



HYDROMORPHOLOGY/ HIDROMORFOLOGIJA

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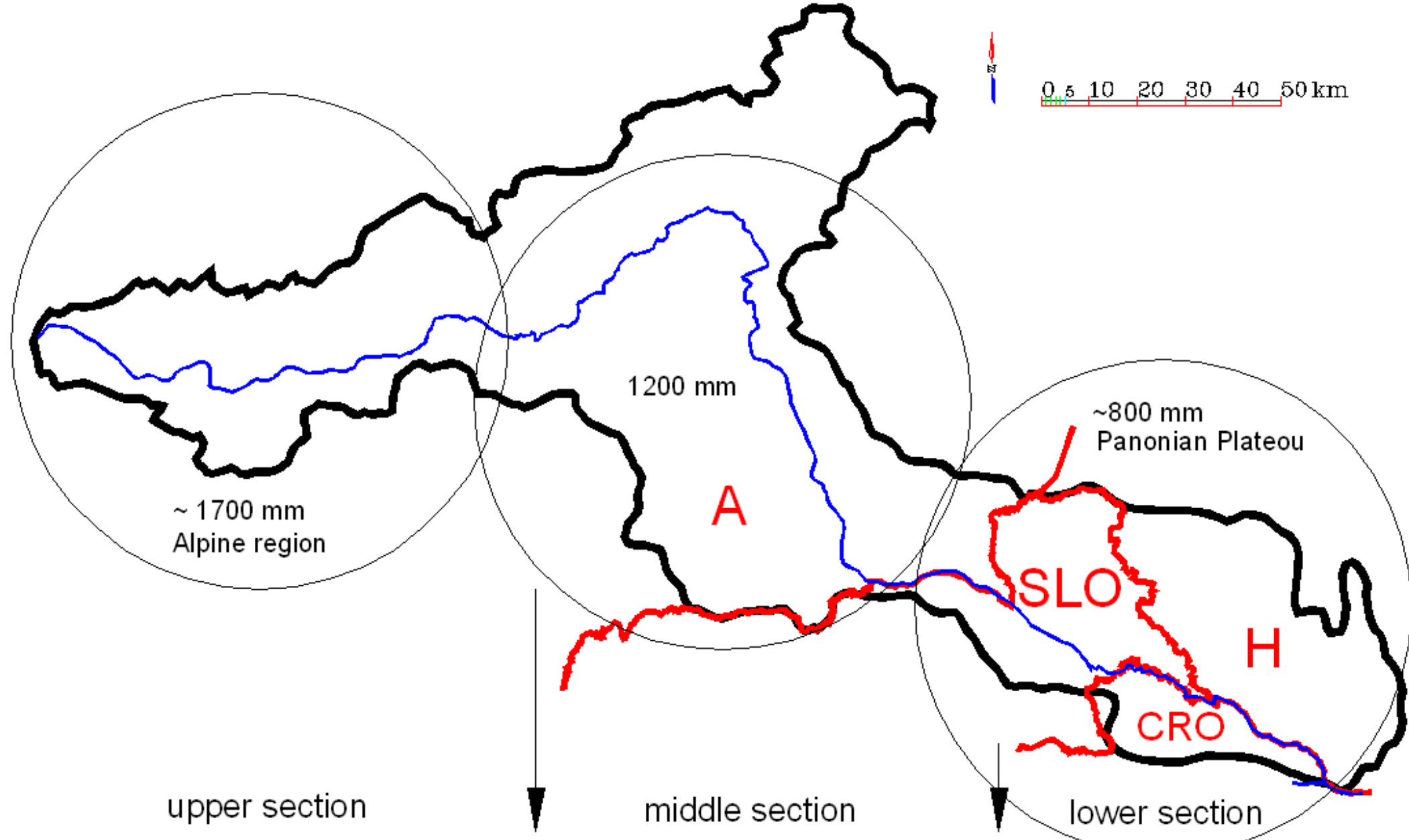
**THE
FUTURE
OF
BORDER
MURA**

