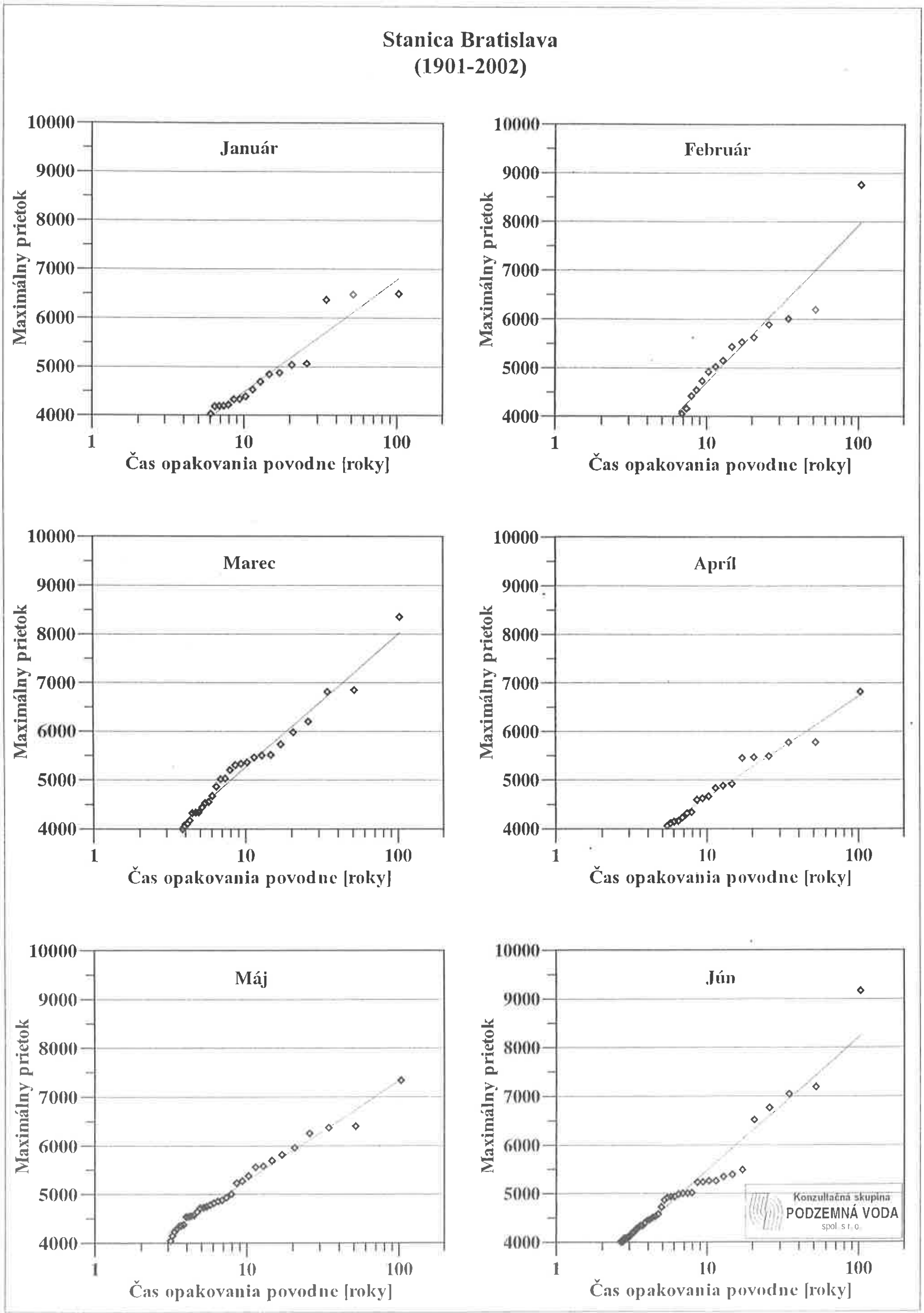
Obr. 4.6a Početnosť výskytu prietokov väčších ako 4000 m^3/s v jednotlivých mesiacoch v roku
Fig. 4.6a Frequency of occurrence of discharges above 4000 m^3/s in individual months in year



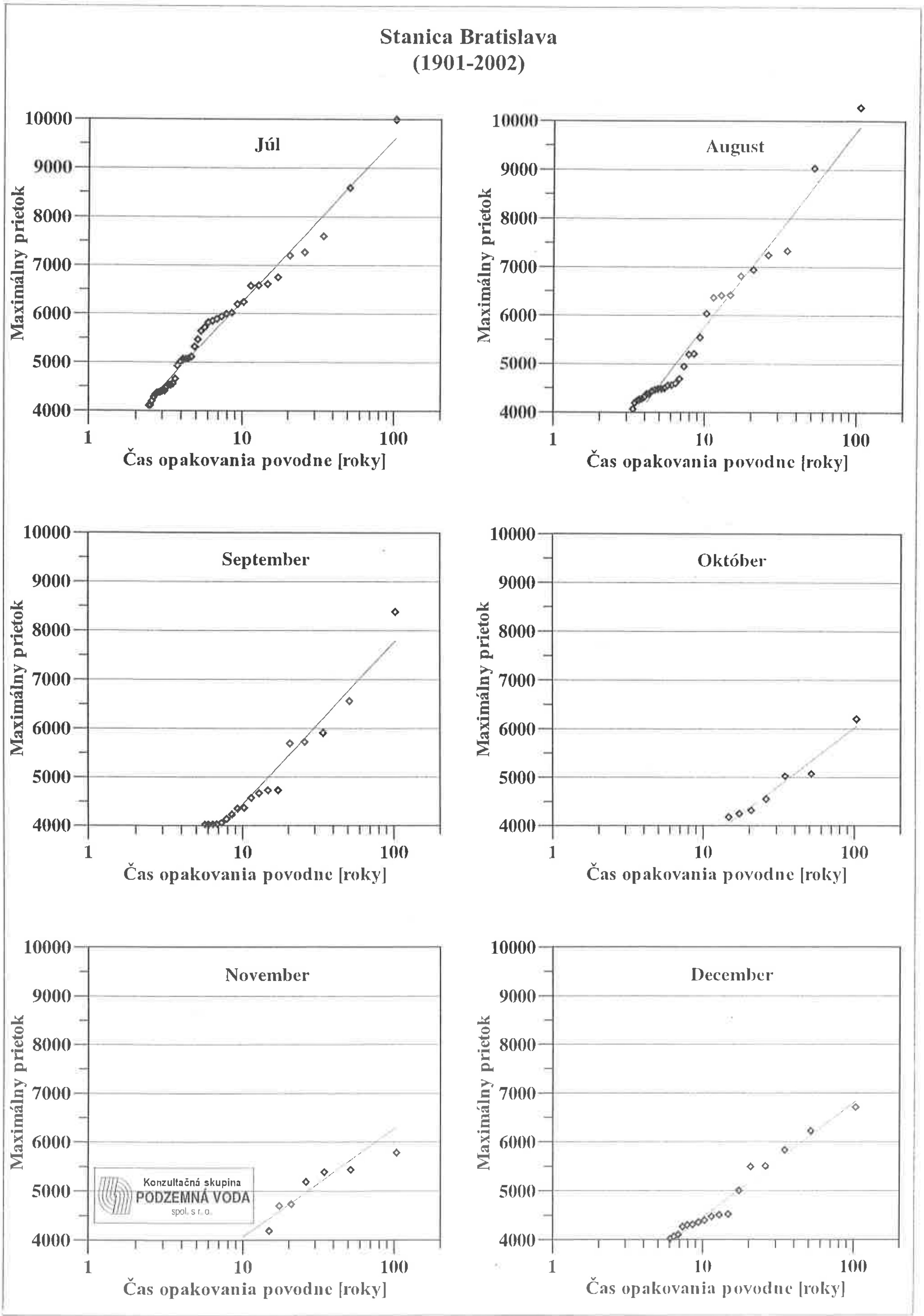
Obr. 4.6b Početnosť výskytu prietokov väčších ako 5000 m^3/s v jednotlivých mesiacoch v roku
Fig. 4.6b Frequency of occurrence of discharges above 5000 m^3/s in individual months in year



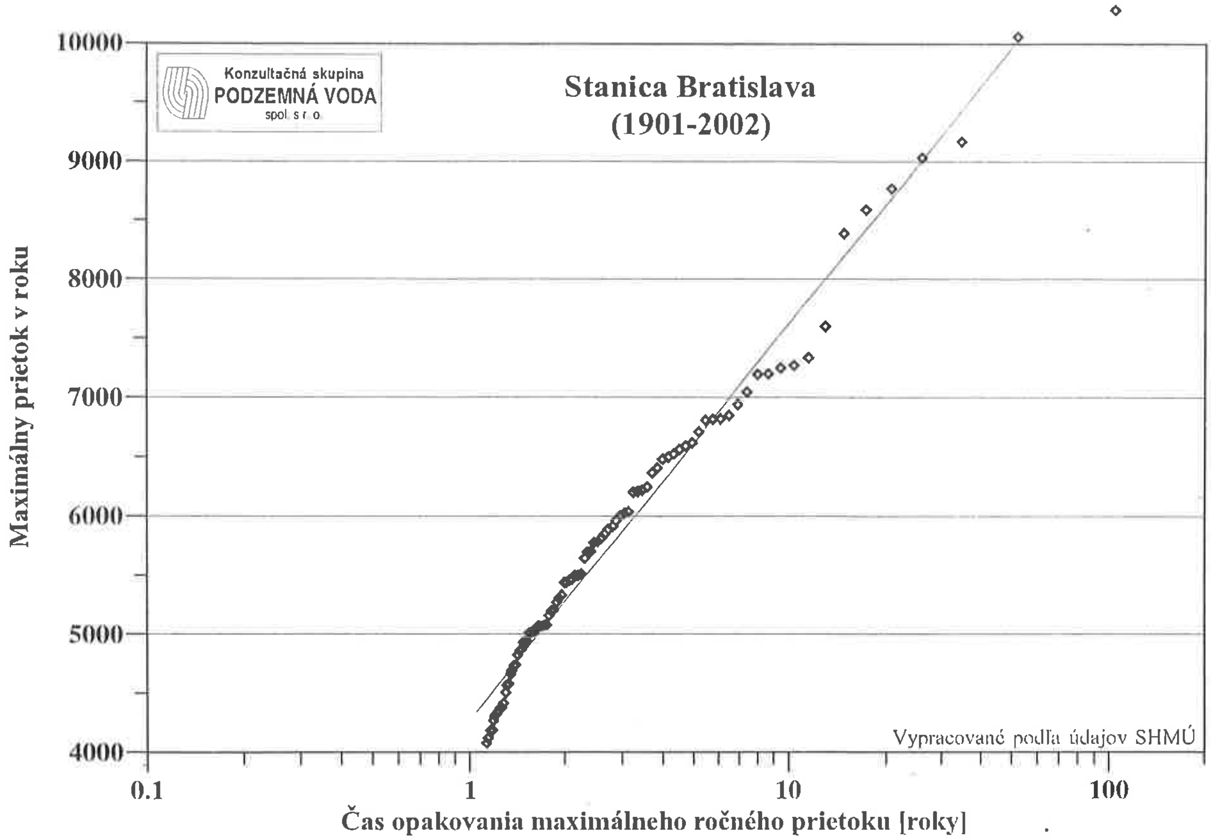
Obr. 4.6c Početnosť výskytu prietokov väčších ako 6000 m^3/s v jednotlivých mesiacoch v roku
Fig. 4.6c Frequency of occurrence of discharges above 6000 m^3/s in individual months in year



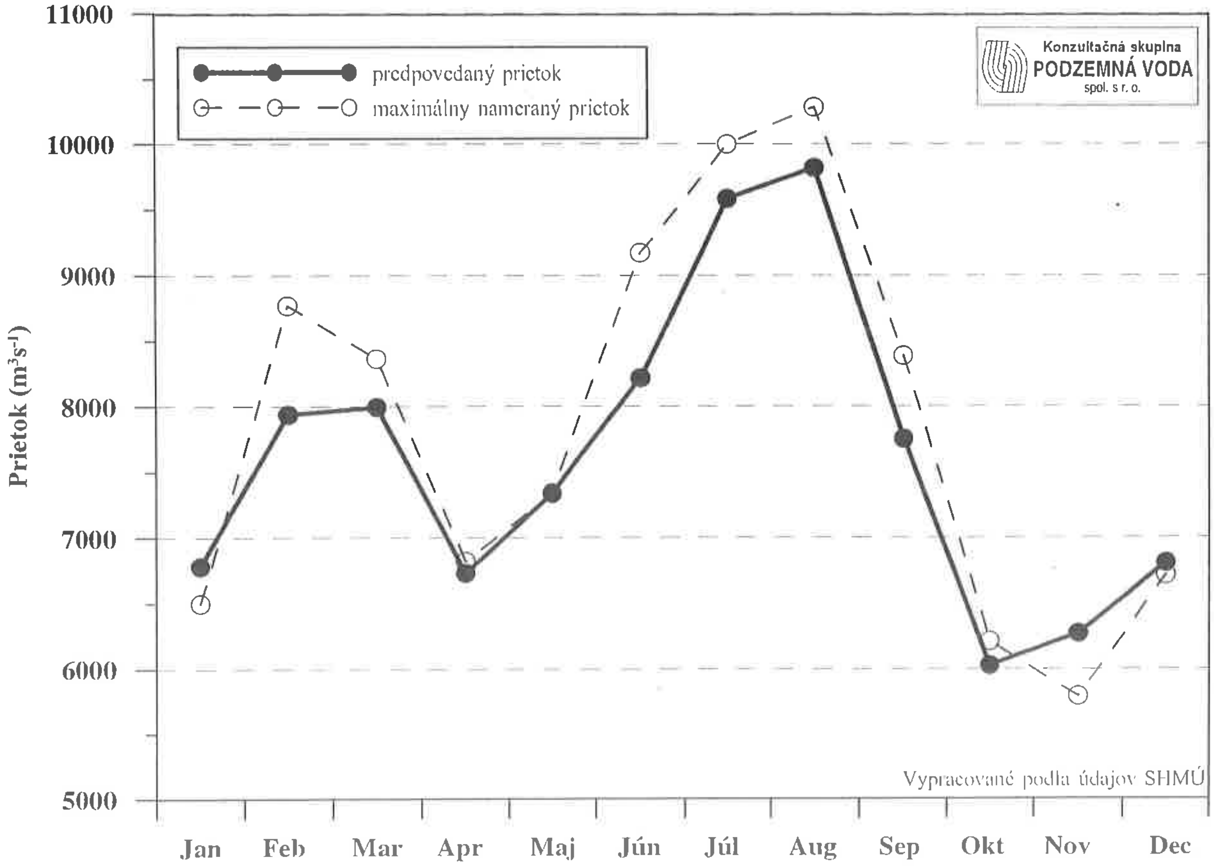
Obr. 4.7a Pravdepodobnosť výskytu maximálneho prietoku v mesiaci
Fig. 4.7a Probability of occurrence of maximal discharge in month



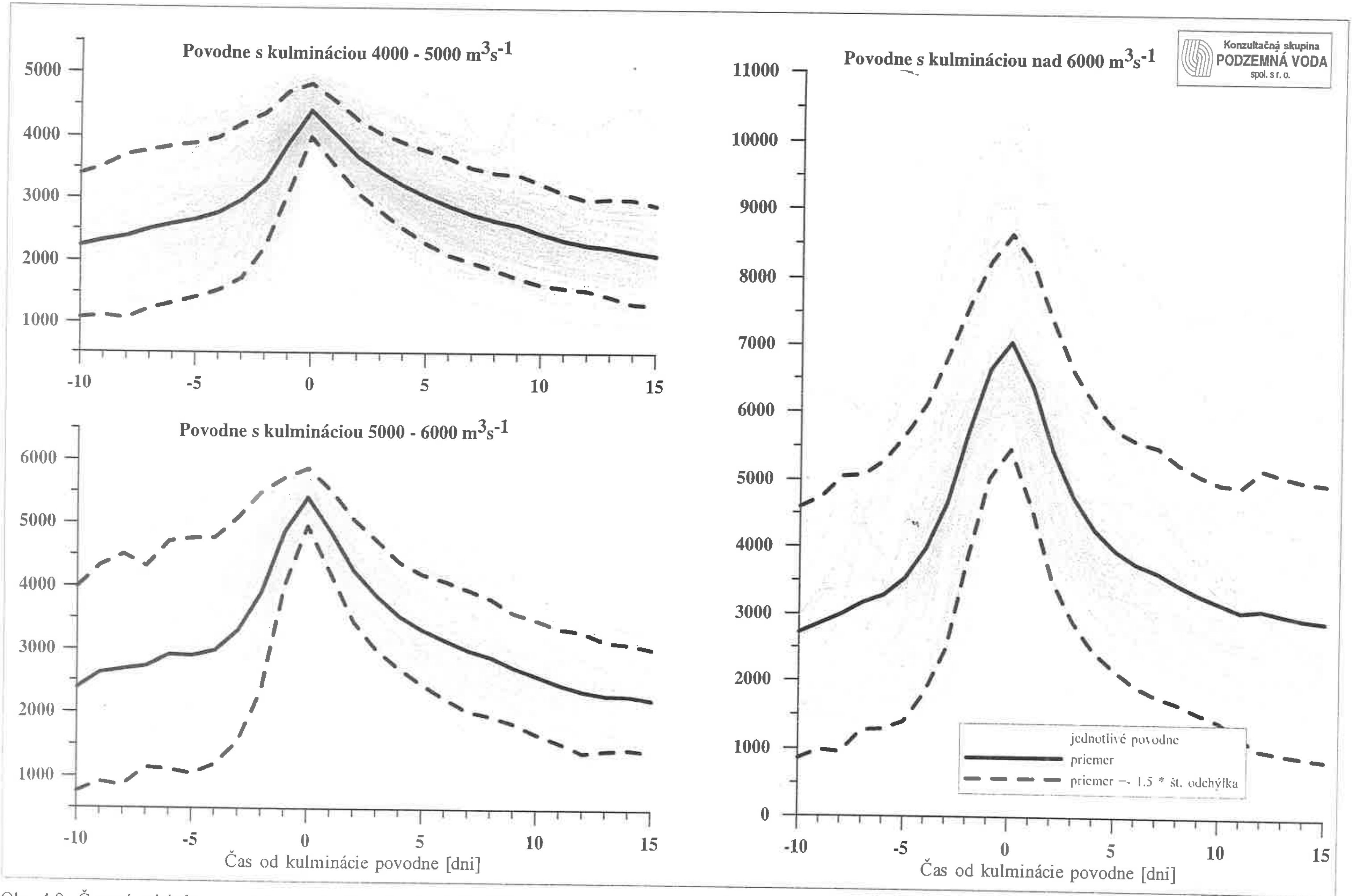
Obr. 4.7b Pravdepodobnosť výskytu maximálneho prietoku v mesiaci
Fig. 4.7b Probability of occurrence of maximal discharge in month