**BILATERAL
CONFERENCE**

Radenci, Slovenia

8. - 9. May 2019



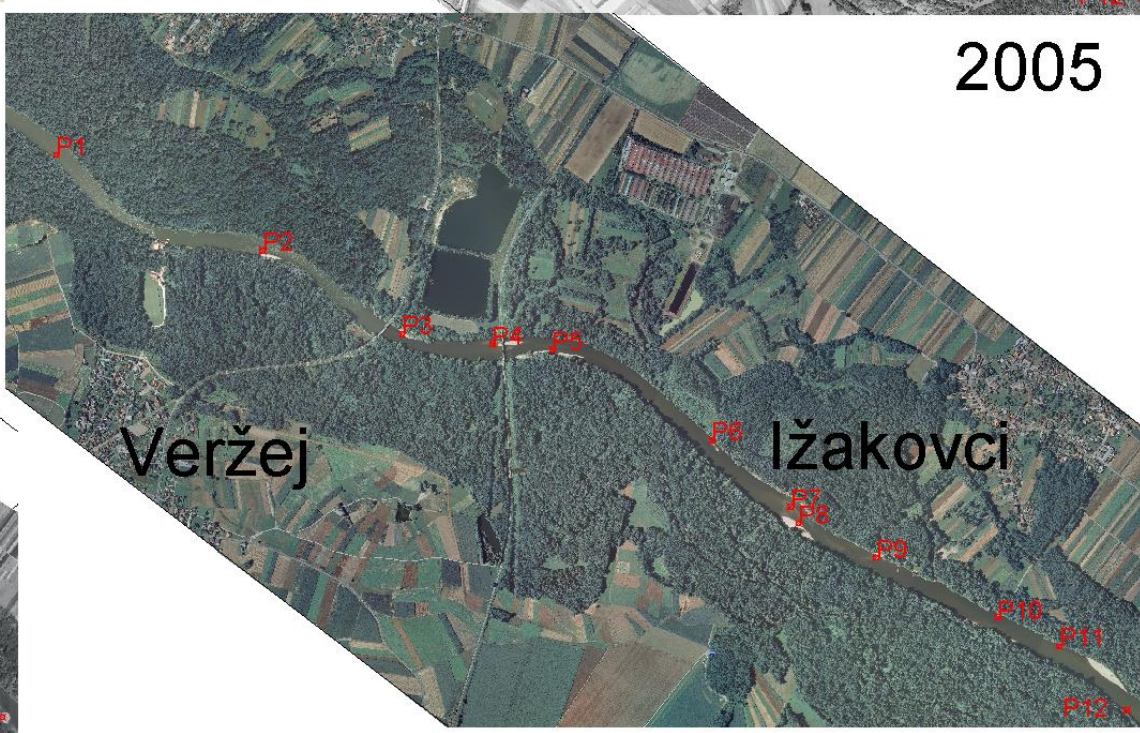
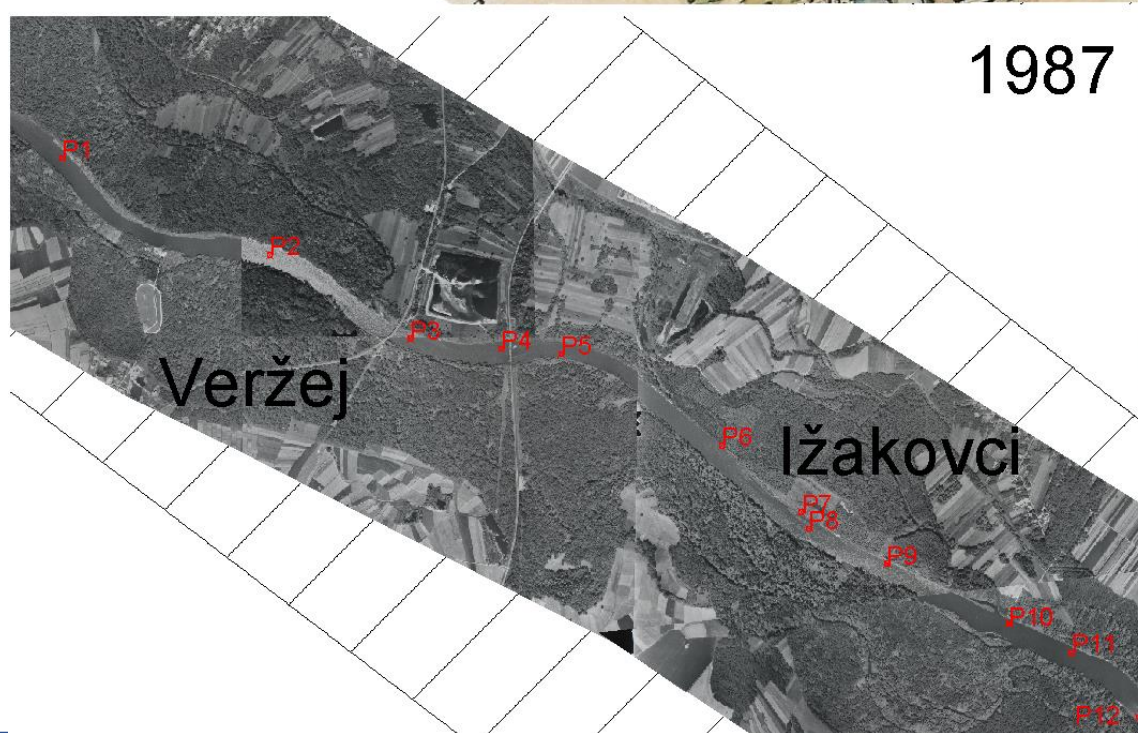
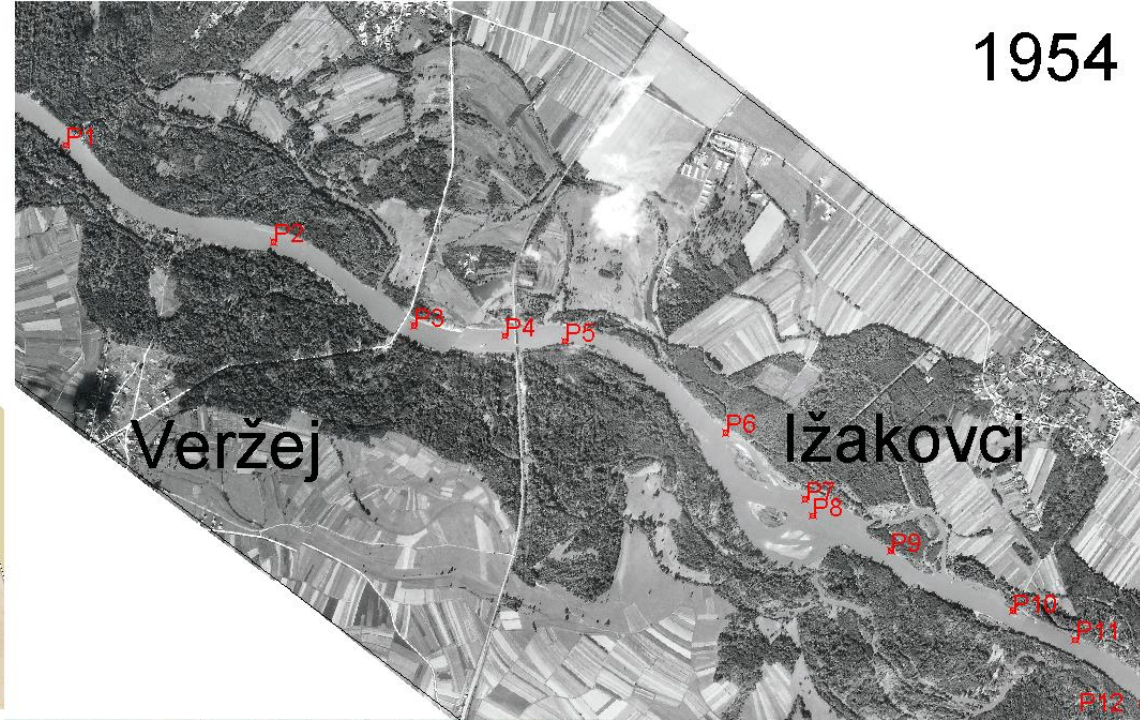
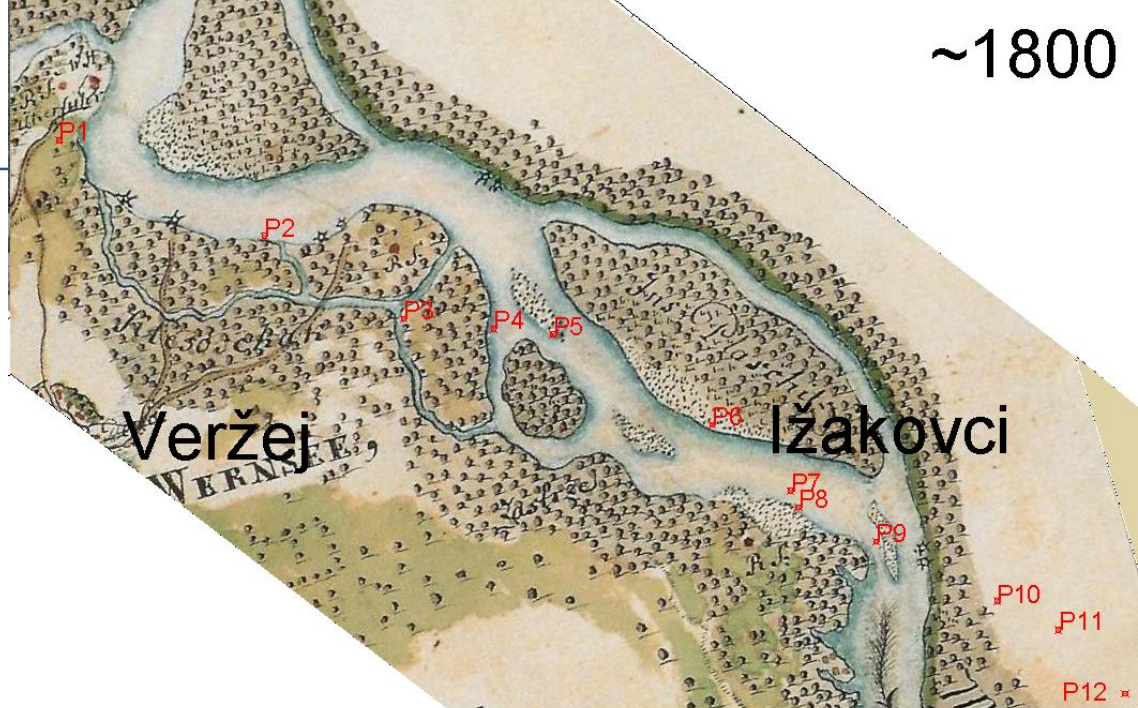