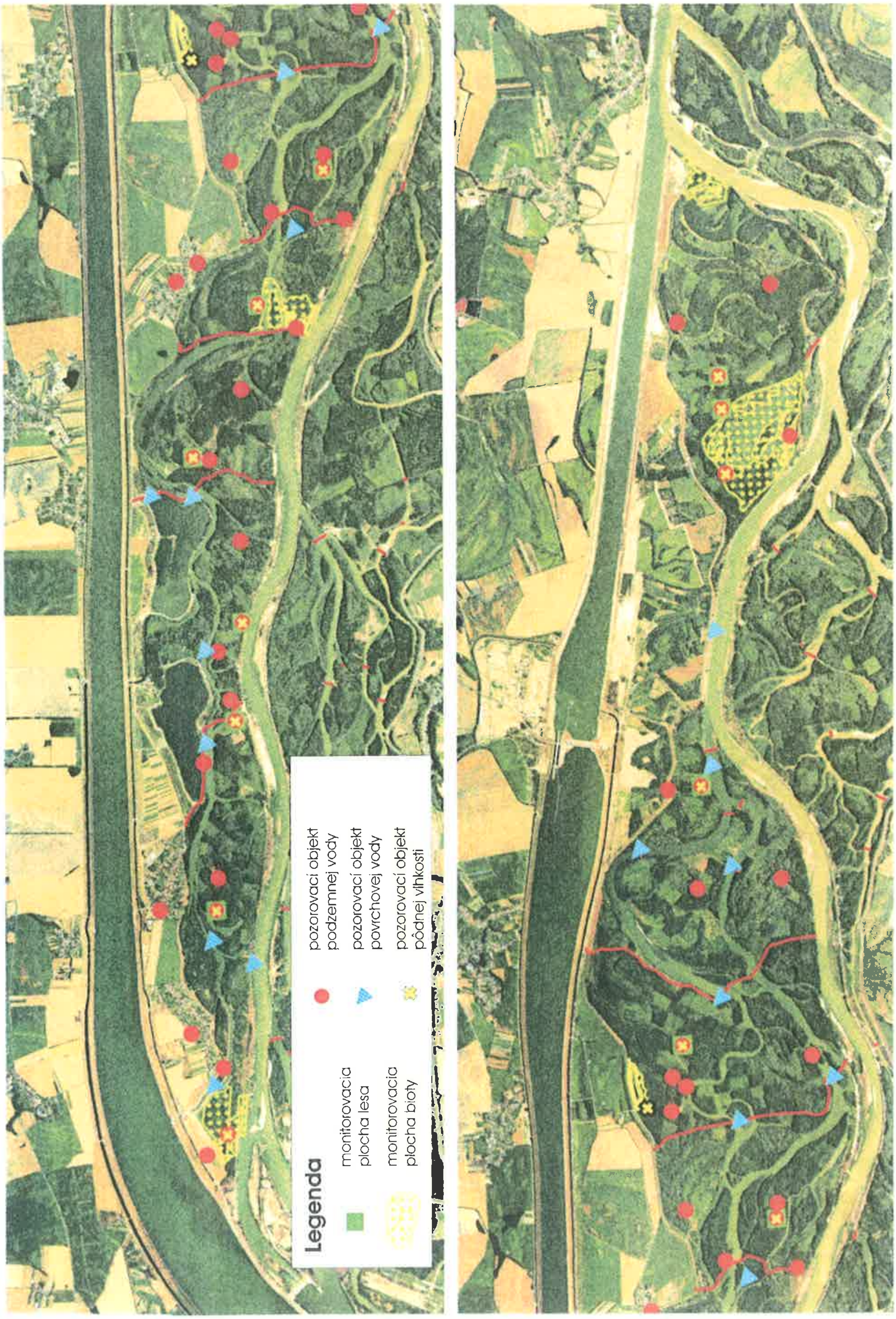
Obr. 4.8a Čas opakovania maximálneho prietoku v roku (z obdobia rokov 1901 až 2002)
Fig. 4.8a Repetition time of maximal discharge occurrence (1901-2002)



Obr. 4.8b Maximálne prietoky vyskytujúce sa v jednotlivých mesiacoch raz za 100 rokov
Fig. 4.8b Occurrence of maximal discharges in individual months once in 100 years

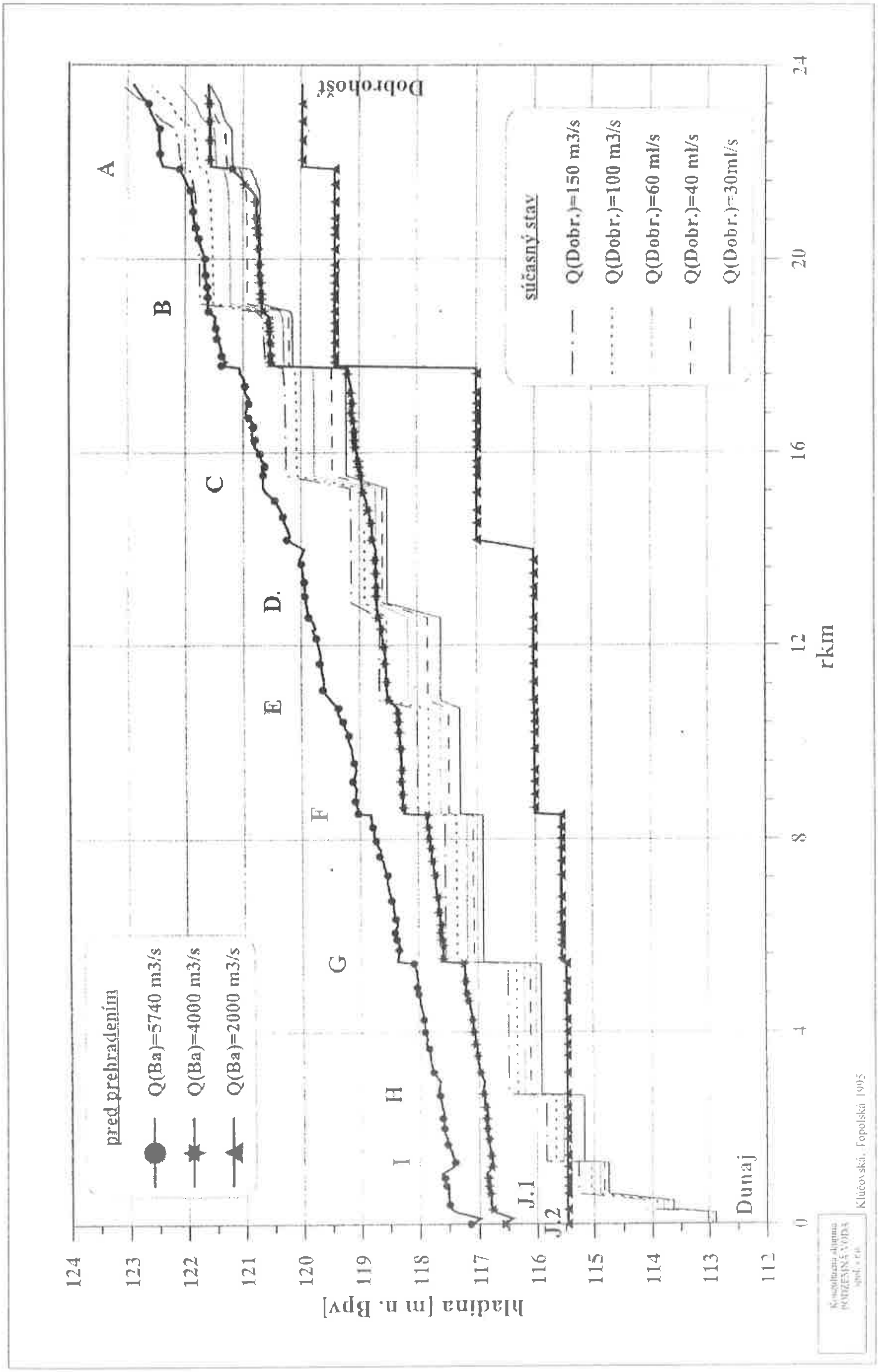


Obr. 4.9 Časové priebehy povodní s maximálnymi prietokmi 4000-5000, 5000-6000 a nad 6000 m^3s^{-1}.
Fig. 4.9 Time (days) courses of flood discharges with the discharges 4000-5000, 5000-6000 and over 6000 m^3/s (0 - day with discharges culmination)

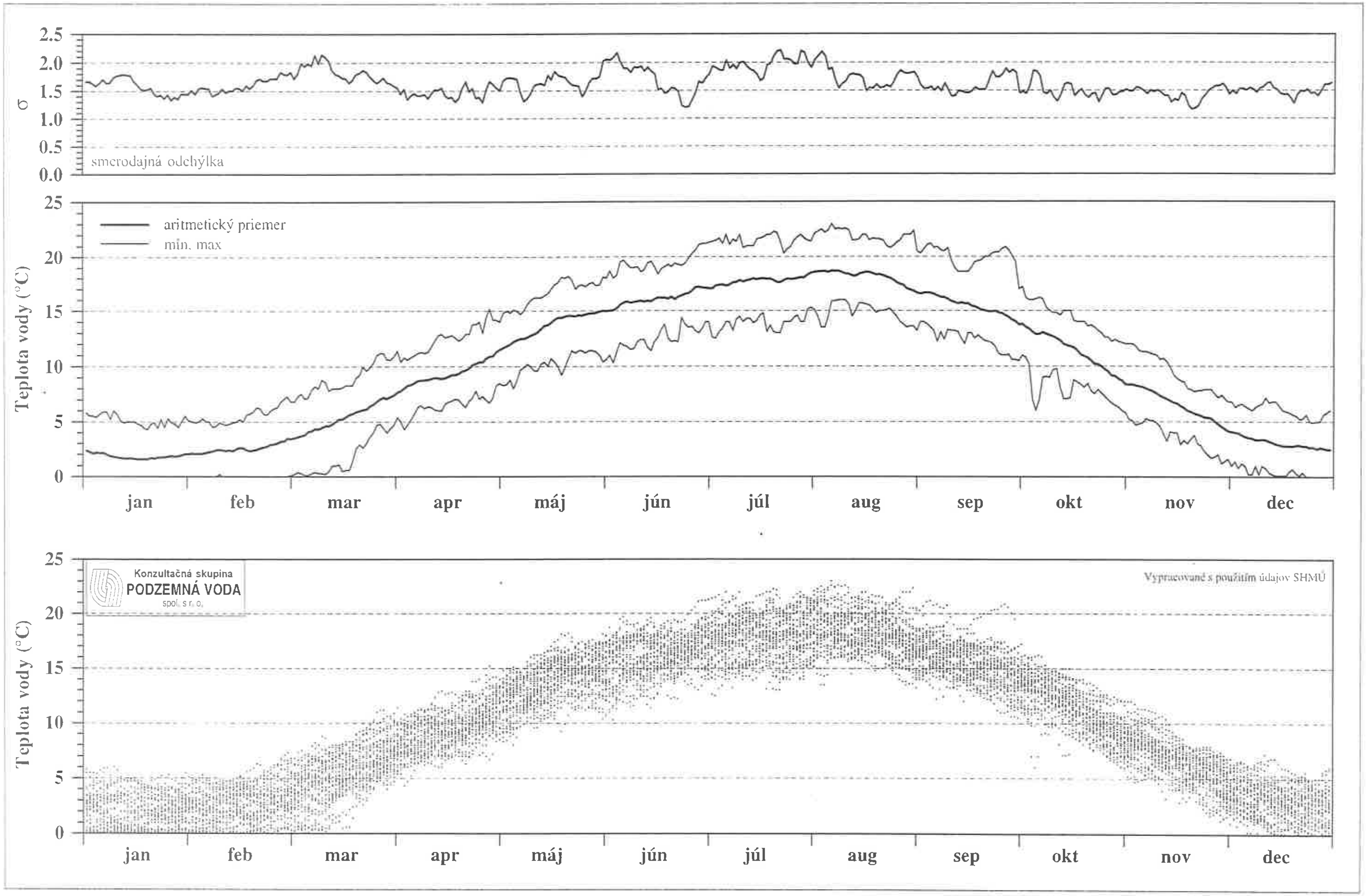


Obr. 4.10 Mapa inundácie s líniami, pozorovacími plochami lesa a bioty, pozorovacími objektmi povrchovej a podzemnej vody a pôdnej vlhkosti

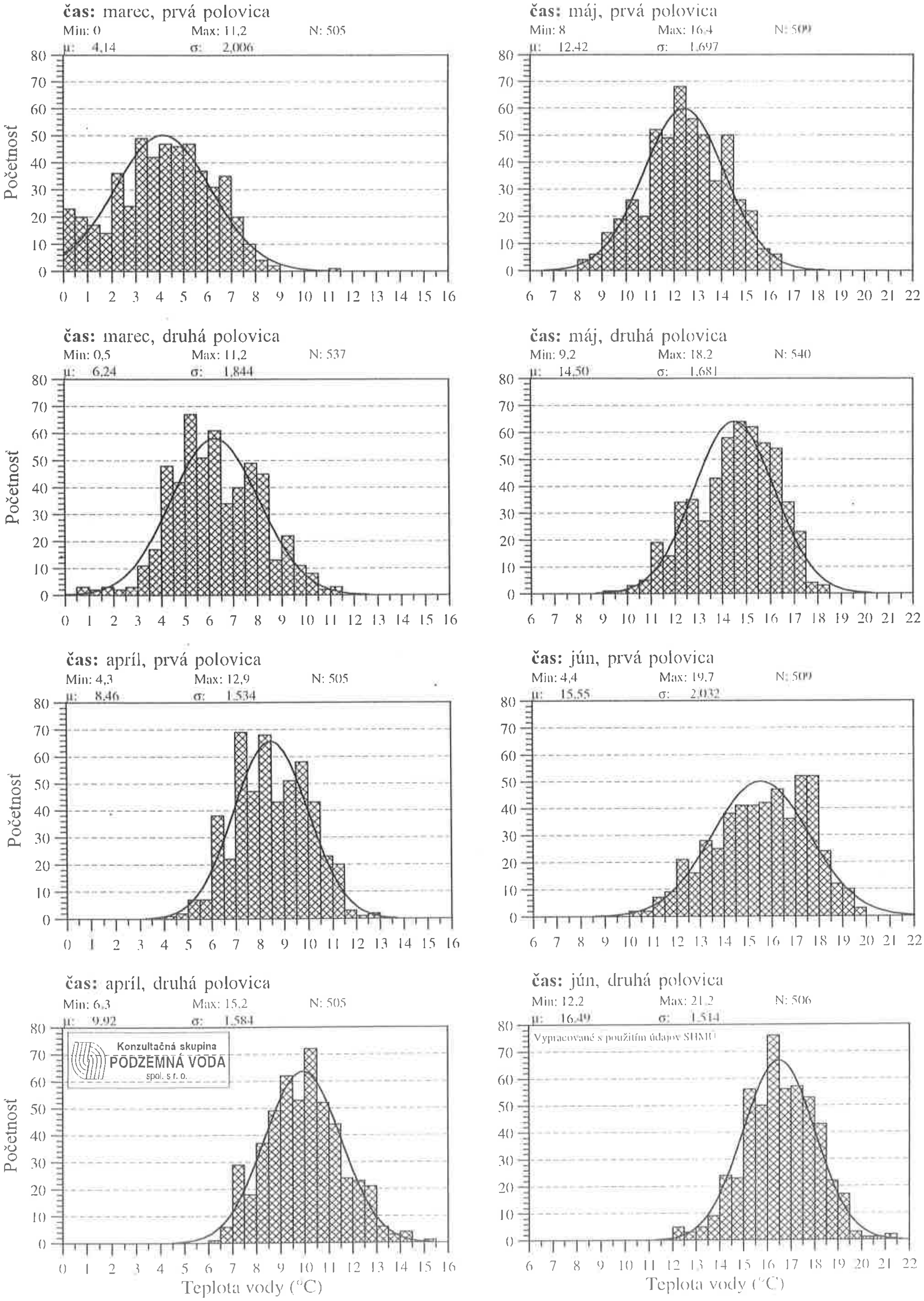
Fig. 4.10 Map of inundation area with the lines of cascades, monitoring plots of forest and biota, monitoring objects of surface and ground water and soil moisture



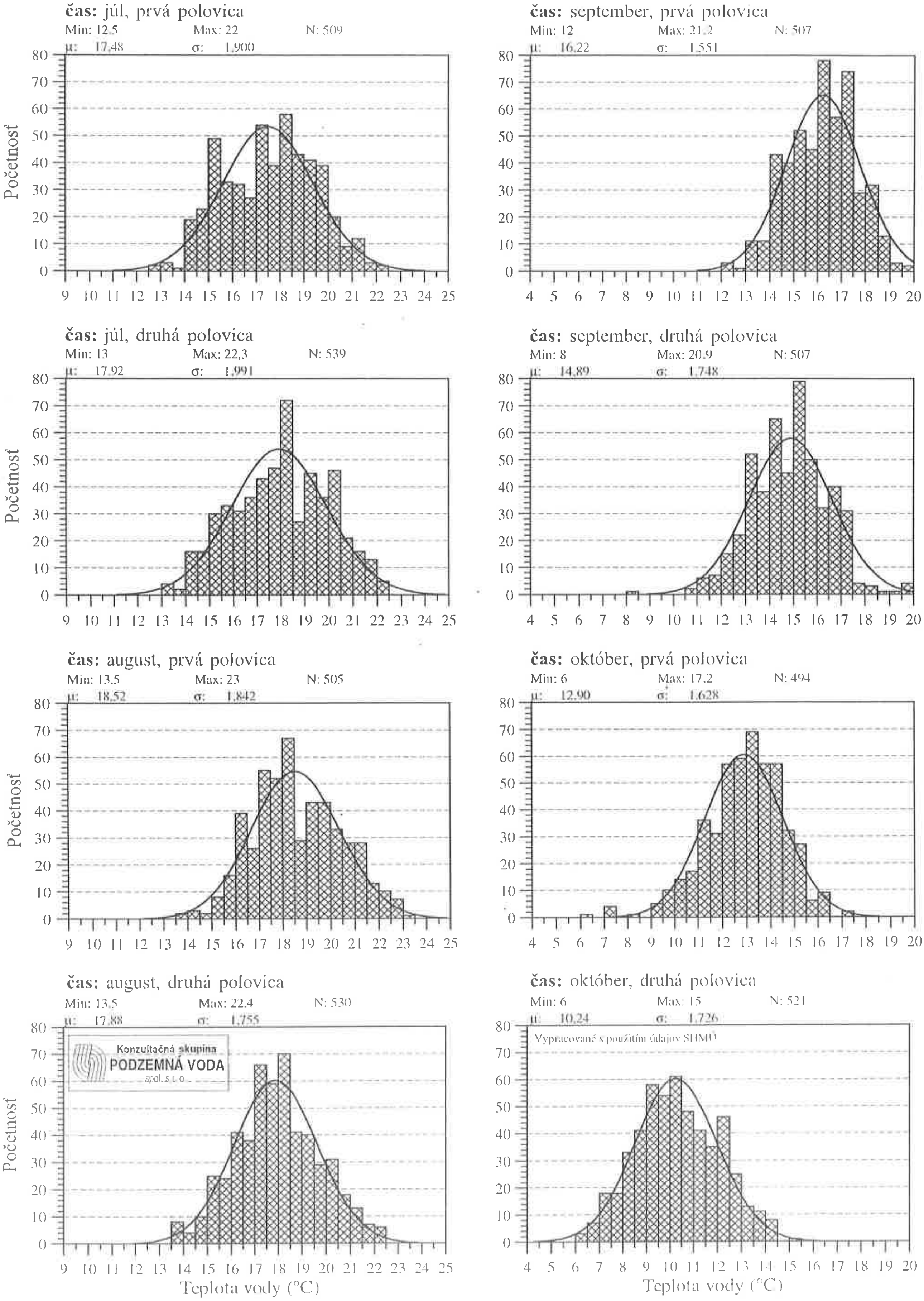
Obr. 4.11 Pozdĺžny profil ramennou sústavou - charakteristické prietoky a vodné stavy
Fig. 4.11 Profile along the river branch system - characteristic discharges and water levels