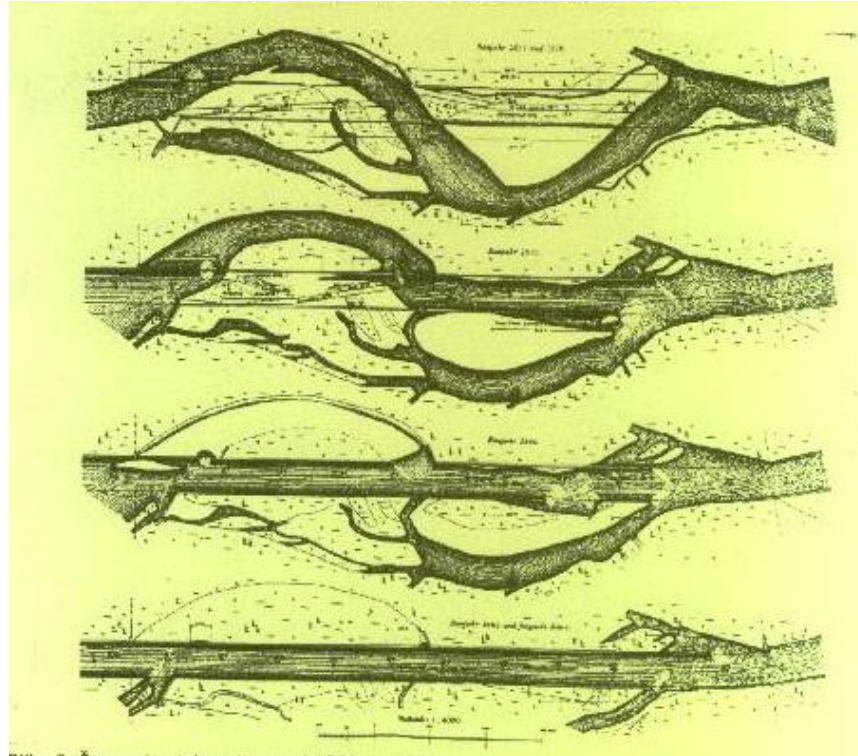
upper section

middle section

lower section

average river slope:	2.1m/1000m (0.21%)	1m/1000m	0.6m/1000m
average discharge:	150 m ³ /s		170 m ³ /s
high water Q 1% probab.:	1800 m ³ /s		
Q 95%:	60 m ³ /s		65 m ³ /s





Boštjana Žajdela (2008):

‘Okoliškemu prebivalstvu so poplave uničevale posevke, odnašale rodovitno prst, jemale imetje in življenja. Za zaščito pred ujmami, so začeli krajšati, izravnovati njen tok, da bi vodo čim hitreje spravili iz pokrajine in pridobili več obdelovalne zemlje.’

Boštjana Žajdela (2008):

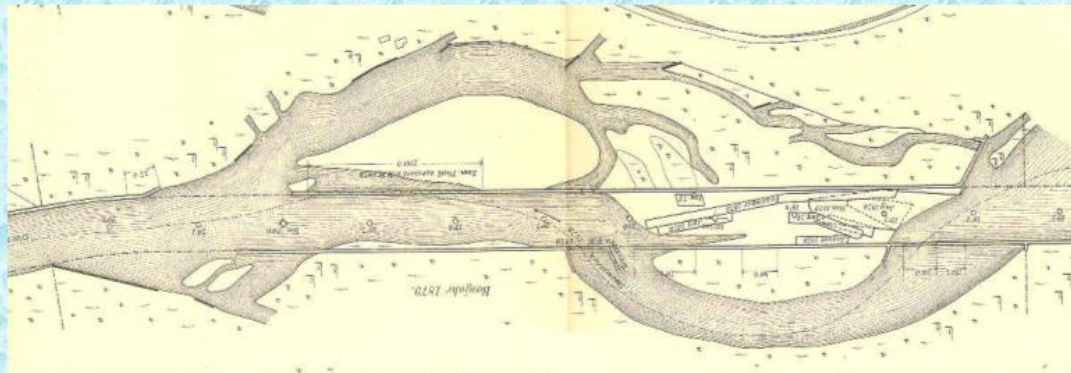
‘Floods destroyed crops, eroded fertile soil, took possession of property and lives. In order to protect themselves from floods, people began to reduce the flow of the river to get water quickly out of the country and gain more cultivable land.’



Mejna Mura z Avstrijo konec 19. stoletja in danes
(Hornich, 2007)

Border Mura with Austria at the end of the 19th century and today
(Hornich, 2007)

Regulacija Mure (Hohenburgova regulacija 1874 – 1891)



Murregulierung in Steiermark.