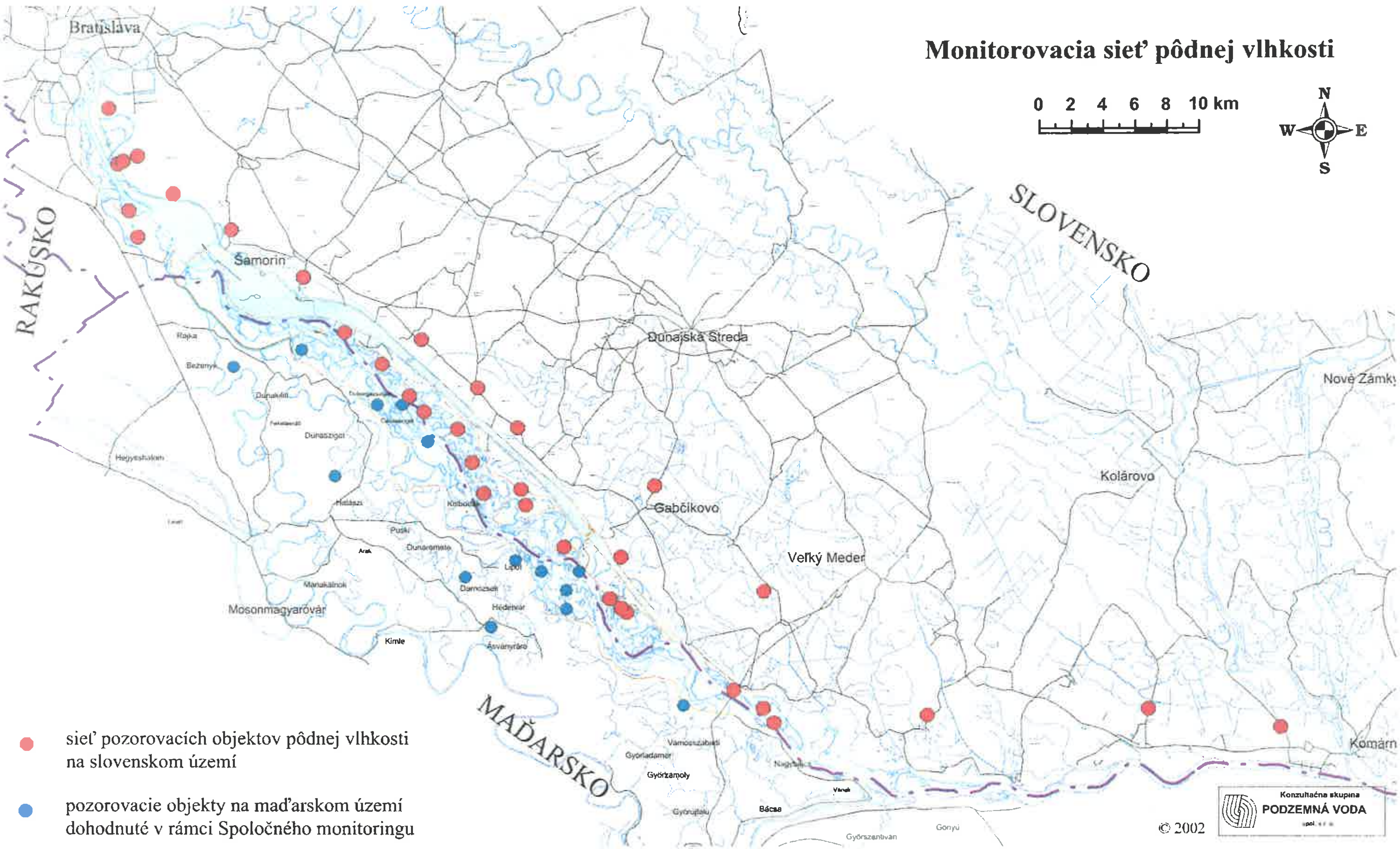
Obr. 4.12 Ilustrácia dlhodobého kolísania teplôt vody v Dunaji
Fig. 4.12 Illustration of long-term water temperature fluctuation in the Danube



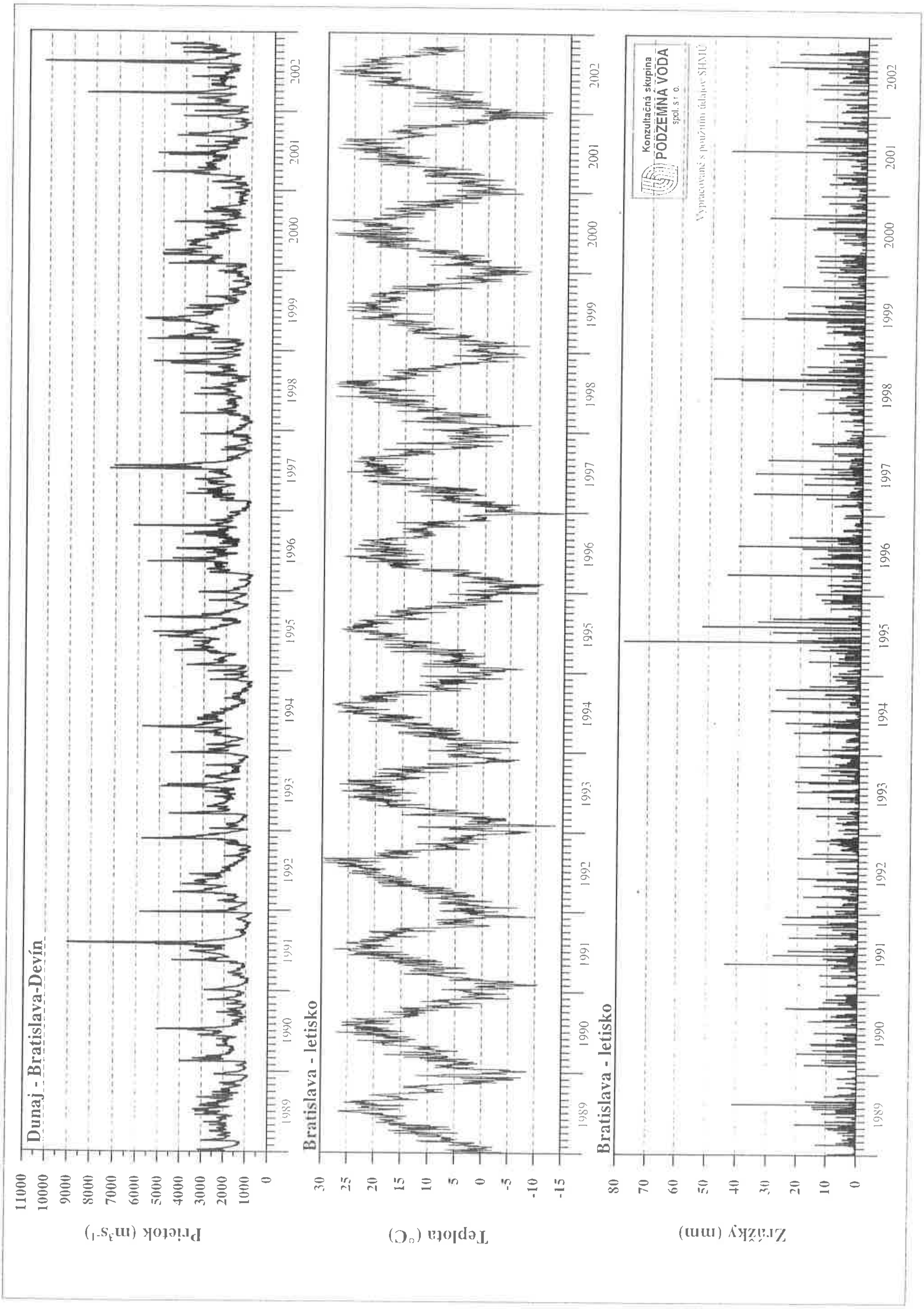
Obr. 4.13a Histogramy a teoretické rozdelenie výskytu teplôt vody v Dunaji v Bratislave
Fig. 4.13a Histograms and theoretical distribution of water temperature in the Danube at Bratislava



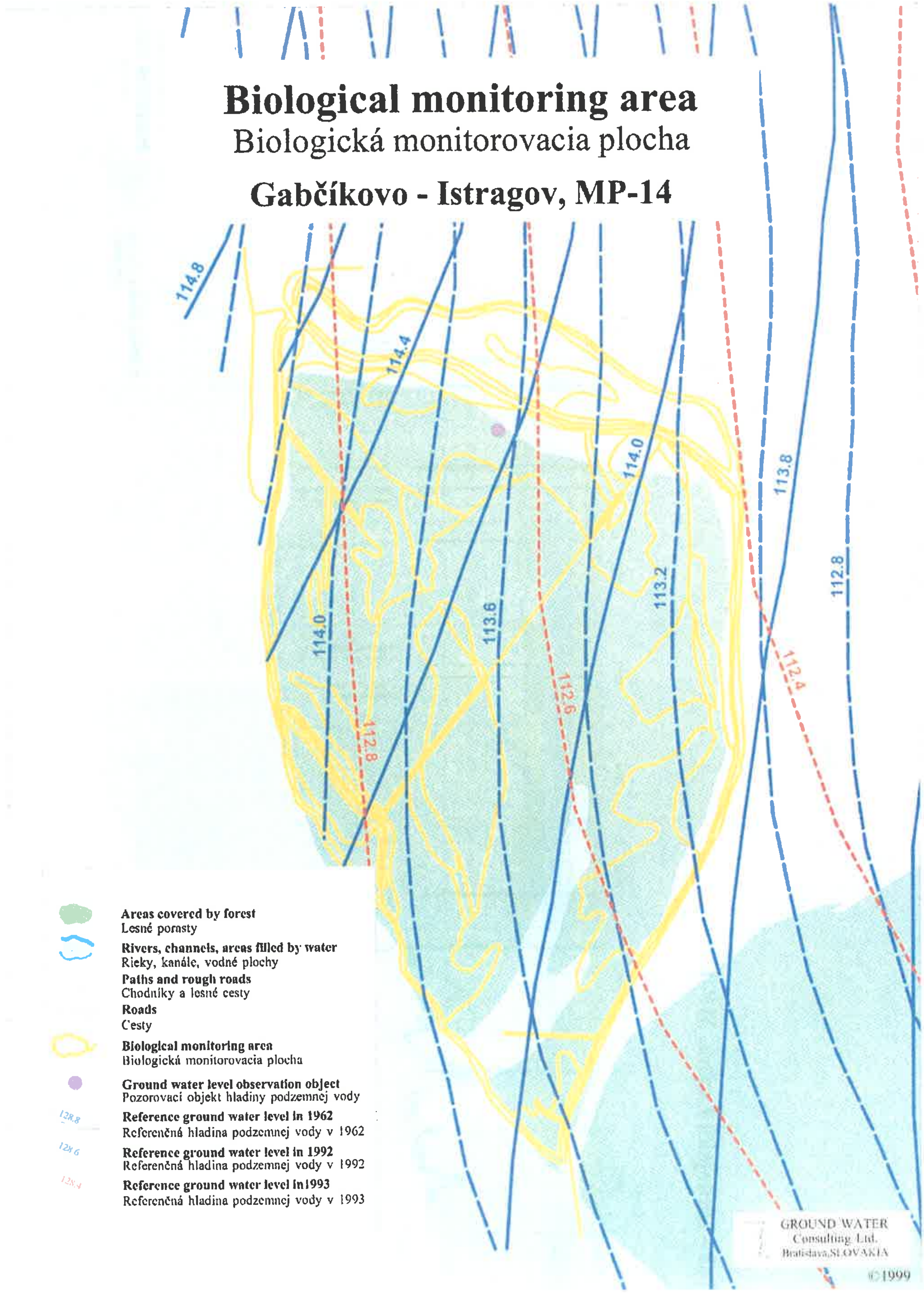
Obr. 4.13b Histogramy a teoretické rozdelenie výskytu teplôt vody v Dunaji v Bratislave
Fig. 4.13b Histograms and theoretical distribution of water temperature in the Danube at Bratislava



Obr. 5.1 Miesta monitorovania pôdnej vlhkosti
Fig. 5.1 Soil moisture monitoring plots



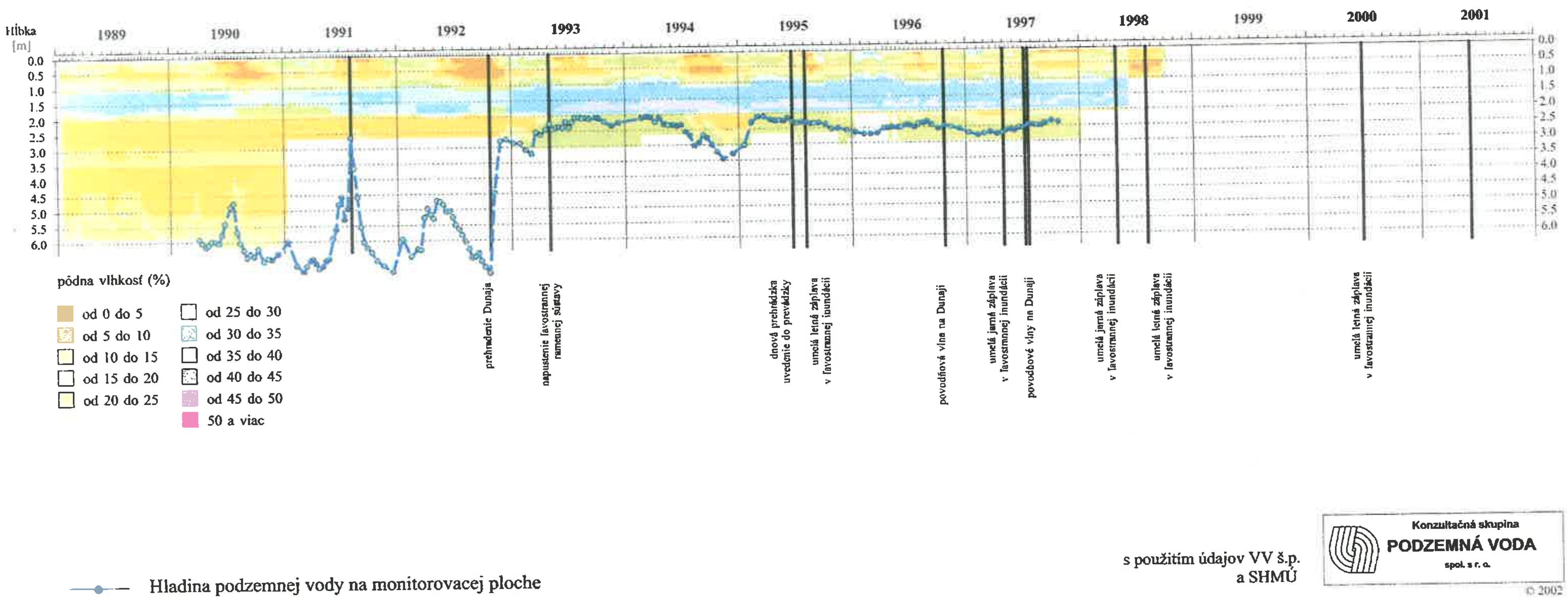
Obr. 5.2 Prietoky Dunaja, zrážky a teplota vzduchu
Fig. 5.2 Danube discharges, precipitation and air temperature



Obr. 5.3 Mapa hladín podzemných vôd monitorovacej plochy Gabčíkovo - Istragov
Fig. 5.3 Map of ground water level monitoring plot Gabčíkovo - Istragov

Monitoring pôdnej vlhkosti

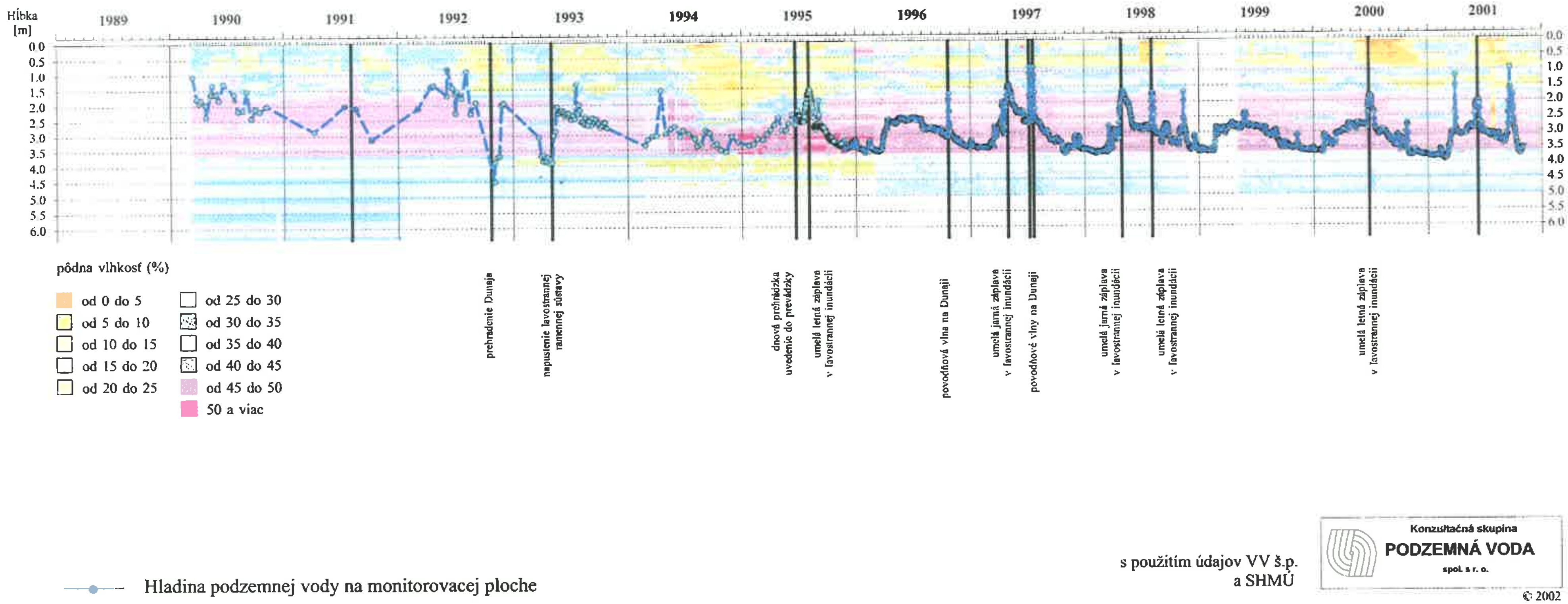
2713 - Dunajská Lužná, MP-1



Obr. 5.4a Monitoring pôdnej vlhkosti na lokalite Dunajská Lužná
Fig. 5.4a Soil moisture monitoring at monitoring plot at Dunajská Lužná