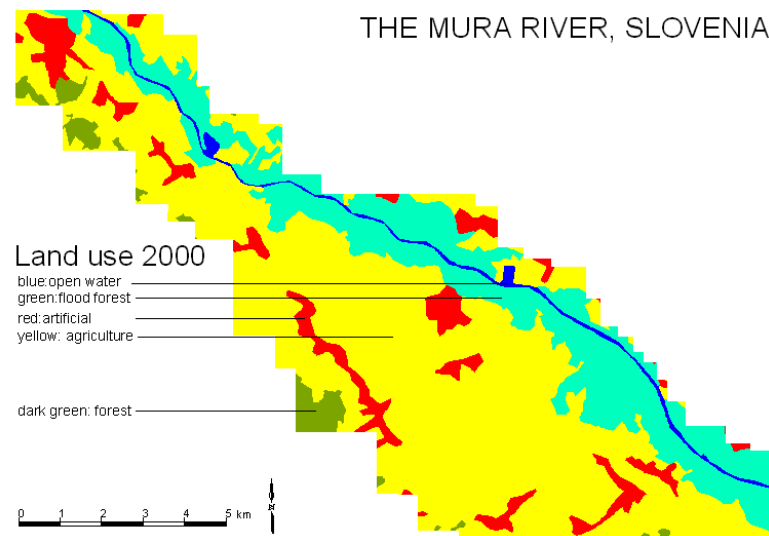
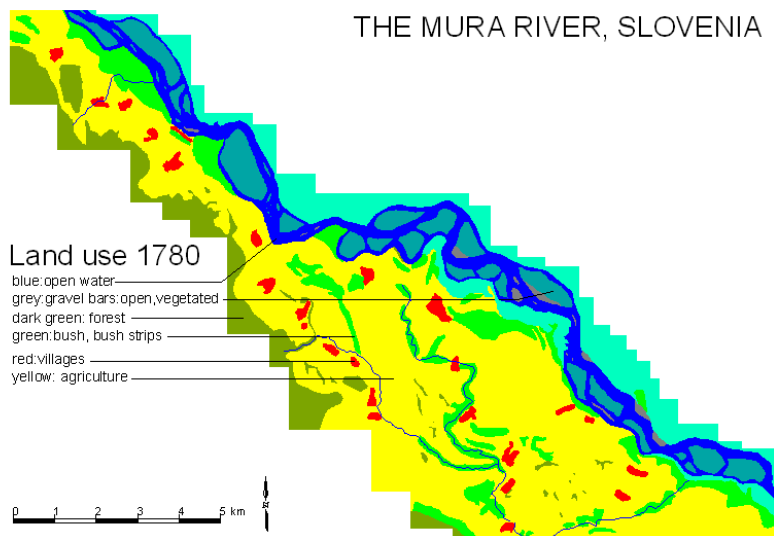
Utrditev bregov



Versicherung der neuen Uferböschungen.

a) mit Kiessteinpflaster.

RABA TAL/LAND USE (90 km²):



	1780	1954	2000
Forest/gozd	8 %	3%	2 %
Agriculture/kmetijske površine	50 %	55%	64 %
open water, gravelbars/voda, prodišča	10 %	8%	4 %
along river forest/obrežni gozd	30 %	28%	23 %
Settlements/naselja	2 %	6%	7 %

SURFACE WATER (Slovenia) trends:

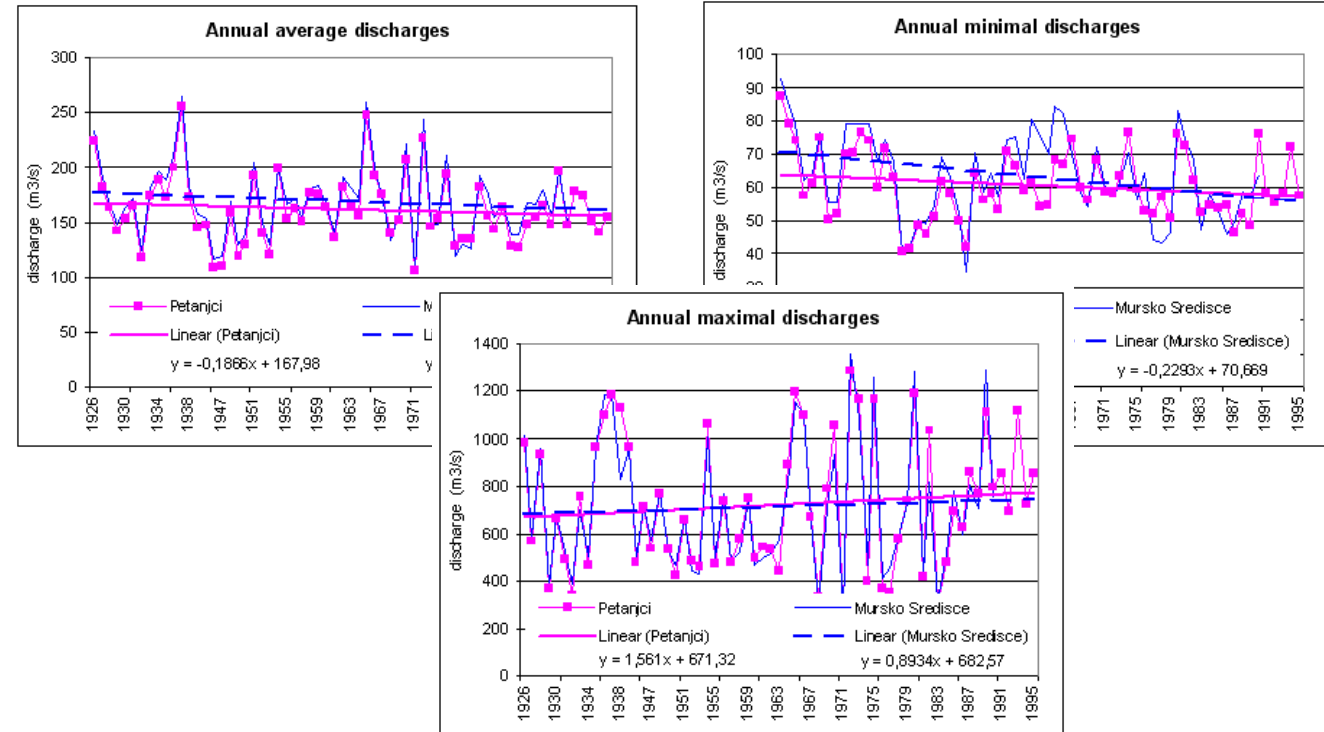
- negative trend for average and low water flows
- positive trend for high water flows (peaks)
- negative trend for 1%, 50% and 80% frequency distribution of discharges (FDC), but positive for 95% and 90%
- negative trend of storage effect of the system