Monitoring pôdnej vlhkosti

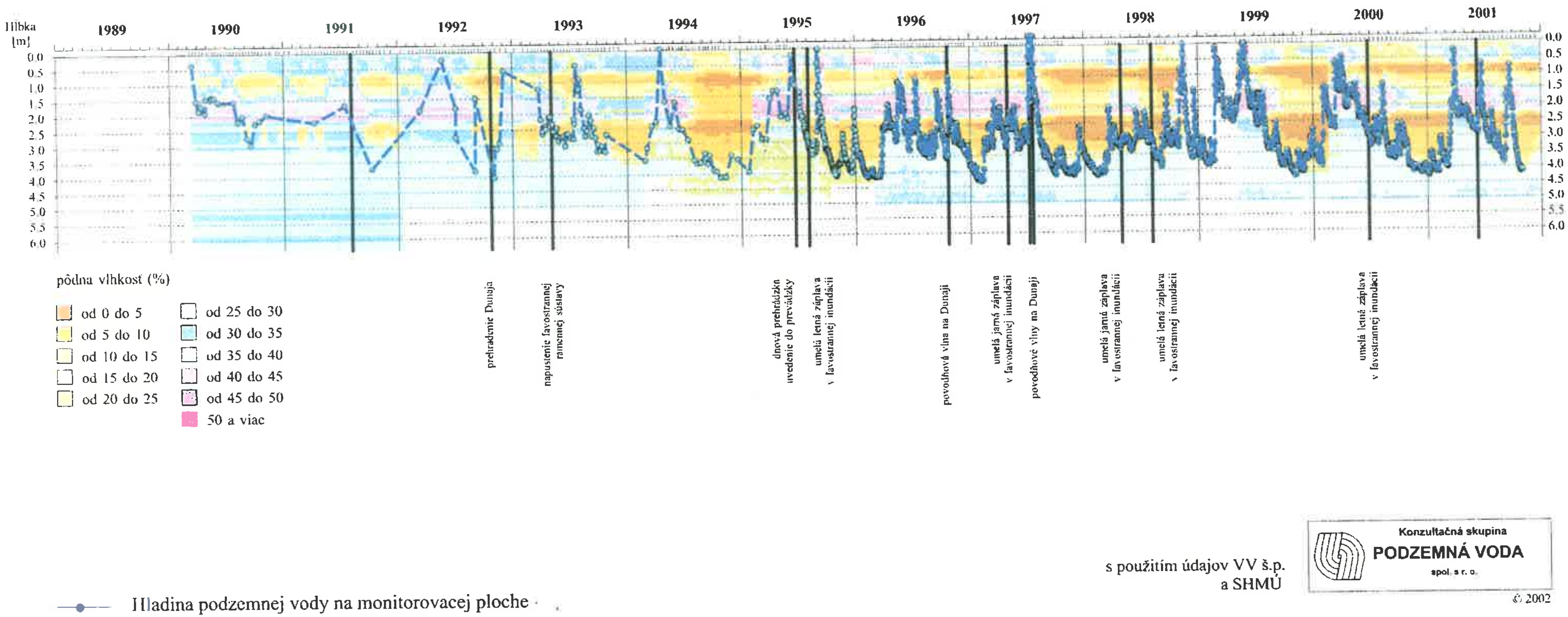
2704 - Bodíky - Bodícka brána, MP-9



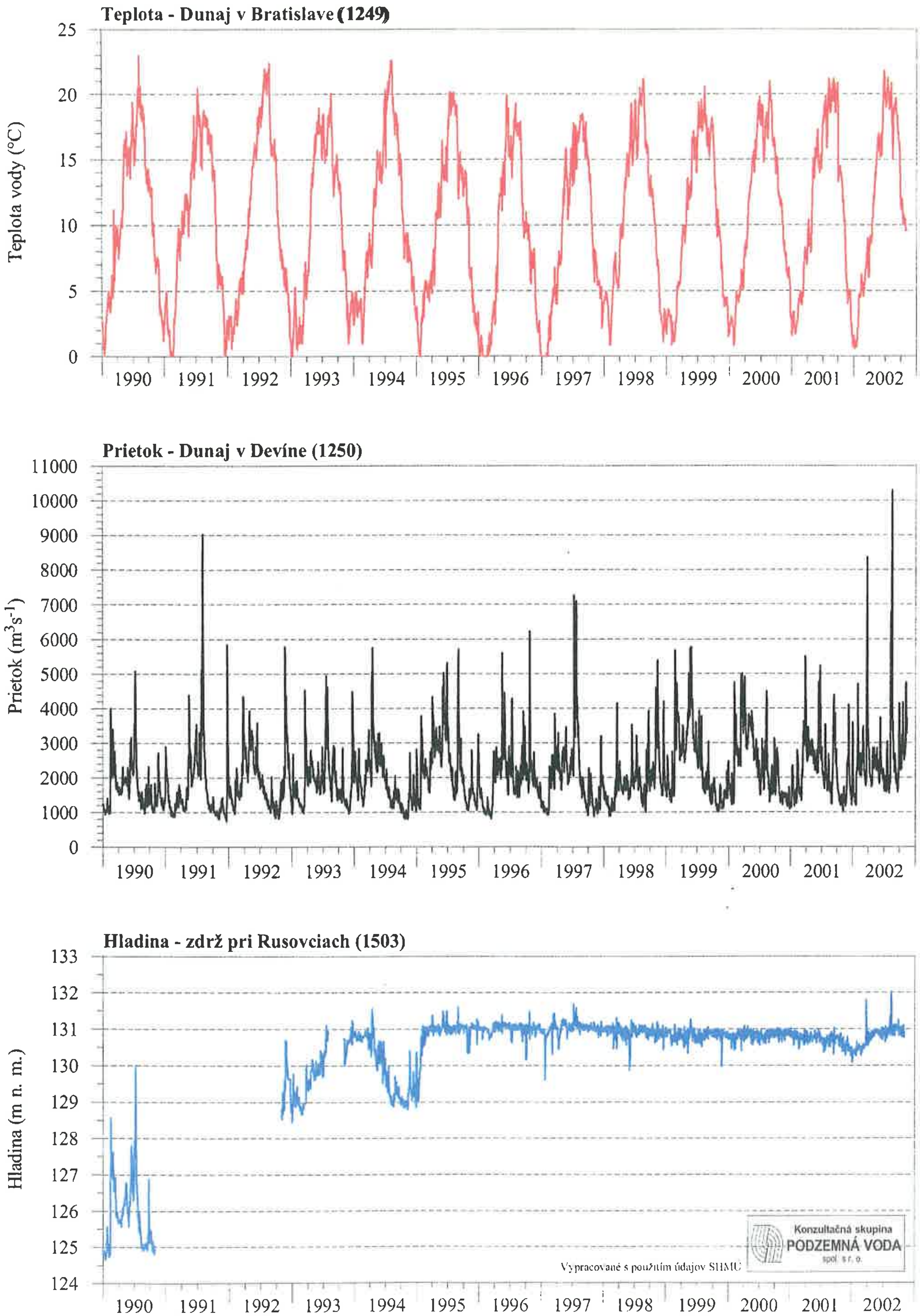
Obr. 5.4b Monitoring pôdnej vlhkosti na lokalite Bodíky
Fig. 5.4b Soil moisture monitoring plot at Bodíky

Monitoring pôdnej vlhkosti

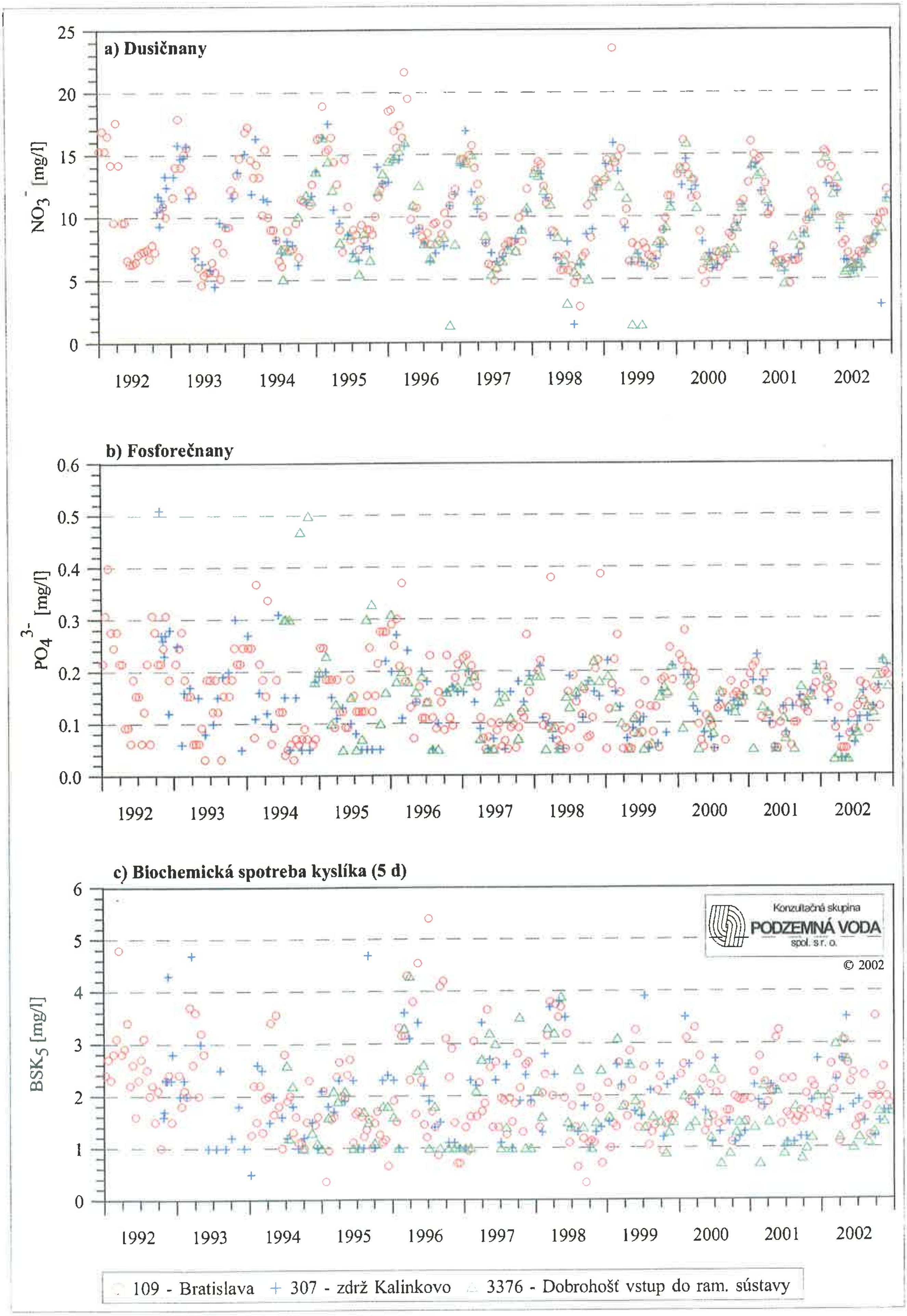
2706 - Gabčíkovo - Istragov, MP-14



Obr. 5.4c Monitoring pôdnej vlhkosti pri Gabčíkove (Istragov)
Fig. 5.4c Soil moisture monitoring plot at Gabčíkovo (Istragov)

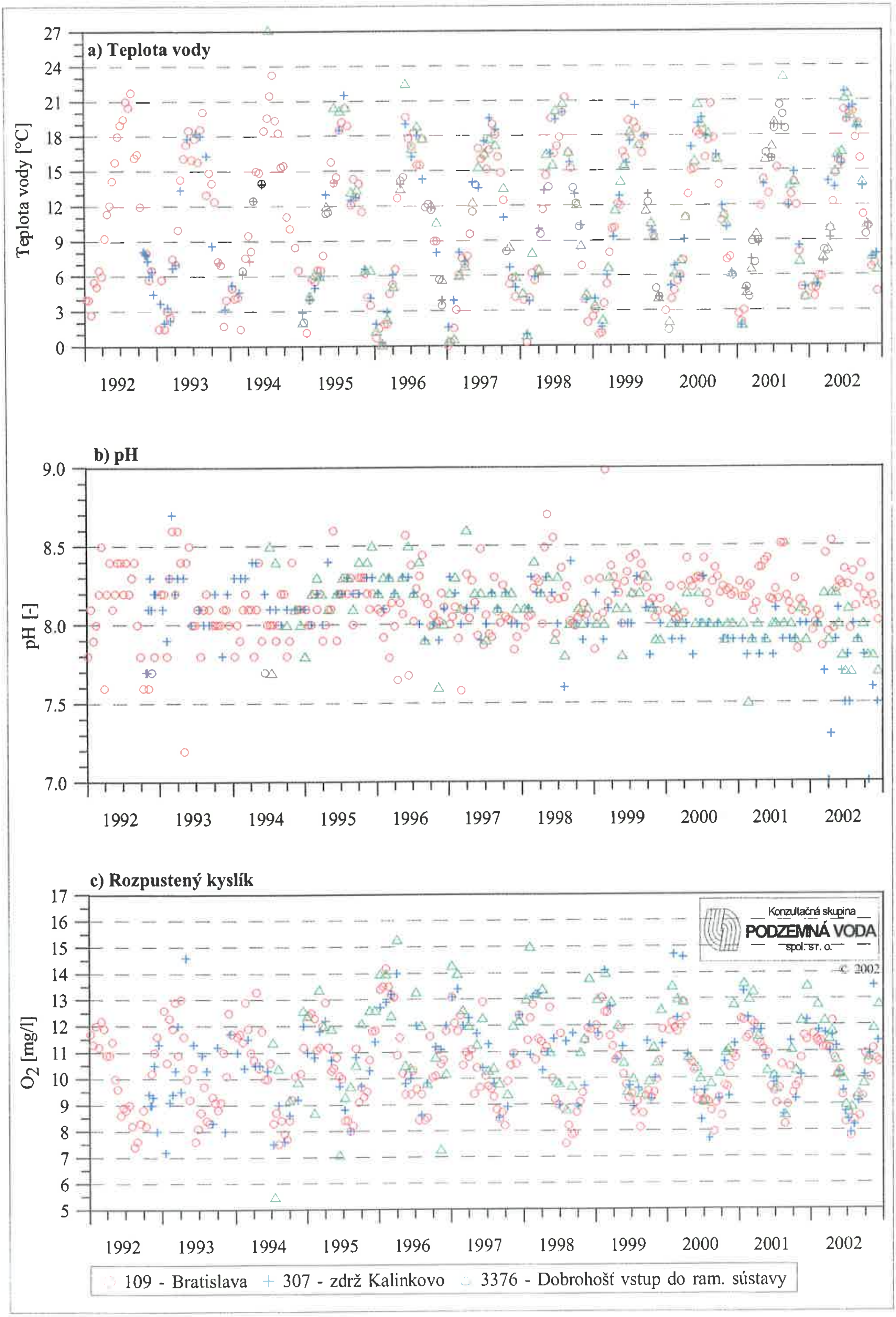


Obr. 5.5 Teplota vody, prietok a hladina v Dunaji
Fig. 5.5 Water temperature, discharge and water level in the Danube

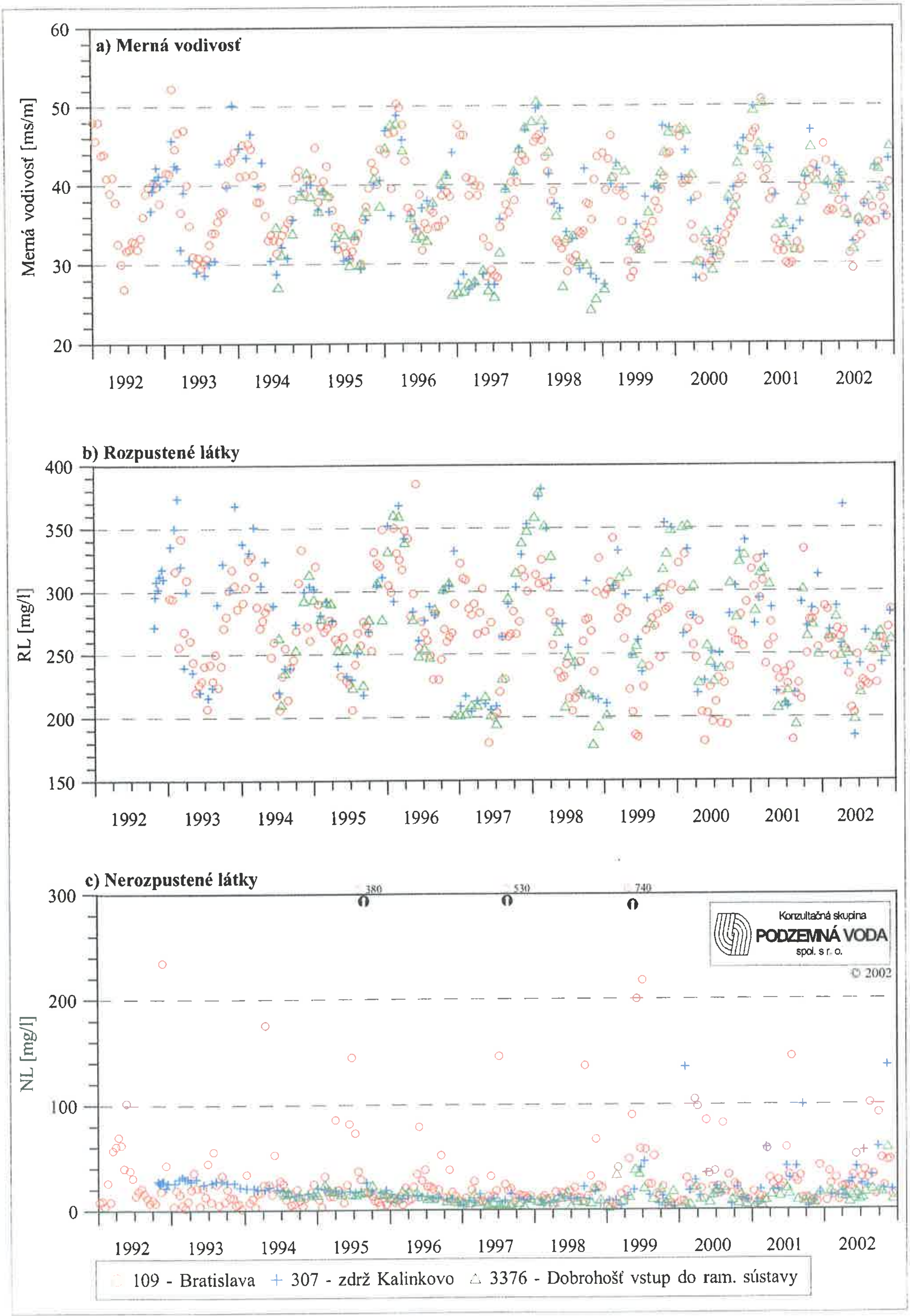


Obr. 5.6 Obsah nutrientov a BSK_5 vo vode Dunaja nad a pod zdržou Čunovo

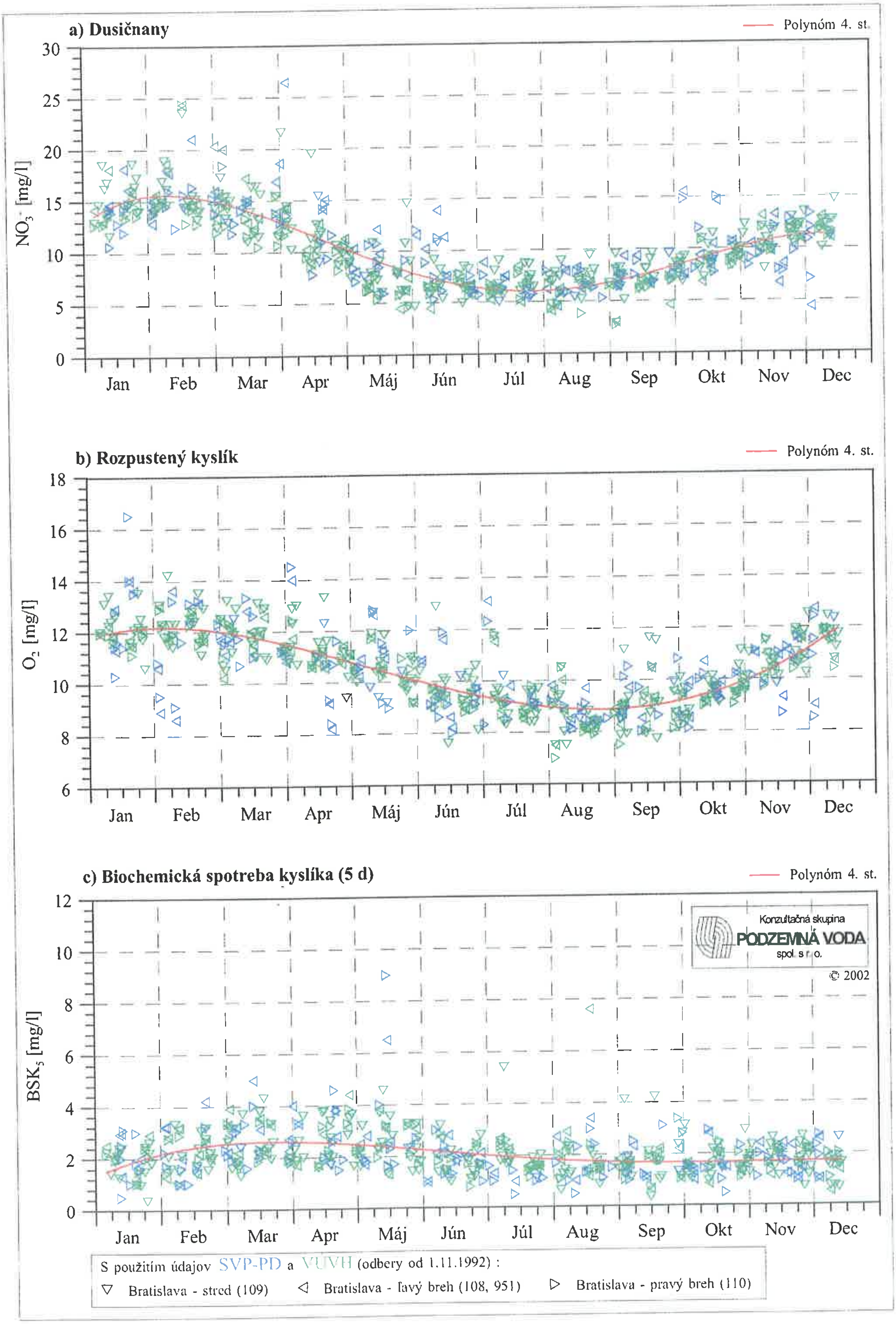
Fig. 5.6 Content of nutrients and BOD_5 in water up and down from Čunovo reservoir