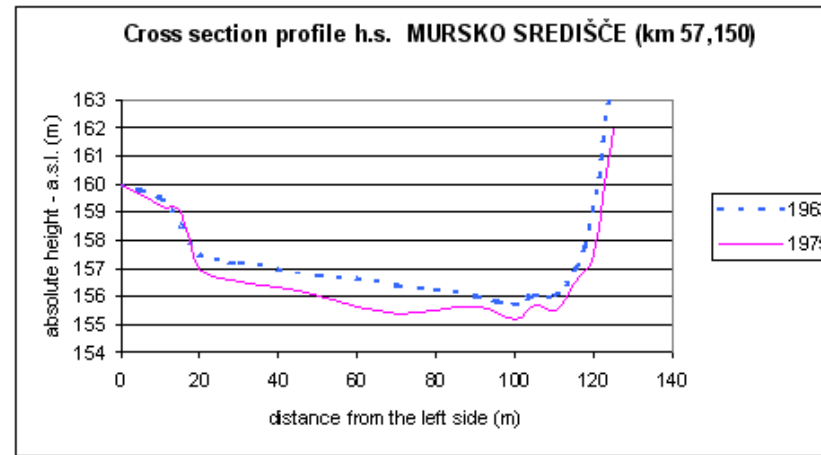
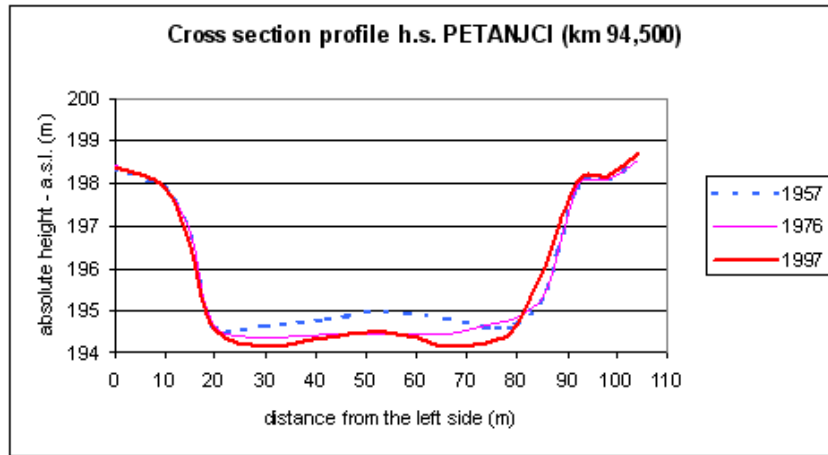
GROUNDWATER:

- water table is lower in dry periods
- shallow aquifer, fed by surface water mostly

SEDIMENT FLOW:

- regular supply lower due to HP chain in Austria: local erosion of river banks (if possible) and bed (larger if bank erosion impossible)
- water and sediment flow dynamics is 'printed' on river morphology (gravelbars, bed erosion)



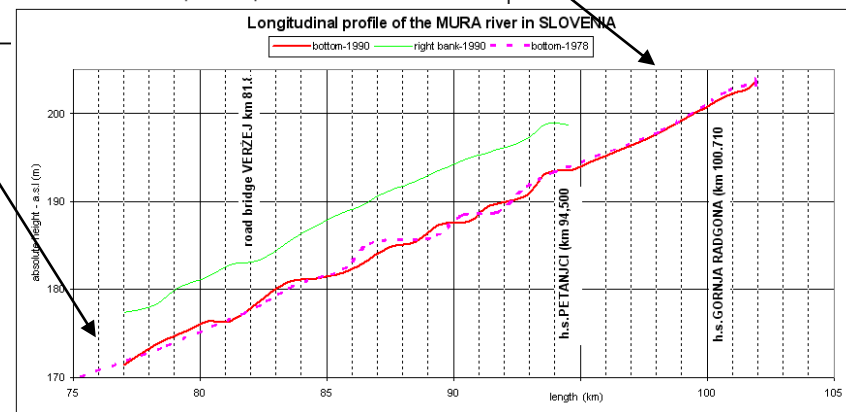
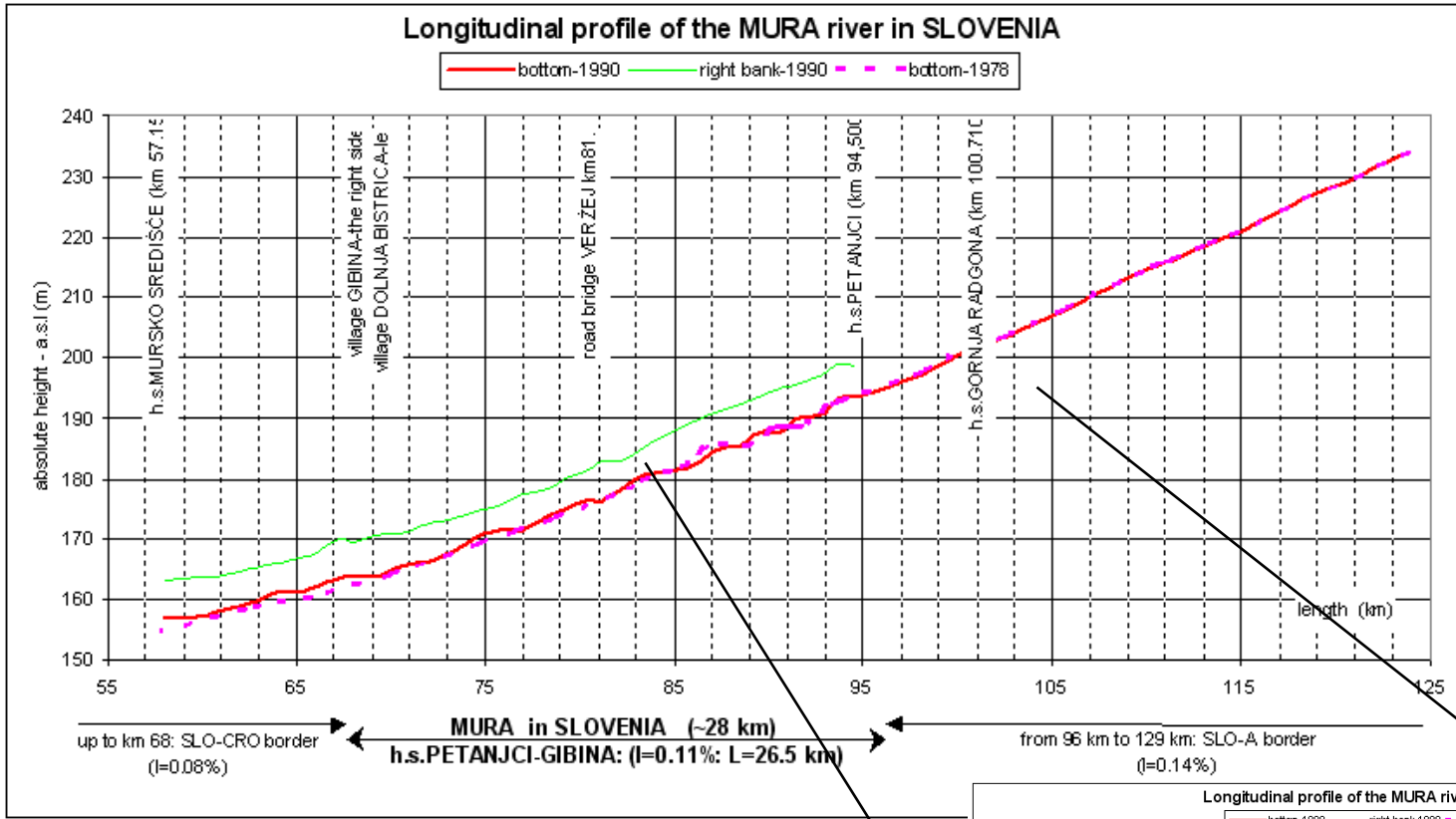