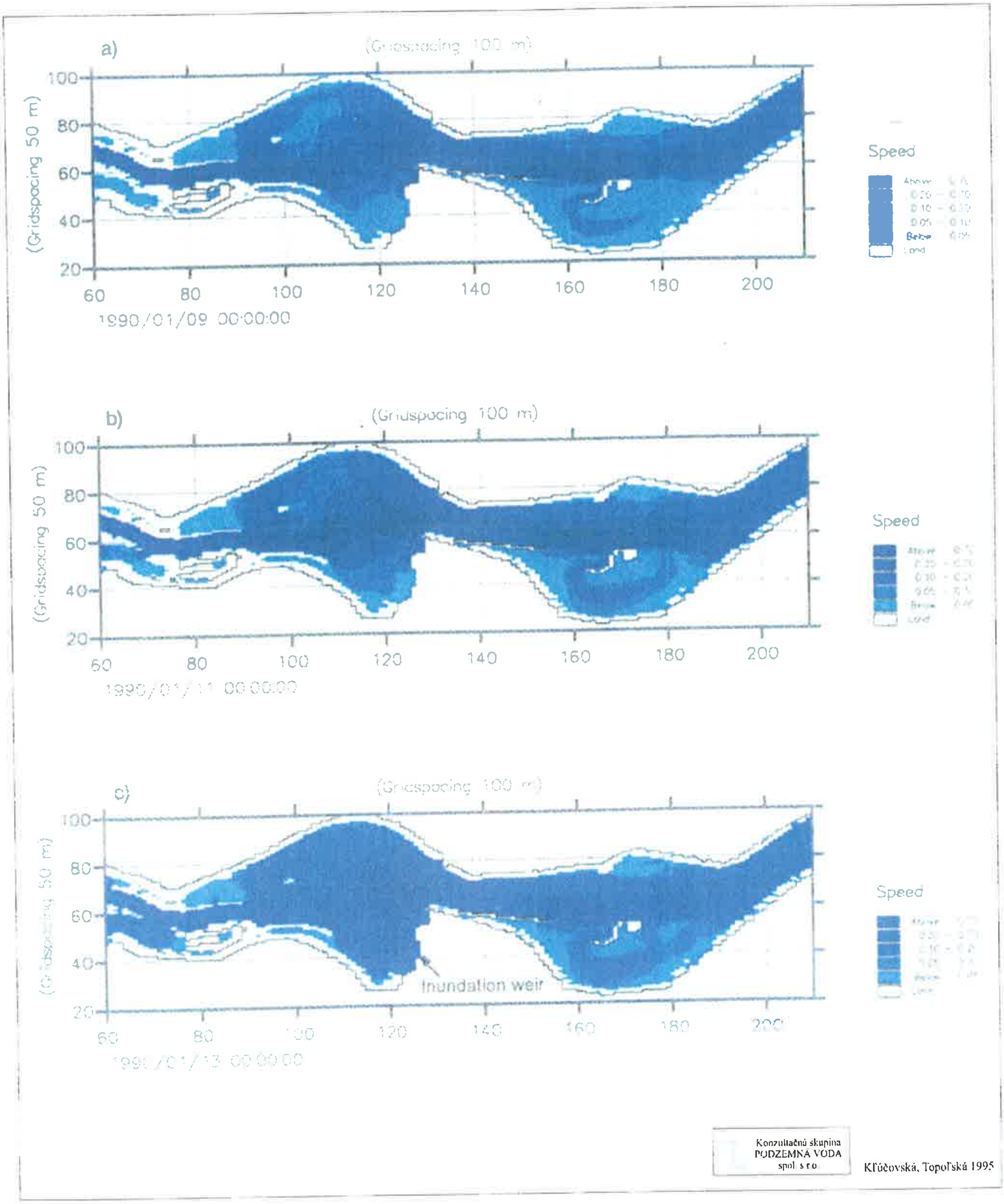
Obr. 5.7 Základné fyzikálno-chemické ukazovatele vody nad a pod zdržou Čunovo
Fig. 5.7 Basic physical-chemical parameters of water up and down from Čunovo reservoir (temperature, pH, dissolved oxygen)



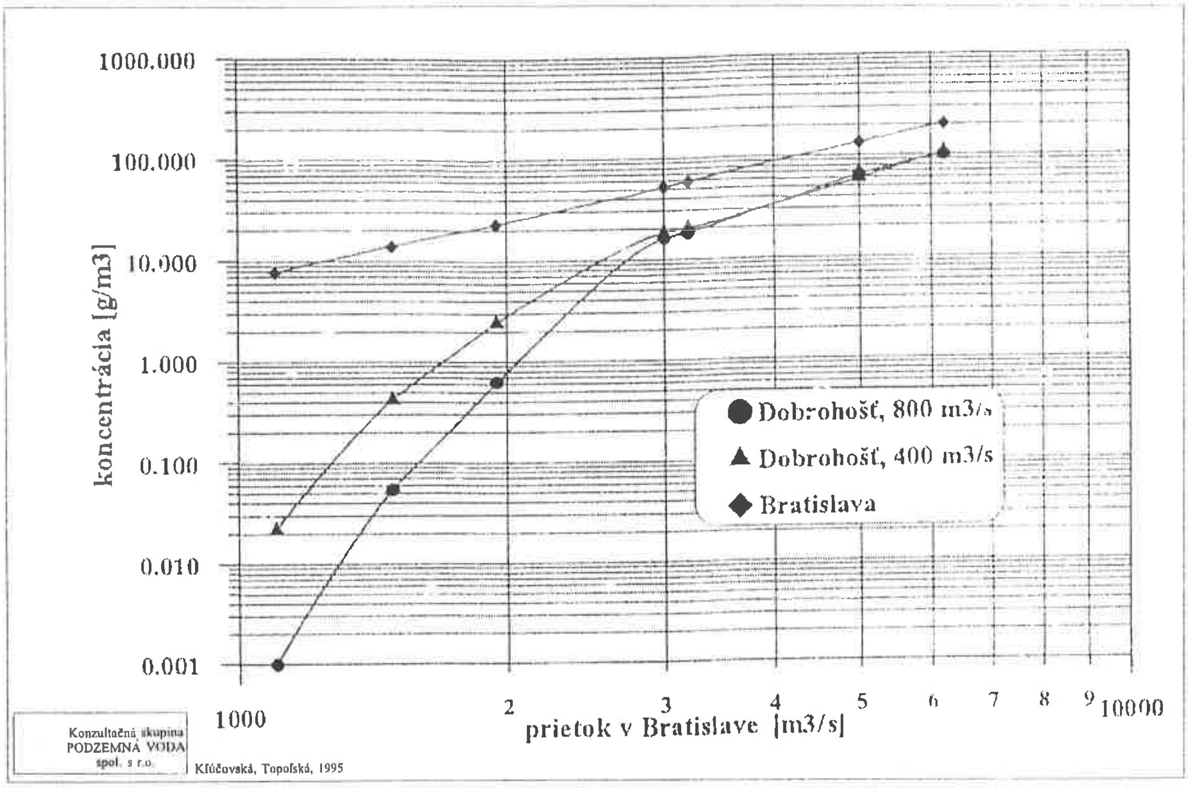
Obr. 5.8 Základné fyzikálno-chemické ukazovatele vody nad a pod zdržou Čunovo
Fig. 5.8 Basic physical-chemical parameters of water up and down from Čunovo reservoir (electric conductivity, dissolved matter, not dissolved matter)



Obr. 5.9 Sezónne kolísanie obsahu živín v Dunaji pri Bratislave v období 1965 - 1994
Fig. 5.9 Seasonal fluctuation of nutrients content in the Danube water at Bratislava in the period 1965-1994

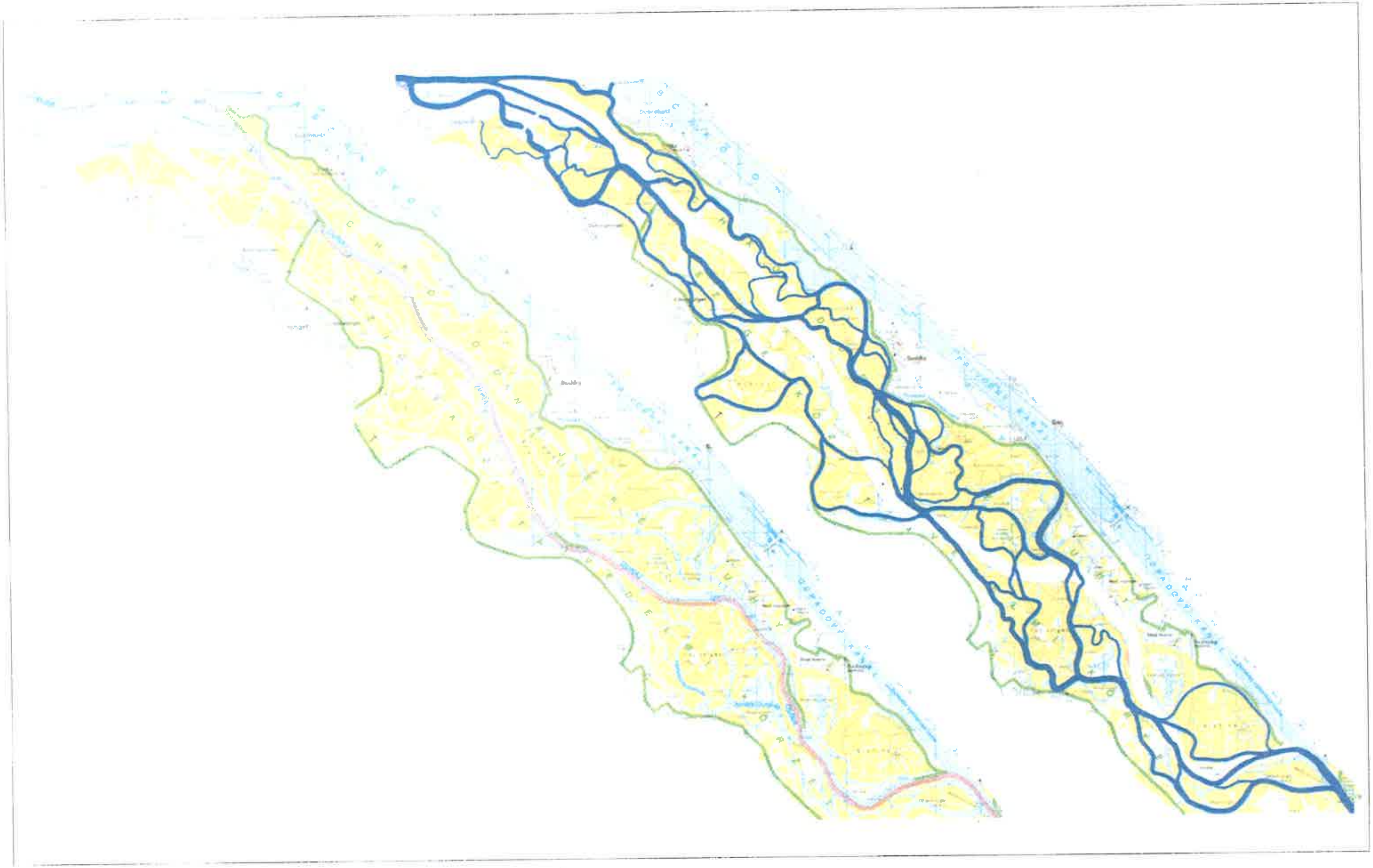


Obr. 5.10 Modelové rozdelenie rýchlostí prúdenia vody v zdrži
Fig. 5.10 Water flow velocity distribution in reservoir based on modelling method



Obr. 5.11 Vplyv zdrže na koncentrácie plavenín v prívodnom kanáli pri odbernom objekte pri Dobrohošti

Fig. 5.11 Impact of reservoir on suspended solids concentration in diversion canal at the intake structure in Dobrohošť



Obr. 8.1 Súčasný stav Dunaja (vľavo) a príklad návrhu úprav (vpravo)
Fig. 8.1 Present stay of the Danube (left) and example of modification proposal (right)

FOTOGRAFIE - PHOTOGRAPHS

FOTOGRAFICKÁ PRÍLOHA

Vo fotografickej prílohe chceme poukázať na procesy, ktoré sa odohrali v záplavovom území Dunaja. Fotografická dokumentácia pochádza z archívu oddelenia ekosozológie ÚZ SAV „OEM" a archívu M. J. Lisického „MJL". Pre lepšie porovnávanie je uvedený aj dátum fotografovania.

FUNKČNÉ ZMENY PO UVEDENÍ VODNÉHO DIELA GABČÍKOVO DO PREVÁDZKY

Fotografie č. 1 – 8:

Hlavný tok Dunaja aj po regulácii koncom 19. storočia mal trvalo prietočnú sústavu ramien. Po odrezaní ramien od hlavného toku v päťdesiatych rokoch minulého storočia až do konca rokov osemdesiatych napĺňal ramená každoročne povrchovou vodou už len pri prietokoch väčších ako 4000 $m^3.s^{-1}$, t.j. 2 – 3 týždne v roku. (**Foto 1**: vtok vody do Vojčianskej sústavy). Po prevedení toku do derivačného kanála prepojenie prakticky zaniklo s výnimkou mimoriadnych povodňových prietokov, ktorých pravdepodobnosť je raz za niekoľko desiatok rokov (**Tab. 4.6, Obr. 4.6 – 4.8, Kap. 4**). Keď takáto situácia nastane (posledne v r. 2002) preteká rieka brehovým opevnením a obnovuje spojenie s ramenami v miestach, kde tak bolo v minulosti (tzv. brány, **Foto 2**). Na takýchto miestach navrhuje štúdia prepojenie maďarskej a slovenskej ramennej sústavy. Na základe maďarsko-slovenskej dohody sa v ostatných rokoch prepúšťajú do starého koryta vo vegetačnom období prietoky 400 – 600 $m^3.s^{-1}$. Takéto množstvo zaplňuje najhlbšiu časť starého koryta, necháva však pri oboch brehoch niekoľko desiatok metrov široké pásma spontánne zarastajúce vŕbami a topoľmi (**Foto 3, 4**). Ramenná sústava je v súčasnosti napájaná cez odberný objekt z derivačného kanála pri Dobrohošti (**Foto 5**) a hladina v ramenách je udržiavaná priečnymi líniami vzdúvajúcimi hladinu (**Foto 6**). Tým sa umožňuje v medzihrádzovom priestore na časti plochy simulácia miernej záplavy, ale bez bývalej povodňovej dynamiky. Tzv. storočná voda vyplní celý medzihrádzový priestor (**Foto 7**) a pôsobí ako selektujúci faktor v biote. Naopak, dlhodobá absencia povodní umožňuje prienik nepôvodným druhom a zaniknutá laterálna erózia v ramenách znamená postupný zánik obnažovaných štrkových a pieskových lavíc i strmých brehov, ktoré sú hniezdnymi biotopmi viacerých druhov vtákov (**Foto 8**).

1	Prepojenie Dunaja s Vojčianskym ramenom	04.05.1990	(MJL)
2	Šulianska brána (r.km. 1832-1833)	30.05.2003	(MJL)
3	Zarastanie ľavej príbrežnej časti starého koryta	30.05.2003	(MJL)
4	Priesek zarasteným korytom r.km 1936 (Vojka)	30.05.2003	(MJL)
5	Dotovanie ramennej sústavy pri Dobrohošti	03.06.1994	(MJL)
6	Pretekané prehrádzky v ramennej sústave: línia D pri Bodíkoch, vľavo ostrov so spontánnym porastom lužného lesa	30.05.2003	(MJL)
7	Povodeň pri Dunajských krivinách	06.08.1991	(MJL)
8	Laterálna erózia kedysi umožňovala obnovu hniezdnych kolónií brehule (*Riparia riparia*)	06.08.1986	(MJL)

MONITOROVACIA PLOCHA DUNAJSKÉ KRIVINY

Fotografie č. 9 – 23:

Vzhľadom na svoju polohu, nad systémom dotujúcim ľavostrannú ramennú sústavu, umožňuje táto monitorovacia plocha urobiť si predstavu o tom, ako by po derivovaní Dunaja reagovali lužné ekosystémy v prípade, že by ramená neboli zásobované vodou. Séria obrázkov z rokov 1989 – 2002 znázorňuje prirodzenú sezónnu dynamiku vo väčšej, severozápadnej časti lokality. Táto ostala po derivácii mimo vplyvu systému zásobovania ramennej sústavy vodou, teda viac ako dvojmetrové zaklesnutie hladiny podzemnej vody nebolo ani v minimálnej miere kompenzované náhradnou brehovou infiltráciou či povrchovou záplavou. Došlo k odumretiu časti vzrastlých drevín (prevažne vŕb a topoľov), pôvodne periodicky zaplavované plochy zarástli najprv burinnými druhmi bylín, nenáročných na pôdnu vlhkosť, neskôr najmä hustým krovinovým zárastom svetlomilnej svídy (*Swida sanguinea*). Zo stromov sa obnovuje topoľ biely, ale na plochu expanduje nepôvodný javorovec (*Negundo aceroides*). Vymizli pôvodné vlhkomilné druhy (napr. *Leucojum aestivum, Polygonum mite* a pod.).

Táto sukcesia zabránila fotograficky zdokumentovať súčasný stav zo stacionárneho miesta (fotobodu); táto séria končí **Fotografiou 16** (stav pol roka po prehradení Dunaja), **Foto 17** a **18** zachytávajú zvyšok krovinami nezarastenej plochy, **Foto 19-21** boli urobené v roku 2003 v blízkom okolí zarasteného fotobodu a už neumožňujú znázorniť súčasný stav plochy. Predstavu o súčasnom stave však ponúkajú zábery (**Foto 22,23**) z poľovníckeho posedu na východnom okraji plochy, teda pohľad otočený o 90 ° vľavo. Na malej ploche na okraji plochy vo vrbine lemujúcej relikt ramena sa prejavil pozitívny vplyv stavidla, ktoré v obmedzenej miere dotuje pôdnu vlhkosť odberom vody z nápustného kanála pri Dobrohošti a k vyschnutiu a následným zmenám tam nedošlo.

9	Dunajské kriviny	15.06.1989	(OEM)
10	Dunajské kriviny	26.09.1989	(OEM)

11	Dunajské kriviny	31.05.1990	(OEM)
12	Dunajské kriviny	22.10.1990	(OEM)
13	Dunajské kriviny	06.03.1991	(OEM)
14	Dunajské kriviny	28.06.1991	(OEM)
15	Dunajské kriviny	23.10.1991	(OEM)
16	Dunajské kriviny	25.06.1993	(OEM)
17	Dunajské kriviny	31.05.1995	(OEM)
18	Dunajské kriviny	26.05.1993	(MJL)
19	Dunajské kriviny	06.09.2003	(MJL)
20	Dunajské kriviny	06.09.2003	(MJL)
21	Dunajské kriviny	06.09.2003	(MJL)
22	Dunajské kriviny	06.09.2003	(MJL)
23	Dunajské kriviny	06.09.2003	(MJL)

MONITOROVACIA PLOCHA BODÍCKA BRÁNA – POBREŽIE
Fotografie č. 24 – 36:

V Bodíckej bráne bola monitorovaná vodná biota veľkého, trvale prietočného ramena, biota systému mokradí (**Foto 26 – 30**) pozostávajúceho z reliktov ramien a terénnych depresií, v minulosti periodicky zaplavovaných povrchovou vodou z vybrežujúceho ramena a priľahlý pobrežný les.

Dotovanie vodou z odberného objektu pri Dobrohošti podporilo vo väčšine dotknutých úsekov ramennej sústavy lotický (prietočný) charakter. V časti tejto lokality, vo vetve Bodíckeho ramena, však došlo k zmene prietočného režimu na prevažne lotický charakter. Nasvedčuje tomu aj zvýšený rozvoj rias koncom jari (porovnaj **Foto 24 a 25**). Ostrov (ľavý okraj uvedených obrázkov) medzi hlavnou vetvou Bodíckeho ramena, kde prebiehal hydrobiologický monitoring, a touto lokalitou, predstavuje z hľadiska genézy a fungovania vzácny prípad spontánne vzniknutého (neobhospodarovaného) mäkkého lužného lesa.

24	Bodícka brána – rameno pod líniou D	31.05.1990	(OEM)
25	Bodícka brána – rameno pod líniou D	31.05.1995	(OEM)
26	Bodícka brána 1	31.05.1990	(OEM)
27	Bodícka brána 1	22.10.1990	(OEM)
28	Bodícka brána 1	06.03.1991	(OEM)
29	Bodícka brána 1	23.10.1991	(OEM)
30	Bodícka brána 1 - periodické jazierko zarástlo a plochu obsadzuje javorovec	30.05.2003	(MJL)
31	V drénovanom pobrežnom páse pri Vojke boli pokusne úspešne vysadené duby a jasene, ktorým však konkurujú vitálne náletové dreviny (pajaseň, javorovec, agát).	30.09.1999	(MJL)
32	Bodícka brána 2	31.05.1990	(OEM)
33	Bodícka brána 2	22.10.1990	(OEM)
34	Bodícka brána 2	06.03.1991	(OEM)
35	Bodícka brána 2	22.10.1991	(OEM)
36	Bodícka brána 2	30.05.1995	(OEM)

MONITOROVACIA PLOCHA ISTRAGOV
Fotografie č. 37 – 41:

Monitorovacia plocha leží už mimo vplyvu dotačného systému, preto po derivovaní Dunaja hlboké obvodové rameno takmer vyschlo a periodicky zaplavované depresie s plytkými vodnými plochami začali zarastať trsťou. Nový vodný režim je ovplyvňovaný spätným vzdutím v starom koryte od sútoku s odpadovým kanálom.

37	Istragov	17.05.1990	(OEM)
38	Istragov	22.11.1990	(OEM)
39	Istragov	06.03.1991	(OEM)
40	Istragov	28.06.1991	(OEM)

41	Istragov	23.10.1991	(OEM)

MONITOROVACIA PLOCHA BODÍCKA BRÁNA – LES
Fotografie č. 42 – 46:

Monitorovacia plocha má vo vzťahu k napájanému Šulianskemu a Bodíckemu ramenu výhodnú polohu, ale drénový efekt starého koryta Dunaja spôsobil vyschnutie plytkých vodných útvarov a zníženú pôdnu vlhkosť v lese, najmä v horizonte do 50 cm, ktorý presychá.

42	Bodícka brána 3	31.05.1990	(OEM)
43	Bodícka brána 3	22.10.1990	(OEM)
44	Bodícka brána 3	06.03.1991	(OEM)
45	Bodícka brána 3	23.10.1991	(OEM)
46	Bodícka brána 3	31.05.1995	(OEM)

„DNO HRUŠOVSKEJ - ČUNOVSKEJ ZDRŽE"
Fotografia č.47:

V priestore ľavostrannej inundácie nad Hrušovom (r.km. 1842) boli lužné lesy odstránené a vznikla zdrž. Loď na obrázku sa plaví v dnes už neexistujúcom Šamorínskom ramene, v pozadí nasypaný breh derivačného kanála.

47	Loď v zdrži v mieste pôvodného Šamorínskeho ramena	16.03.1988	(MJL)

MONITOROVACIA PLOCHA KRÁĽOVSKÁ LÚKA
Fotografie č. 48 – 61:

Monitorovacia plocha predstavuje relikt významného dunajského ramena (**Foto 48 – 55**), ktoré sa v posledných desaťročiach zazemňuje, v bezprostrednom susedstve protipovodňovej hrádze. Vodný režim je závislý na prítoku povrchovej vody, ktorý je možné zabezpečiť manipuláciou v dotovanej časti ramennej sústavy.

48	Kráľovská lúka 1	31.05.1990	(OEM)
49	Kráľovská lúka 1	25.06.1993	(OEM)
50	Kráľovská lúka 1	31.05.1995	(OEM)
51	Kráľovská lúka 2	07.11.1990	(OEM)
52	Kráľovská lúka 2	06.03.1991	(OEM)
53	Kráľovská lúka 2	28.06.1991	(OEM)
54	Kráľovská lúka 2	23.10.1991	(OEM)
55	Kráľovská lúka 2	31.05.1995	(OEM)
56	Kráľovská lúka 3	31.05.1990	(OEM)
57	Kráľovská lúka 3	07.11.1990	(OEM)
58	Kráľovská lúka 3	06.03.1991	(OEM)
59	Kráľovská lúka 3	28.06.1991	(OEM)
60	Kráľovská lúka 3	23.10.1991	(OEM)
61	Kráľovská lúka 3	31.05.1995	(OEM)

MONITOROVACIA PLOCHA STARÝ LES
Fotografie 62 – 63:

Monitorovacia plocha leží v oblasti neovplyvnenej deriváciou Dunaja, ale zároveň významnej tým, že tu pri povodni v roku 1965 došlo k pretrhnutiu protipovodňovej hrádze. **Fotografie 62 a 63** znázorňujú výraznú medziročnú dynamiku podunajských mokraďných ekosystémov v prirodzených podmienkach.

62	Starý les	10.08.1989	(OEM)
63	Starý les	24.08.1990	(OEM)

MONITOROVACIA PLOCHA SPORNÁ SIHOŤ
Fotografie 64 – 71:

Monitorovacia plocha bola založená v monitoringu bioty ako referenčná, deriváciou Dunaja neovplyvnená lokalita s vodným útvarom s veľkou prirodzenou sezónnou i medziročnou dynamikou (**Foto 64 – 70**), brehovým lužným lesom (bol v r. 1991 z väčšej časti vyrúbaný) a priľahlou lúkou. Práve takéto, v našom inundačnom území zriedkavé kosienky (**Foto 71**), by mohli byť vytvorené pri renaturácii v derivovanom úseku na znižovanie hydraulickej drsnosti pri prevedení povodňových prietokov.

64	Sporná sihoť 1	10.08.1989	(OEM)
65	Sporná sihoť 1	25.10.1989	(OEM)
66	Sporná sihoť 1	17.05.1990	(OEM)
67	Sporná sihoť 1	07.11.1990	(OEM)
68	Sporná sihoť 1	06.03.1991	(OEM)
69	Sporná sihoť 1	28.06.1991	(OEM)
70	Sporná sihoť 1	23.10.1991	(OEM)
71	Sporná sihoť 2	23.10.1991	(OEM)

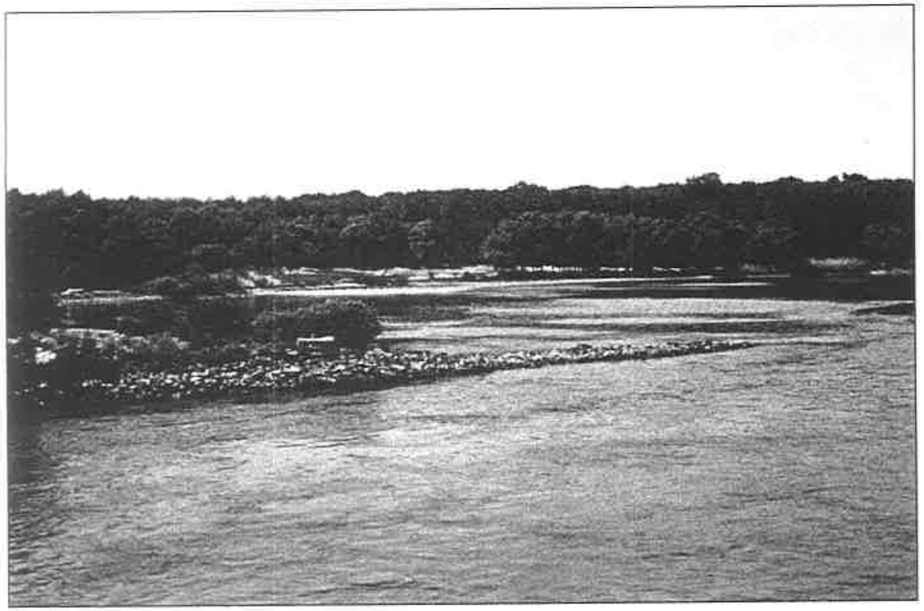


Foto 1 Prepojenie Dunaja s Vojčianskym ramenom 04.05.1990 (MJL)

Foto 2 Šulianska brána (r.km 1832-1833) 30.05.2003 (MJL)

Foto 3 Zarastanie ľavej príbrežnej časti starého koryta 30.05.2003 (MJL)

Foto 4 Priesek zarasteným korytom r.km 1936 (Vojka) 30.05.2003 (MJL)

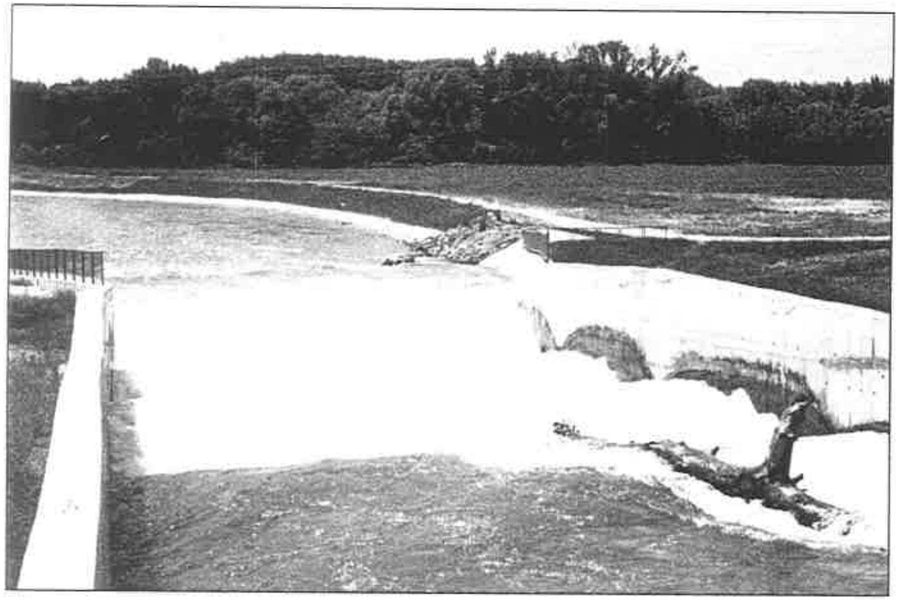


Foto 5 Dotovanie ramennej sústavy pri Dobrohošti 03.06.1994 (MJL)

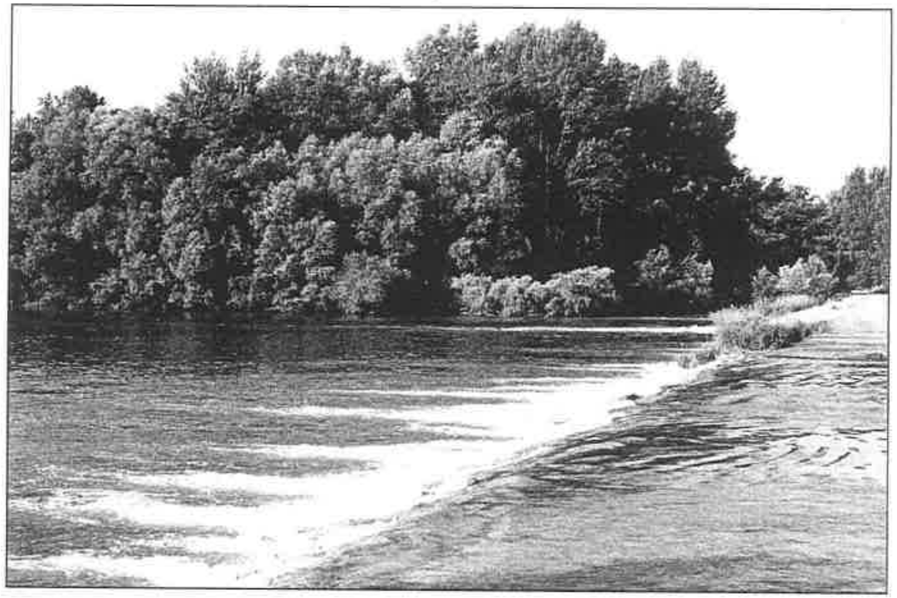


Foto 6 Pretekené prehrádzky v ramennej sústave: línia D pri Bodíkoch, vľavo ostrov so spontánnym porastom lužného lesa 30.05.2003 (MJL)

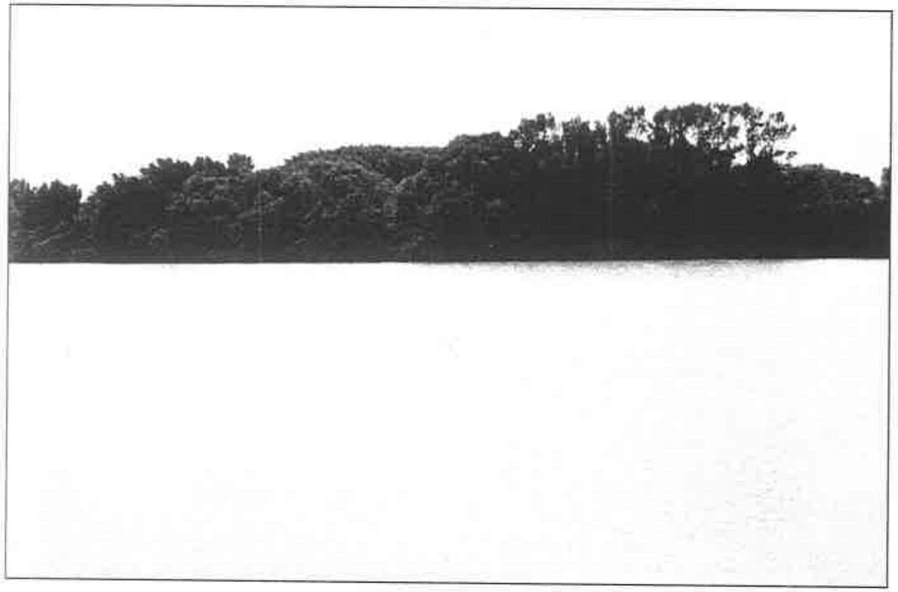


Foto 7 Povodeň pri Dunajských krivinách 06.08.1991 (MJL)

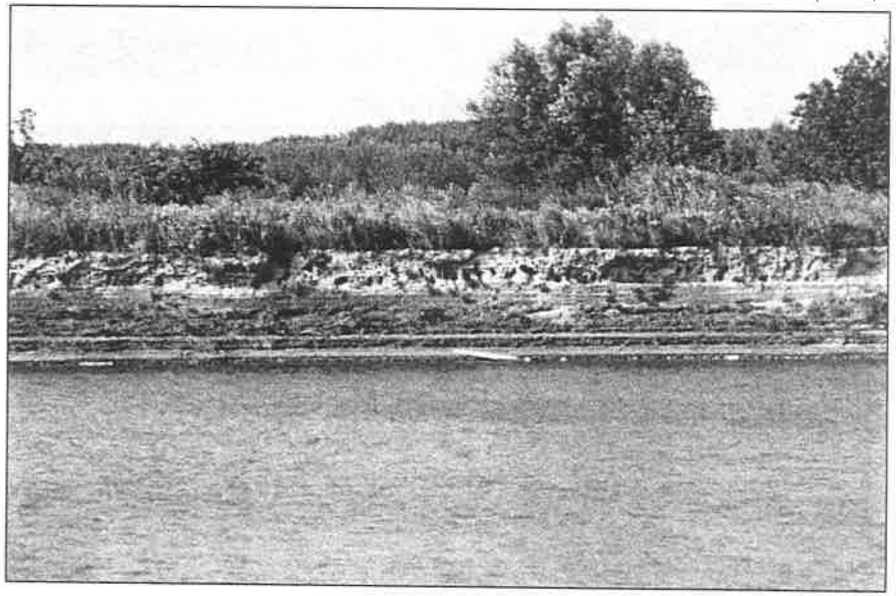


Foto 8 Laterálna erózia kedysi umožňovala obnovu hniezdnych kolónií brehule (*Riparia riparia*) 06.08.1986 (MJL)

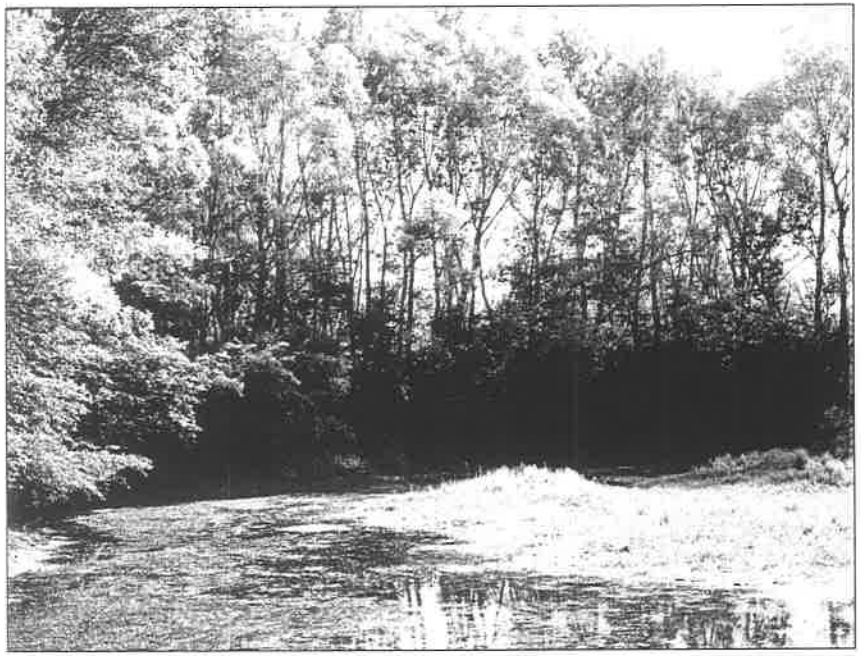


Foto 9 Dunajské kriviny 15.06.1989 (OEM)

Foto 10 Dunajské kriviny 26.09.1989 (OEM)

Foto 11 Dunajské kriviny 31.05.1990 (OEM)

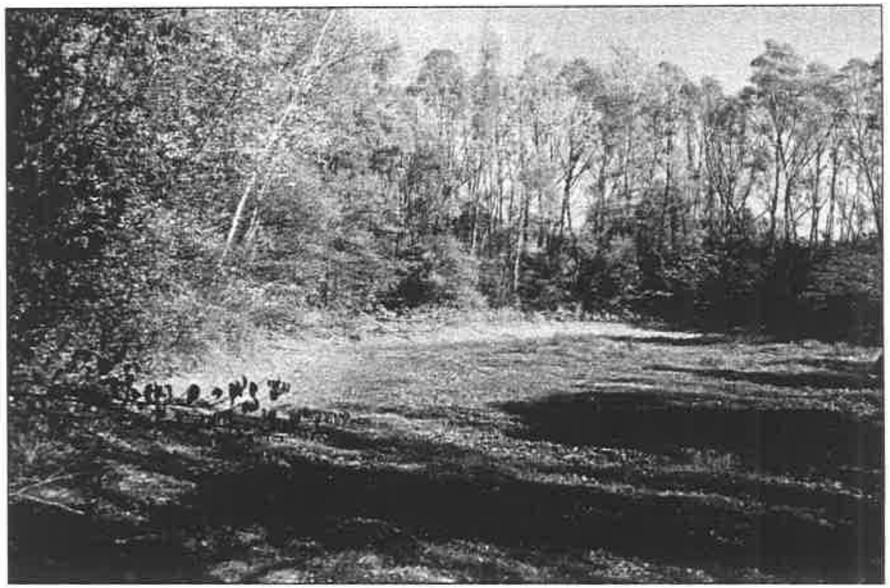


Foto 12 Dunajské kriviny 22.10.1990 (OEM)

Foto 13 Dunajské kriviny 06.03.1991 (OEM)