1) 1957-1997: river bottom level lowered in average for 0.3 m; on critical locations between 0,5 and 0,9 m;

2) different morpho-dynamics along the river (three sections):

- AT-SLO border
- Mura in SLOVENIA
- SLO-HR border

RIVER MORPHOLOGY:



- (1) SLO-A section (no hydropower stations anymore). average drop 0.50 m; max 0.88
- (2) SLO: 22 cm drop; river bottom drop and rise interchange; hinge point section; effect disappears;
- (3) SLO-CRO (stabilising section: more gravelbars as deposit sites of eroded materials from river banks upstream mostly)



1954

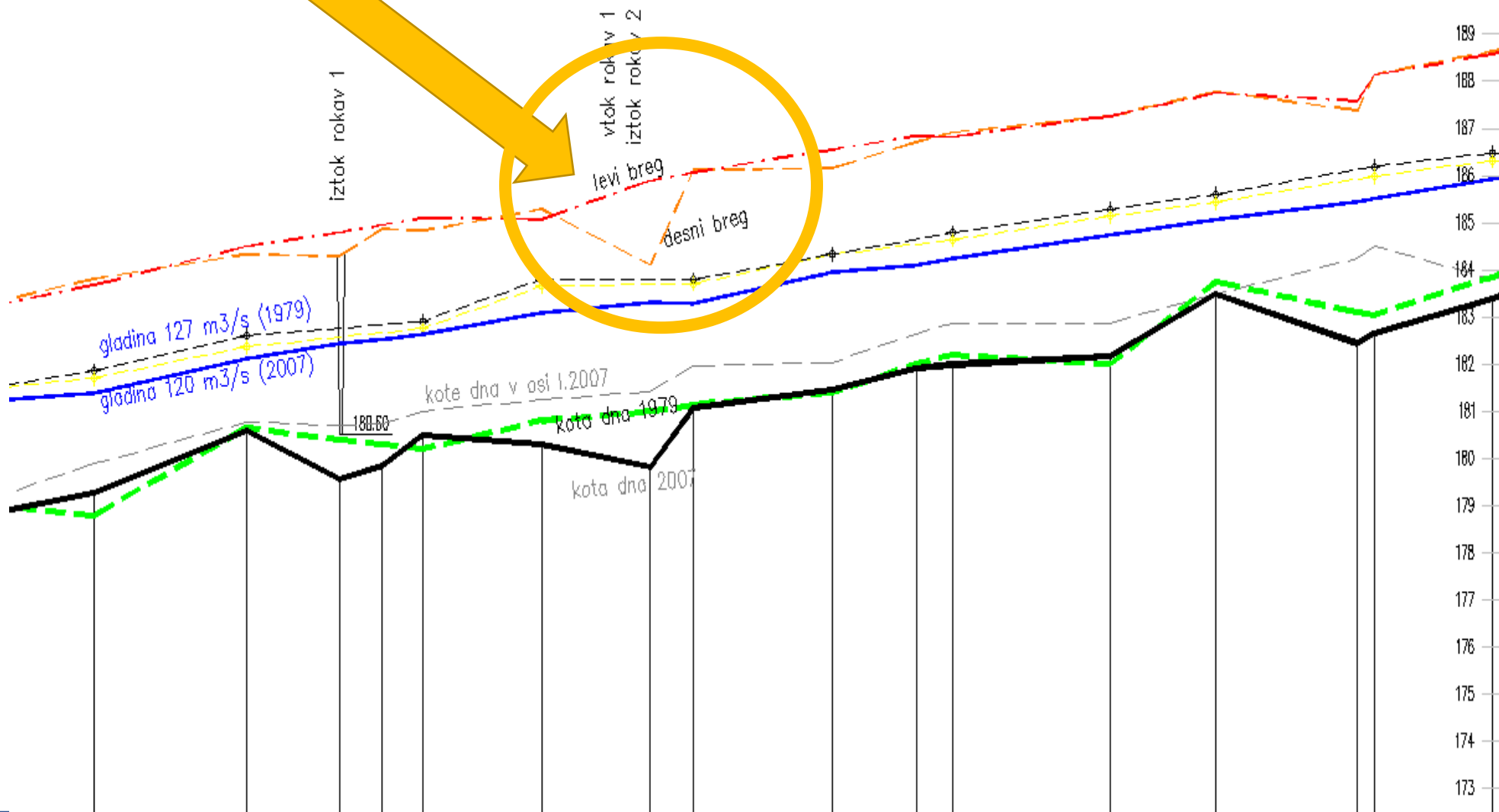


2007

Inflow to side channel:

~ 1960: at 130 m³/s (60% days in the year)

~ 2007: at 170 m³/s (in 1960: 40 % days in the year; in 2007: 30% days)



1 MORPHOLOGICAL MONOTONY and CHANGED RIVER CHARACTER: Long term dynamics (of changes) of morphology of channel (channel regulation, bank stabilization) and flooding patterns (hydropower, land use), coupled with short term human impacts (pumping, drainage network on agricultural land) are factors influencing morphology of the river and riparian zone.

2 REDUCED HYDROLOGICAL DYNAMICS: Nowadays water from the main channel of the Mura fills only few remaining side channels and fills floodplain soil only at flood pulse (level of the river above its banks).

The level of groundwater and water in the channel are mutually dependent.

Existing backwaters and oxbows, once typical for the floodplain areas along the Mura River, now have very weak or no connection at all with the river waters (river regulation, silting, no-renewal).

3 ECOLOGICAL CHANGES: Area of riparian forest has declined for 30%, but among this forest 10% is degraded by alien *Robinia pseudoacacia*. Only 35% of area is completely natural or nature-close stage.

No new side channels are formed, no widening of rivers, no large gravel bars less water, fast drainage....



STILL VALUABLE NATURAL CHARACTERISTICS



gravel bars, eroded river banks, side channels, oxbow lakes, flood forest, wet meadows...