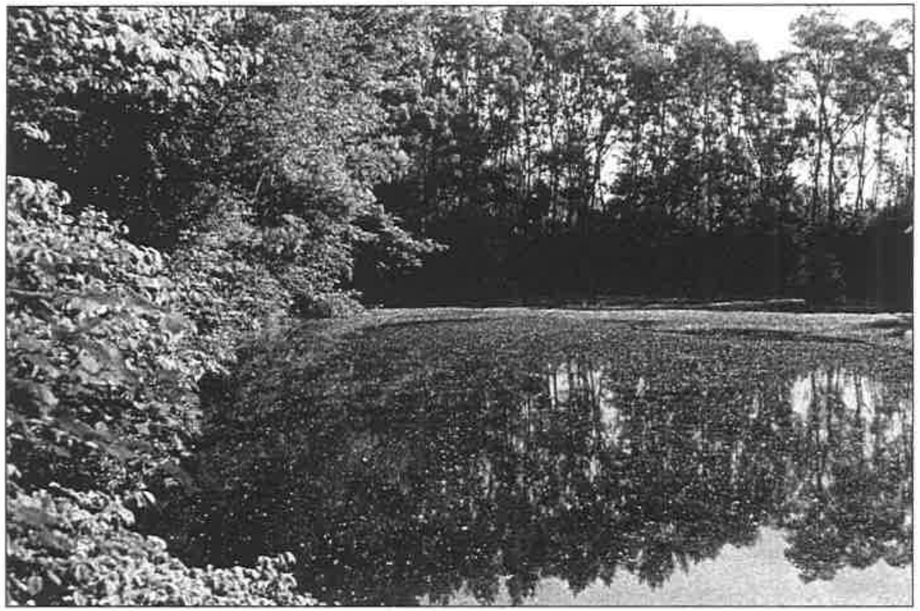


Foto 14 Dunajské kriviny 28.06.1991 (OEM)

Foto 15 Dunajské kriviny 23.10.1991 (OEM)

Foto 16 Dunajské kriviny 25.06.1993 (OEM)

Foto 17 Dunajské kriviny 31.05.1995 (OEM)

Foto 18 Dunajské kriviny 26.05.1993 (MJL)

Foto 19 Dunajské kriviny 06.09.2003 (MJL)

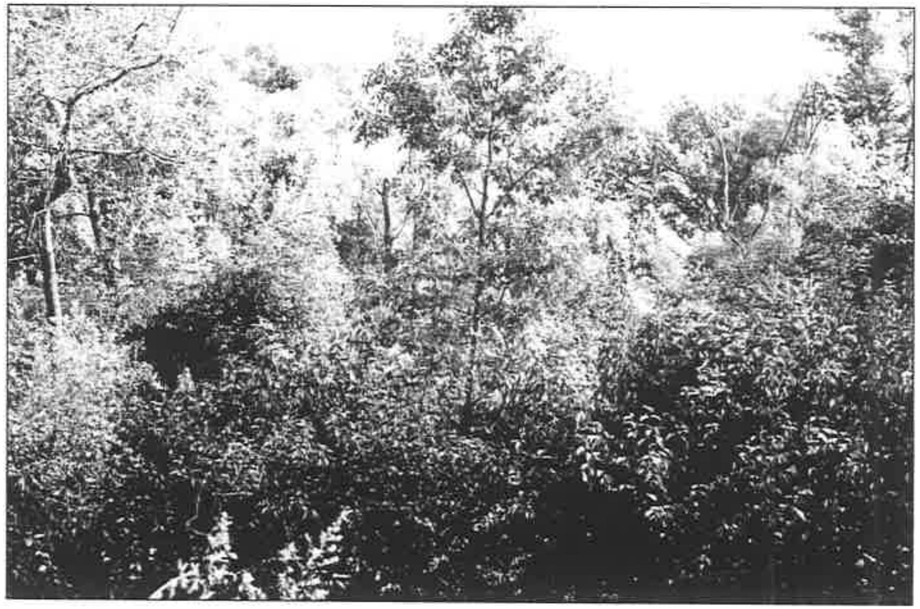


Foto 20 Dunajské kriviny 06.09.2003 (MJL)


Foto 21 Dunajské kriviny 06.09.2003 (MJL)

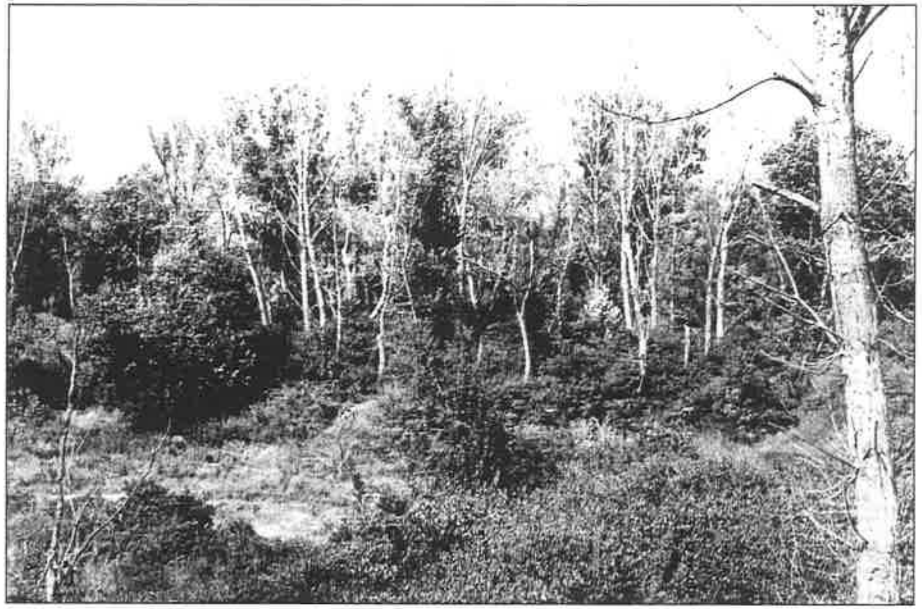


Foto 22 Dunajské kriviny 06.09.2003 (MJL)

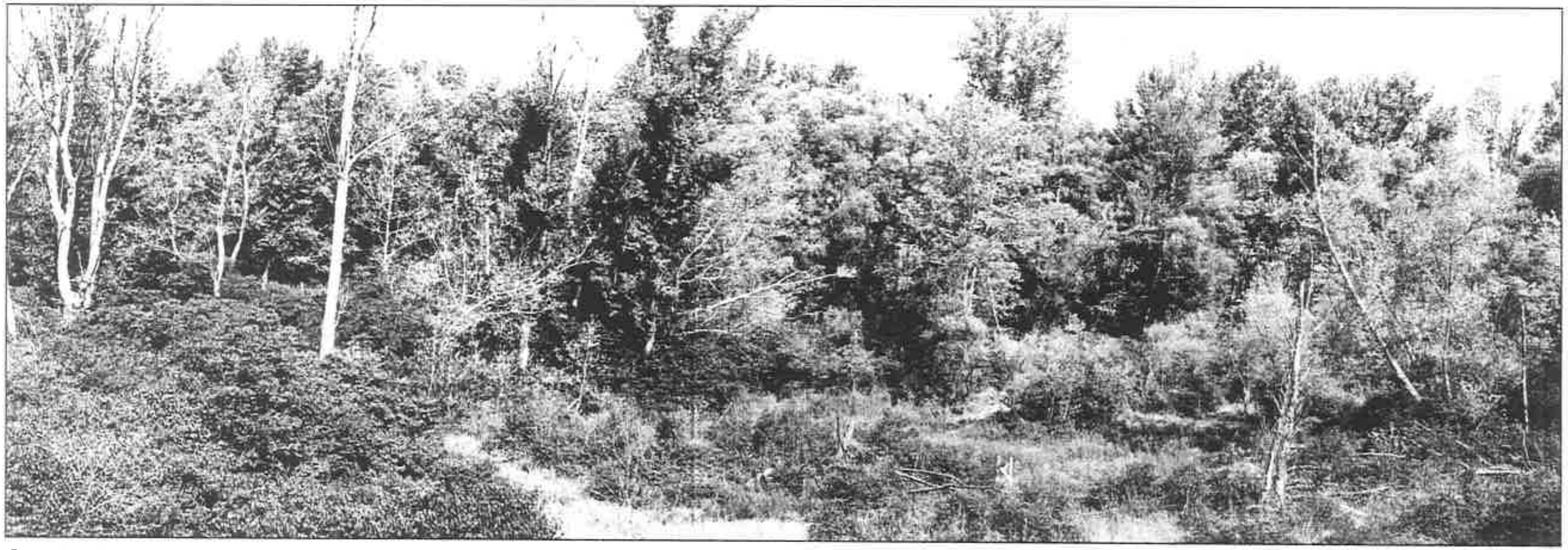


Foto 23 Dunajské kriviny 06.09.2003 (MJL)

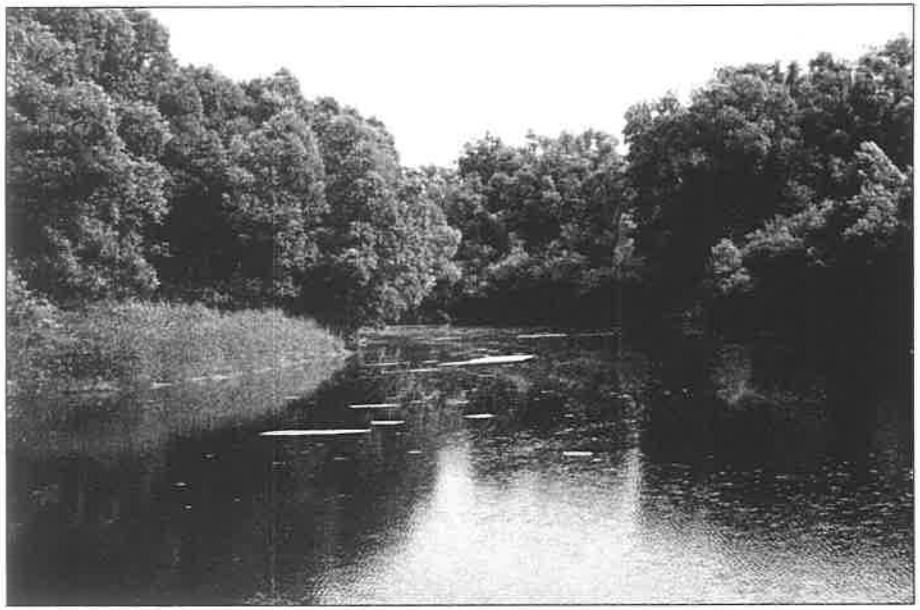


Foto 24 Bodícka brána - rameno pod líniou D 31.05.1990 (OEM)

Foto 25 Bodícka brána - rameno pod líniou D 31.05.1995 (OEM)

Foto 26 Bodícka brána 1 31.05.1990 (OEM)

Foto 27 Bodícka brána 1 22.10.1990 (OEM)

Foto 28 Bodícka brána I 06.03.1991 (OEM)

Foto 29 Bodícka brána I 23.10.1991 (OEM)

Foto 30 Bodícka brána I - periodické jazierko zarástlo a plochu obsadzuje javorovec 30.05.2003 (MJL)

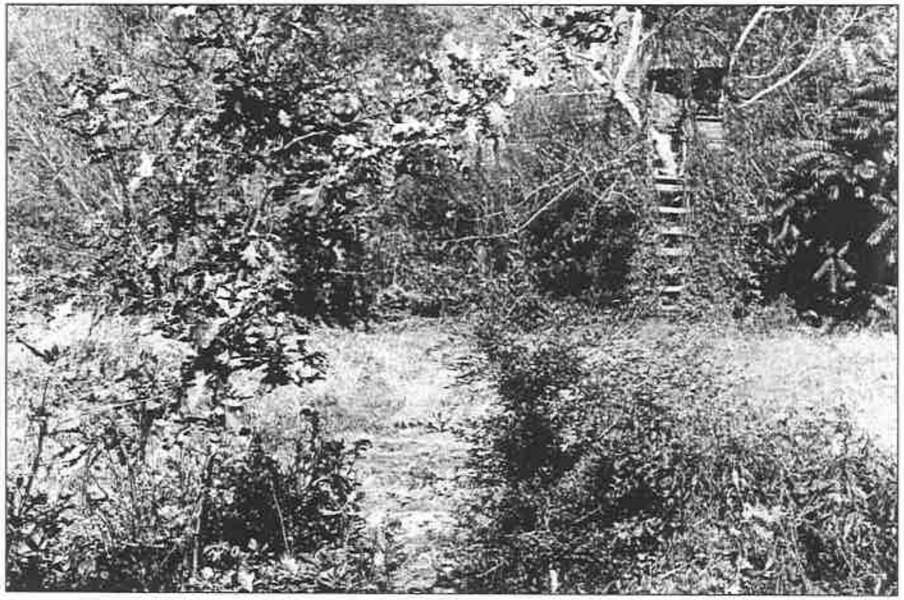


Foto 31 V drénovanom pobrežnom páse pri Vojke boli pokusne úspešne vysadené duby a jasene, ktorým však konkurujú vitálne náletové dreviny (pajaseň, javorovec, agát) 30.09.1999 (MJL)

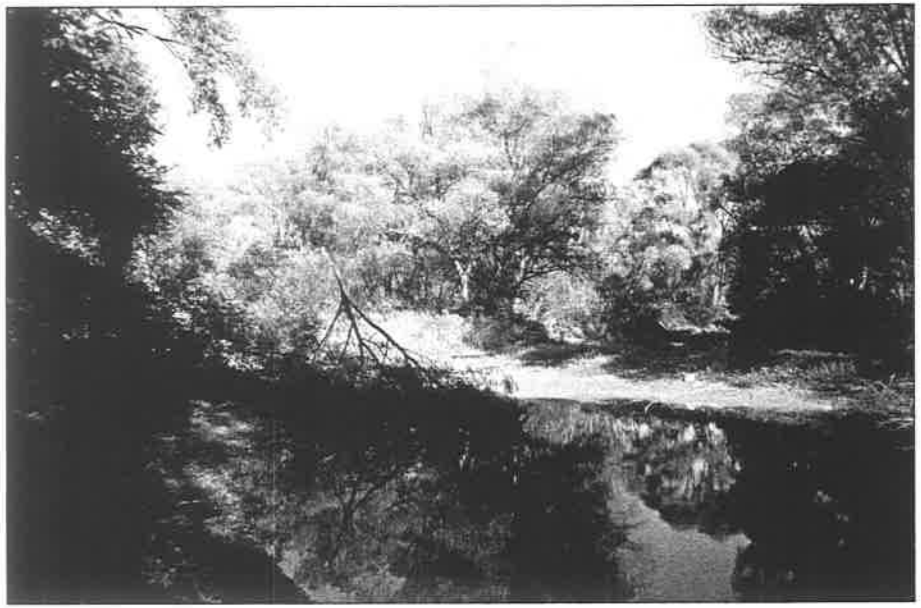


Foto 32 Bodícka brána 2 31.05.1990 (OEM)

Foto 33 Bodícka brána 2 22.10.1990 (OEM)

Foto 34 Bodícka brána 2 06.03.1991 (OEM)

Foto 35 Bodícka brána 2 22.10.1991 (OEM)

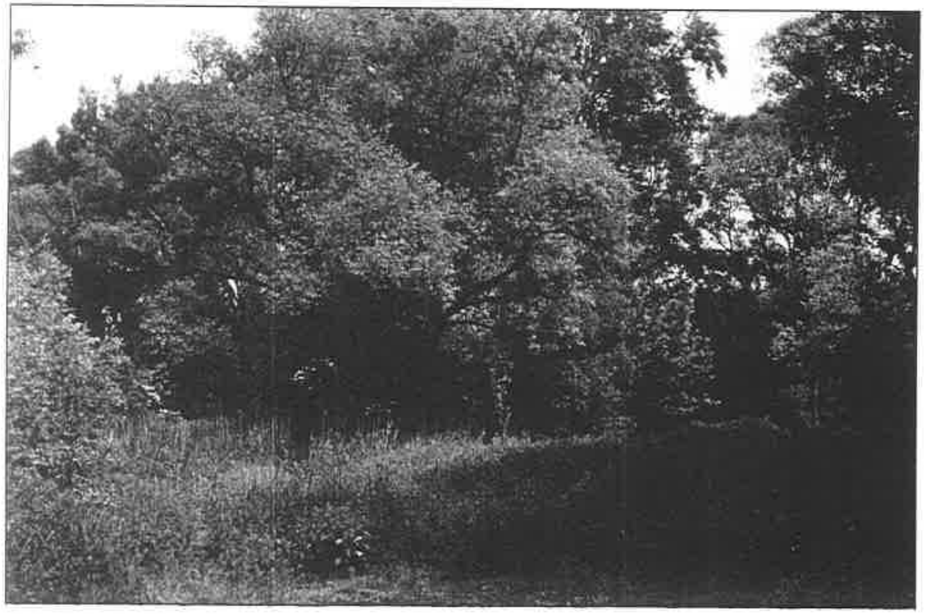


Foto 36 Bodícka brána 2 30.5.1995 (OEM)

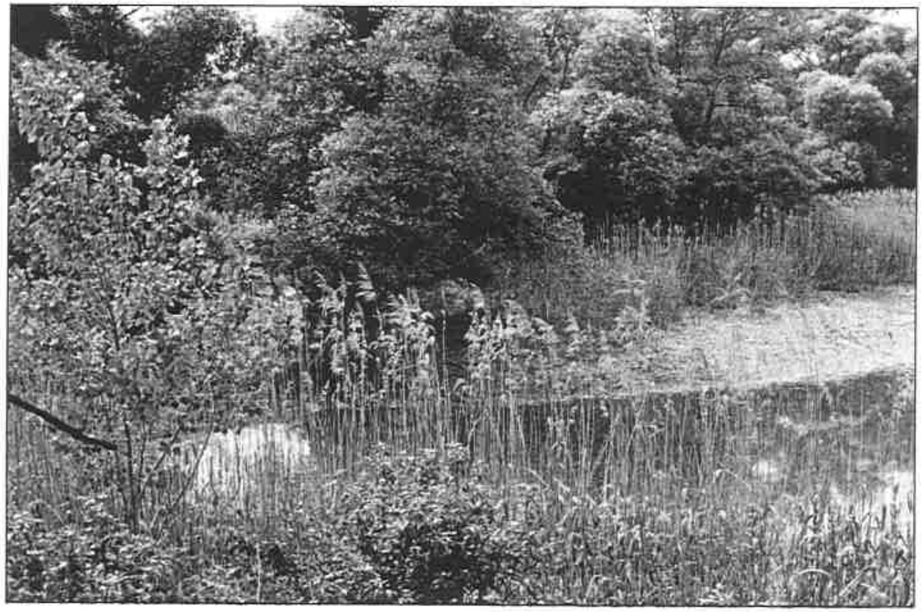


Foto 37 Istragov 17.05.1990 (OEM)

Foto 38 Istragov 22.11.1990 (OEM)

Foto 39 Istragov 06.03.1991 (OEM)

Foto 40 Istragov 28.06.1991 (OEM)

Foto 41 Istragov 23.10.1991 (OEM)

Foto 42 Bodícka brána 3 31.05.1990 (OEM)

Foto 43 Bodícka brána 3 22.10.1990 (OEM)

Foto 44 Bodícka brána 3 06.03.1991 (OEM)

Foto 45 Bodícka brána 3 23.10.1991 (OEM)

Foto 46 Bodícka brána 3 31.05.1995 (OEM)

Foto 47 Loď v zdrži v mieste pôvodného Šamorínskeho ramena 16.03.1988 (MJL)

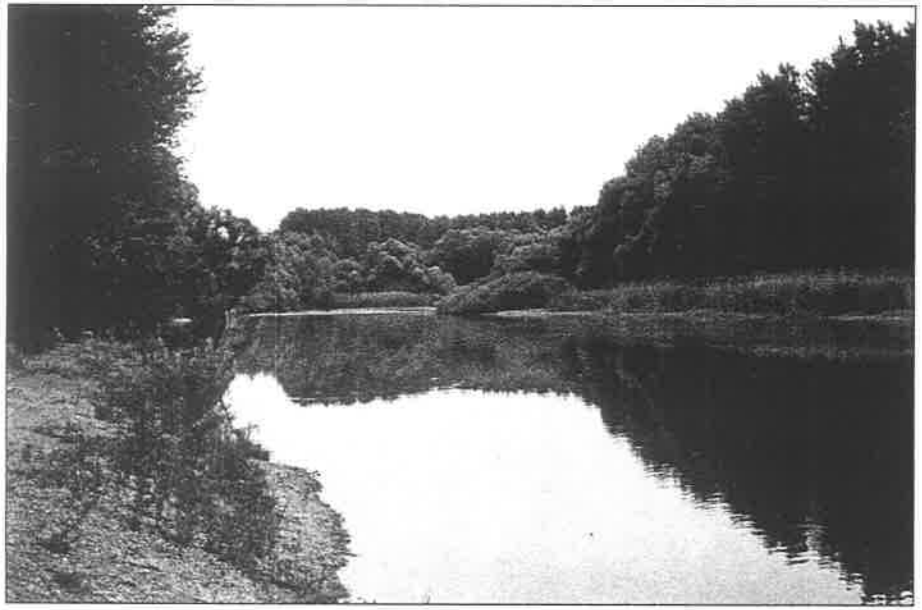


Foto 48 Kráľovská lúka 1 31.05.1990 (OEM)

Foto 49 Kráľovská lúka 1 25.06.1993 (OEM)

Foto 50 Kráľovská lúka 1 31.05.1995 (OEM)

Foto 51 Kráľovská lúka 2 07.11.1990 (OEM)

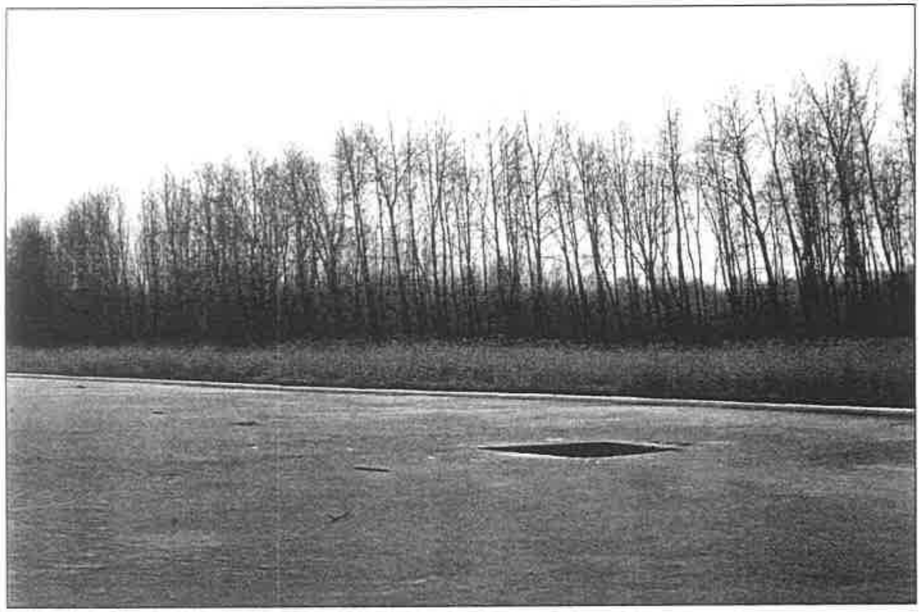


Foto 52 Kráľovská lúka 2 06.03.1991 (OEM)

Foto 53 Kráľovská lúka 2 28.06.1991 (OEM)

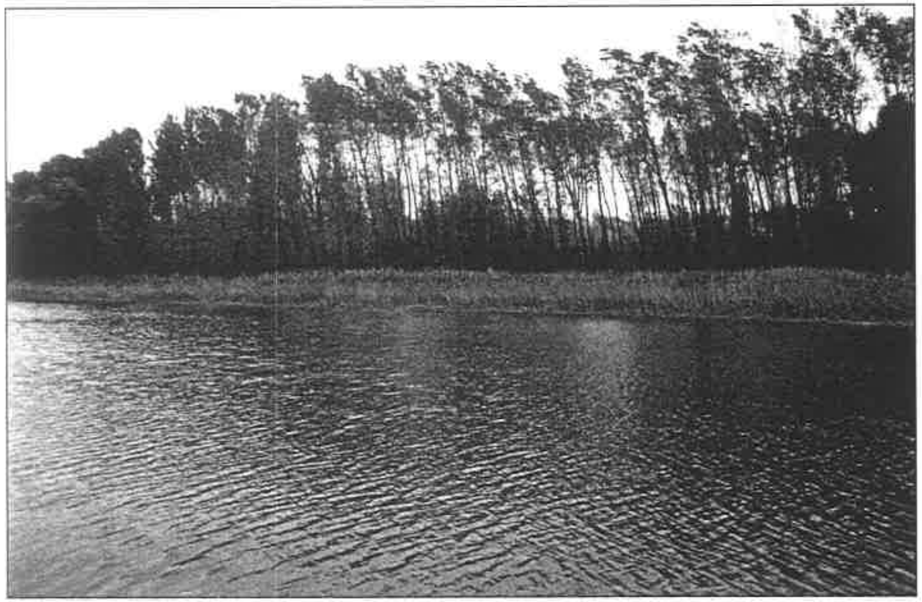


Foto 54 Kráľovská lúka 2 23.10.1991 (OEM)

Foto 55 Kráľovská lúka 2 31.05.1995 (OEM)


Foto 56 Kráľovská lúka 3 31.05.1990 (OEM)


Foto 57 Kráľovská lúka 3 07.11.1990 (OEM)


Foto 58 Kráľovská lúka 3 06.03.1991 (OEM)


Foto 59 Kráľovská lúka 3 28.06.1991 (OEM)

Foto 60 Kráľovská lúka 3 23.10.1991 (OEM)

Foto 61 Kráľovská lúka 3 31.05.1995 (OEM)

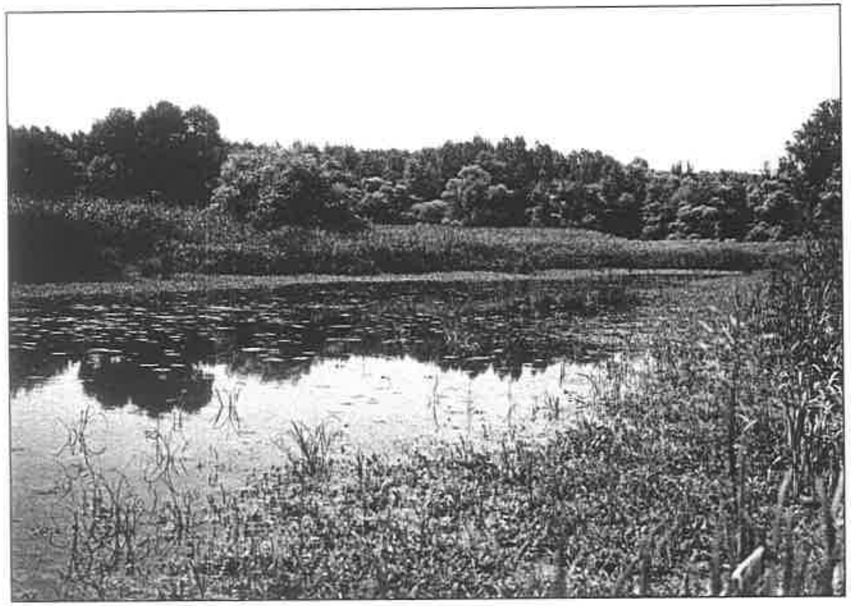


Foto 62 Starý les 10.08.1989 (OEM)

Foto 63 Starý les 24.08.1990 (OEM)

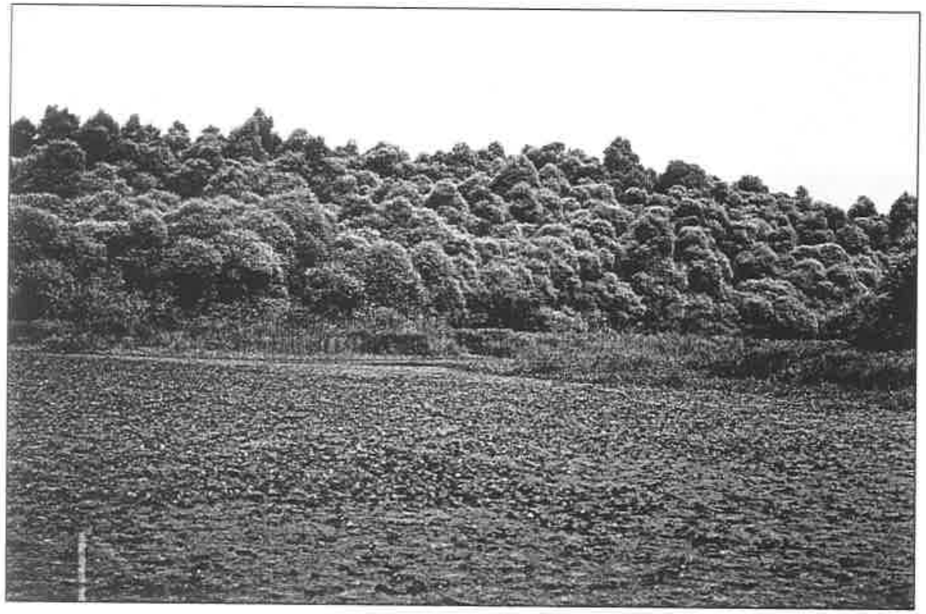


Foto 64 Sporná sihoť 1 10.08.1989 (OEM)

Foto 65 Sporná sihoť 1 25.10.1989 (OEM)

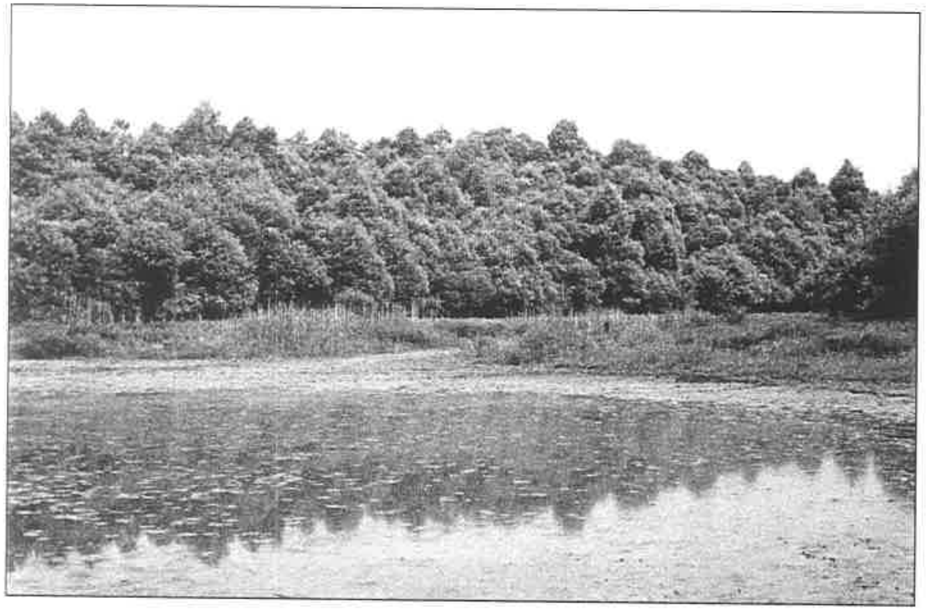


Foto 66 Sporná sihoť 1 17.05.1990 (OEM)

Foto 67 Sporná sihoť 1 07.11.1990 (OEM)

Foto 68 Sporná sihoť 1 06.03.1991 (OEM)

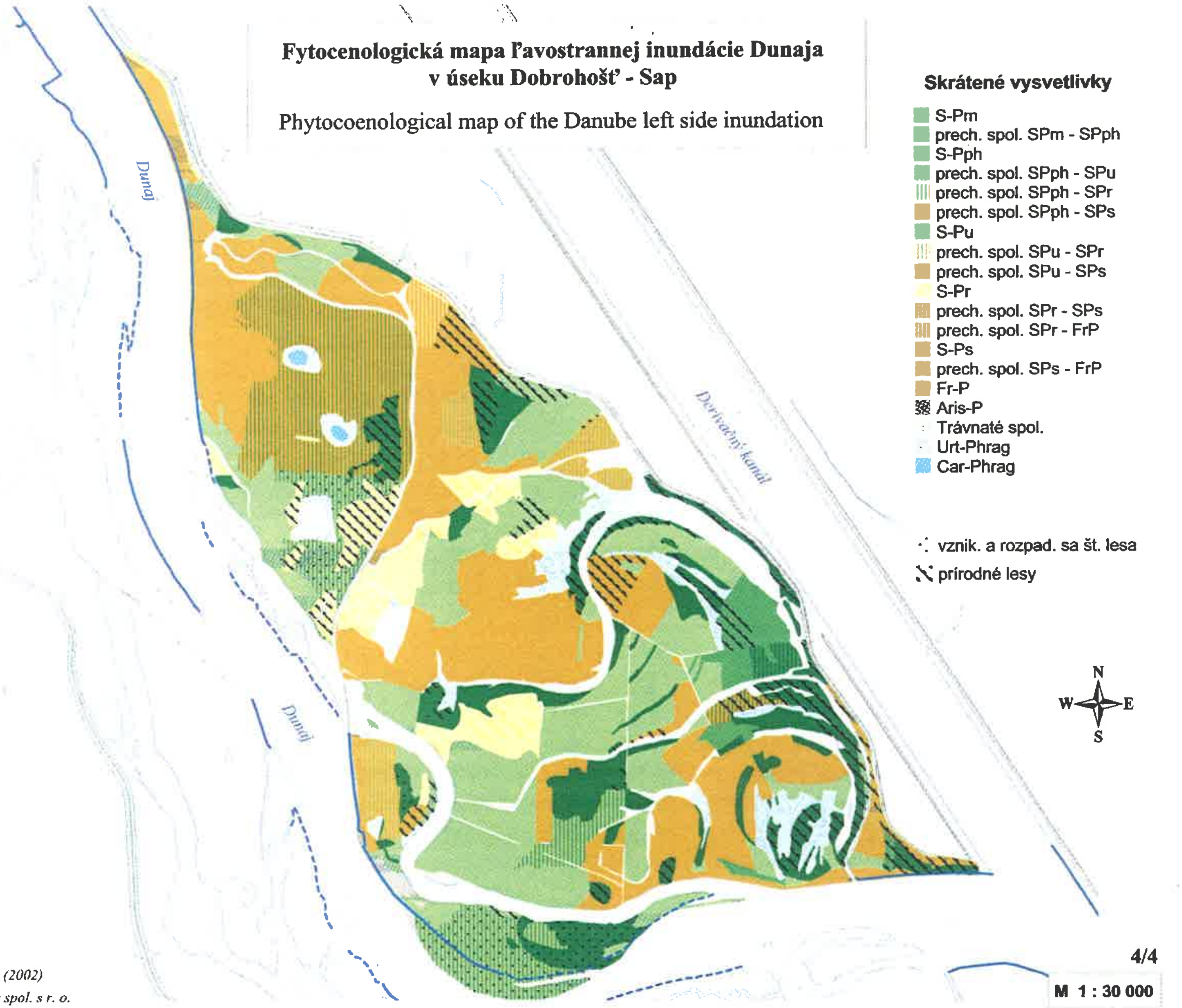
Foto 69 Sporná sihoť 1 28.06.1991 (OEM)

Foto 70 Sporná sihoť 1 23.10.1991 (OEM)

Foto 71 Sporná sihoť 2 23.10.1991 (OEM)

Fytocenologická mapa ľavostrannej inundácie Dunaja v úseku Dobrohošť - Sap

Phytocoenological map of the Danube left side inundation



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M 1 : 30 000

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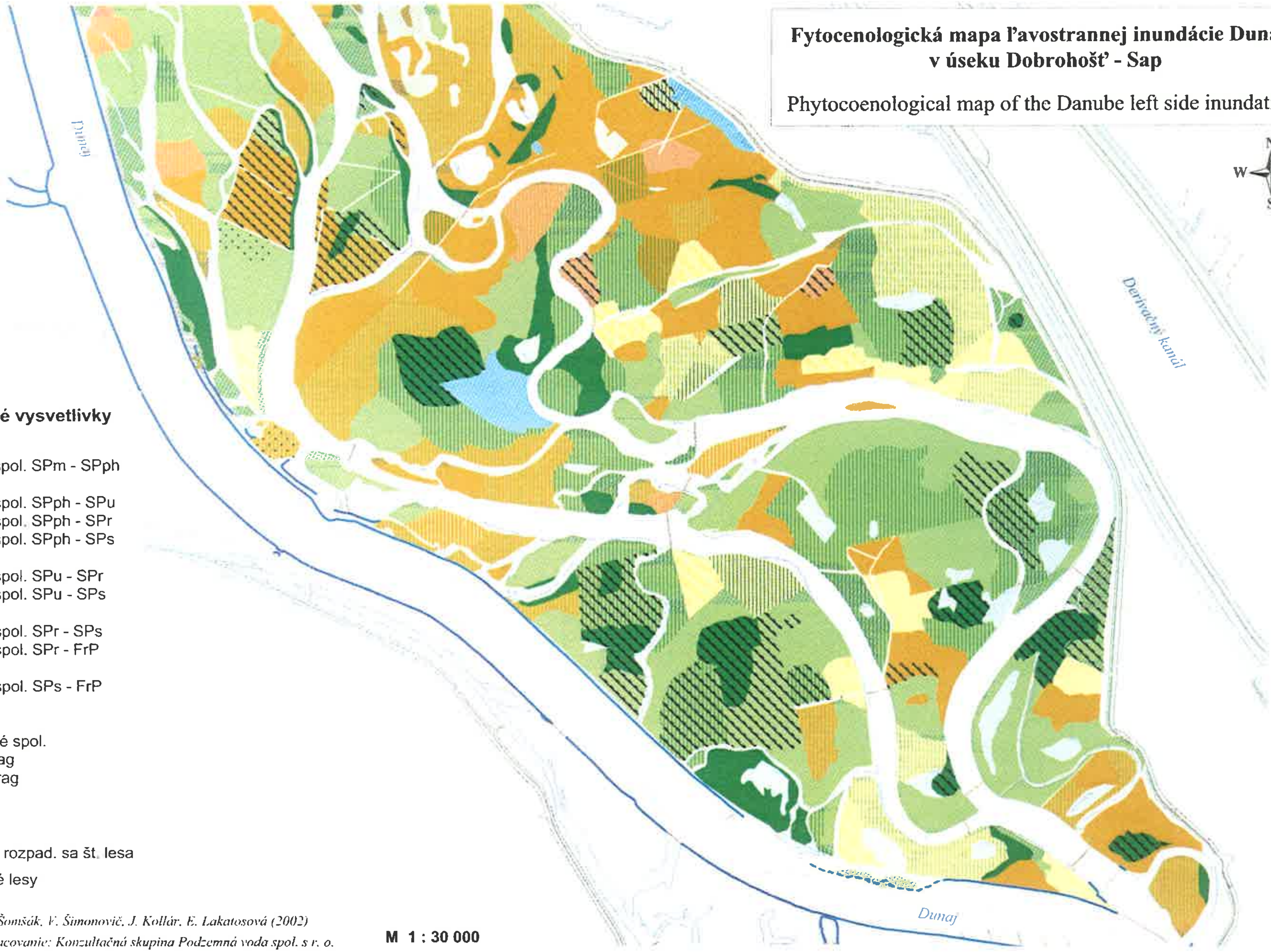
Digitálne spracovanie: Konzultačná skupina Podzemná voda spol. s r. o.

Fytocenologická mapa ľavostrannej inundácie Dunaja v úseku Dobrohošť - Sap

Phytocoenological map of the Danube left side inundation



Skrátené vysvetlivky

- S-Pm
- prech. spol. SPm - SPph
- S-Pph
- prech. spol. SPph - SPu
- prech. spol. SPph - SPr
- prech. spol. SPph - SPs
- S-Pu
- prech. spol. SPu - SPr
- prech. spol. SPu - SPs
- S-Pr
- prech. spol. SPr - SPs
- prech. spol. SPr - FrP
- S-Ps
- prech. spol. SPs - FrP
- Fr-P
- Aris-P
- Trávnaté spol.
- Urt-Phrag
- Car-Phrag

- vznik. a rozpad. sa št. lesa
- prírodné lesy

M 1 : 30 000

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