BIODIVERSITY FACTS:

- **47 fish + 1 lumprey species**
- **44 bird species**
- **33 other species**

NATURA 2000 site:
30 bird sp., 20 other sp.,
8 habitats

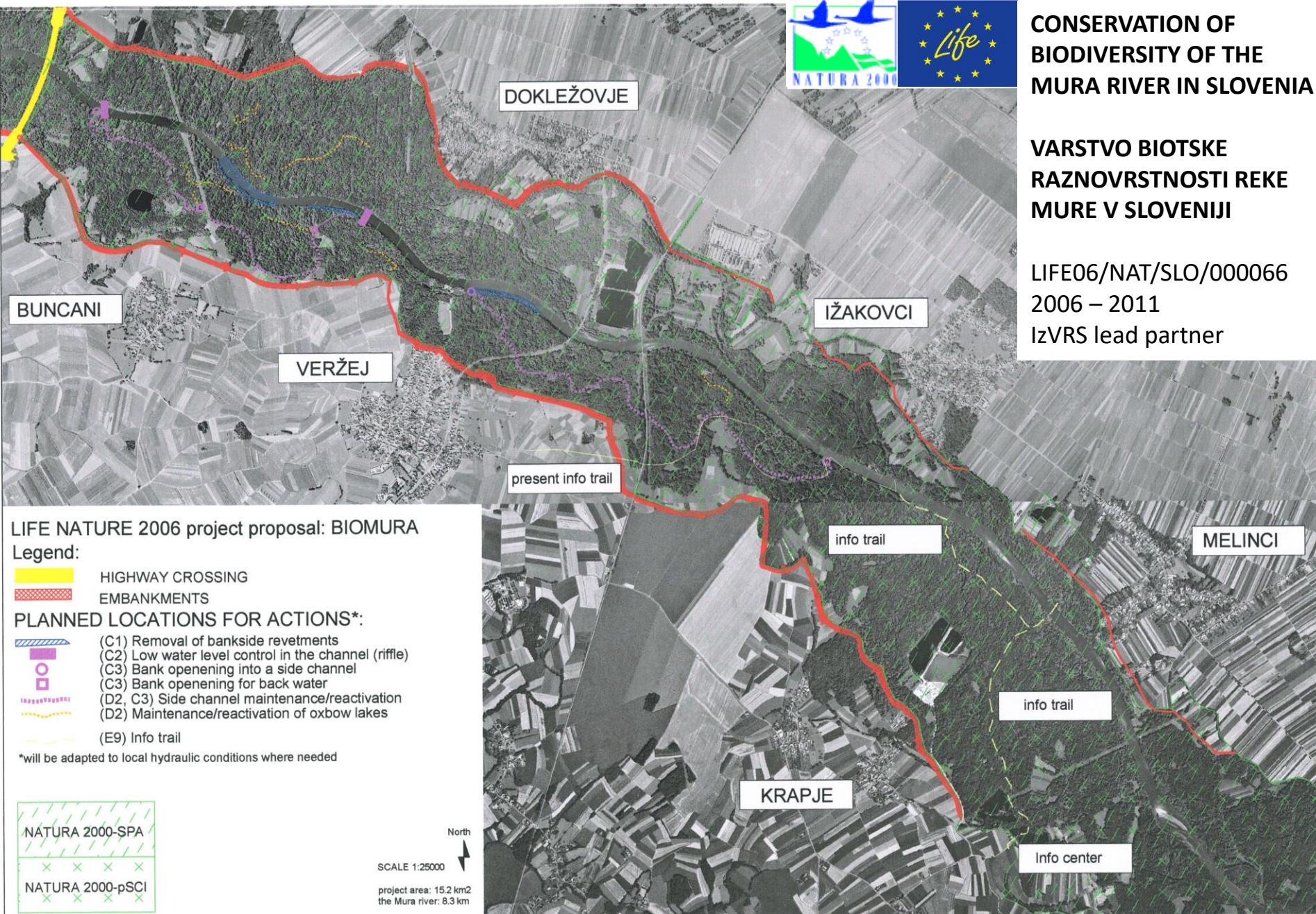
BIOMURA PROJECT



CONSERVATION OF BIODIVERSITY OF THE MURA RIVER IN SLOVENIA

VARSTVO BIOTSKE RAZNOVRSTNOSTI REKE MURE V SLOVENIJI

LIFE06/NAT/SLO/000066
 2006 – 2011
 IzVRS lead partner










LIFE NATURE 2006 project proposal: BIOMURA

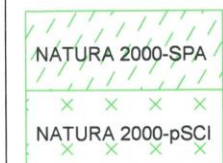
Legend:

-  HIGHWAY CROSSING
-  EMBANKMENTS

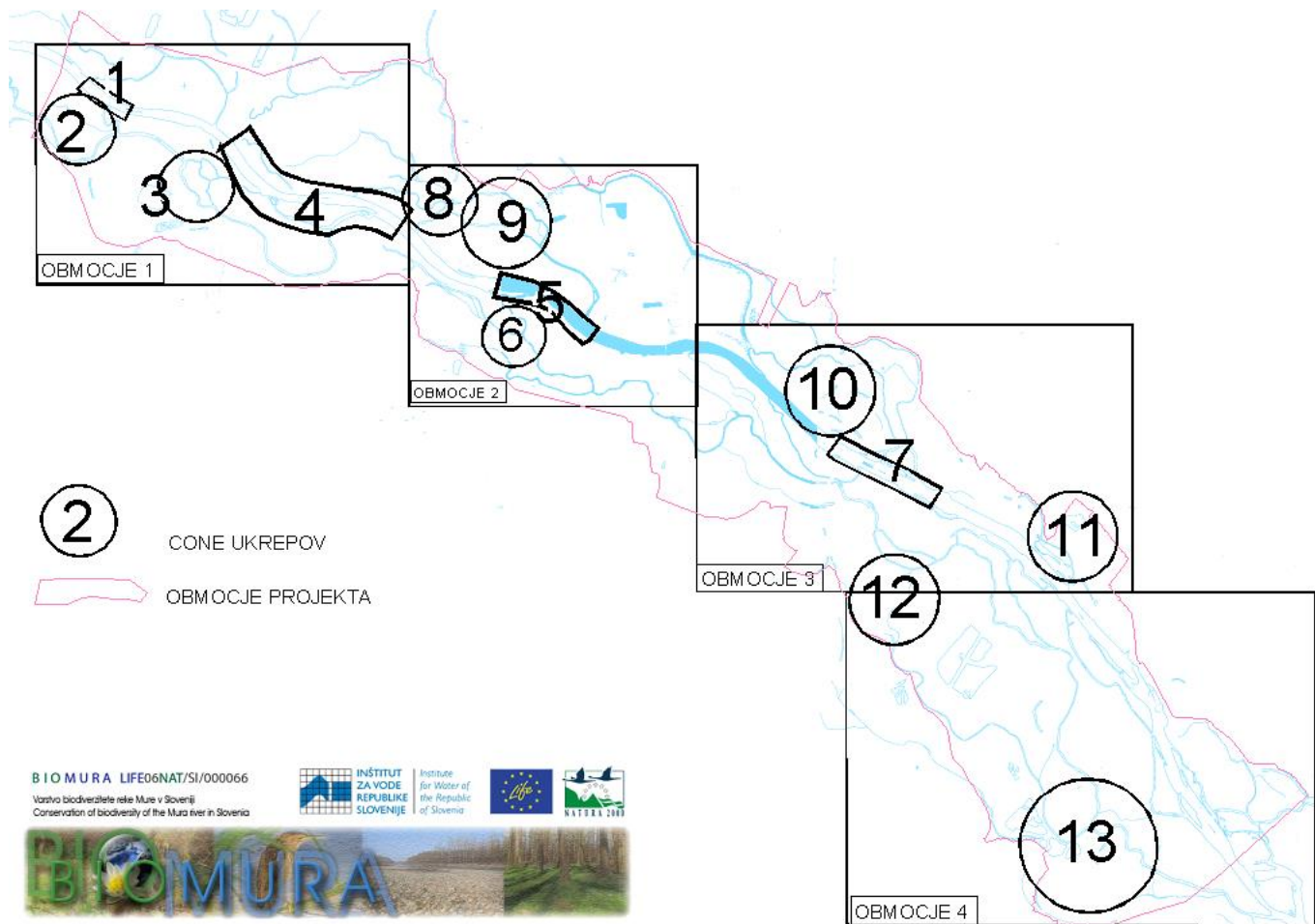
PLANNED LOCATIONS FOR ACTIONS*:

-  (C1) Removal of bankside revetments
-  (C2) Low water level control in the channel (riffle)
-  (C3) Bank opening into a side channel
-  (C3) Bank opening for back water
-  (D2, C3) Side channel maintenance/reactivation
-  (D2) Maintenance/reactivation of oxbow lakes
-  (E9) Info trail

*will be adapted to local hydraulic conditions where needed

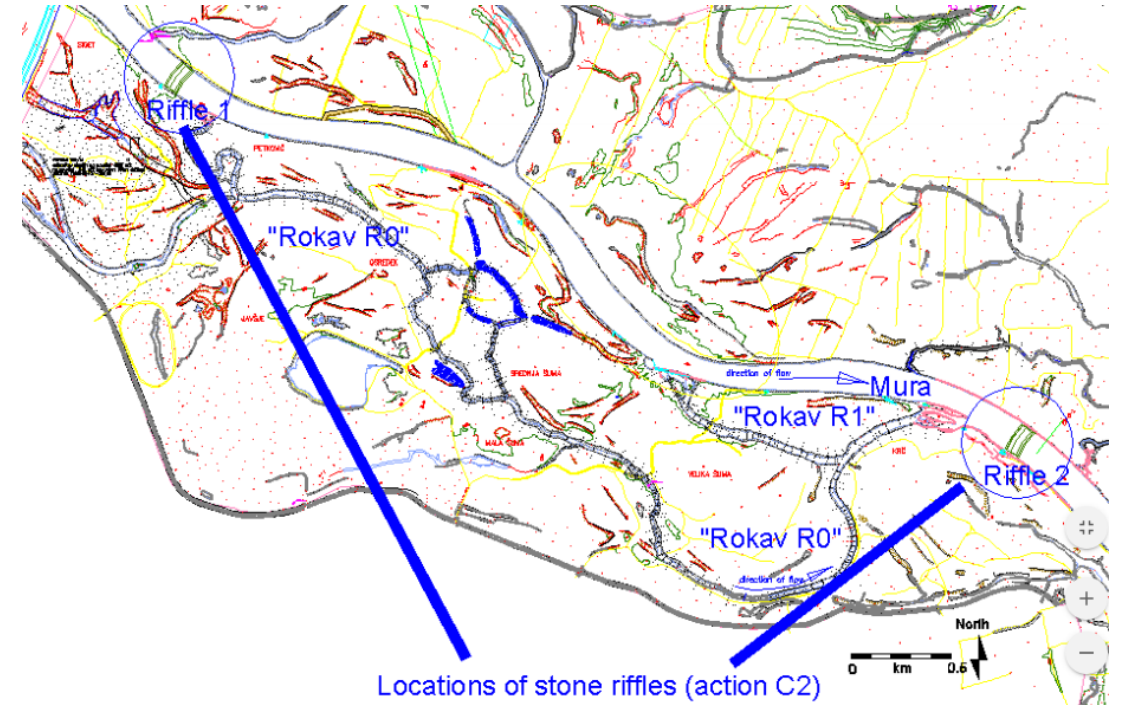
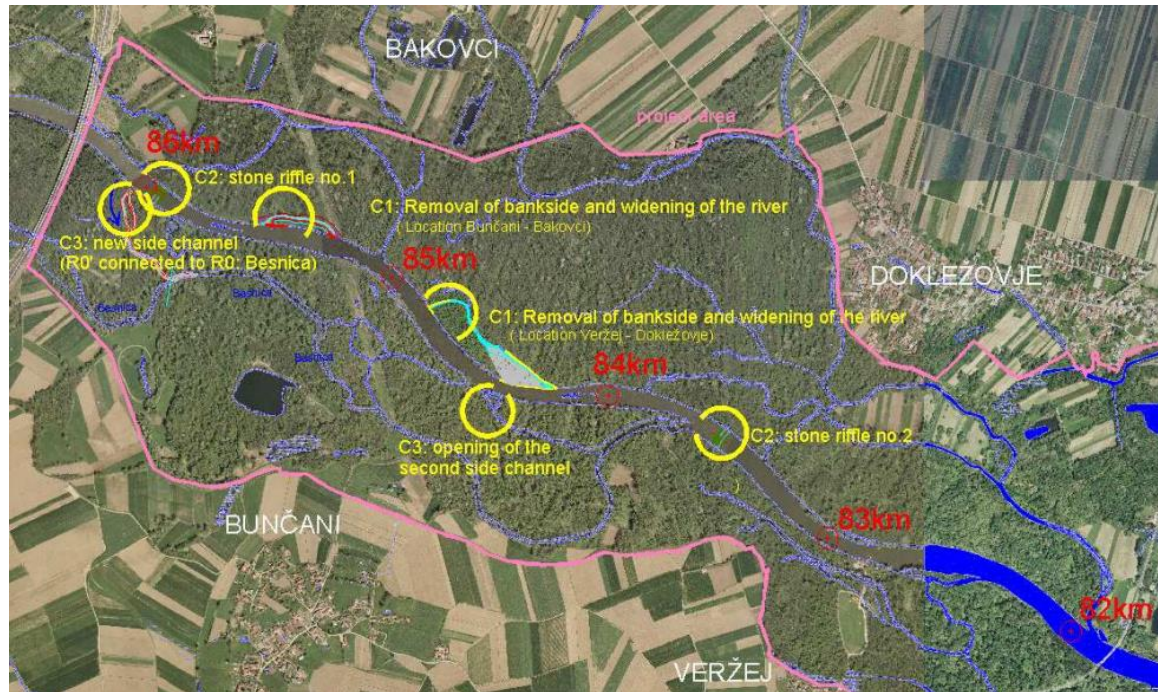


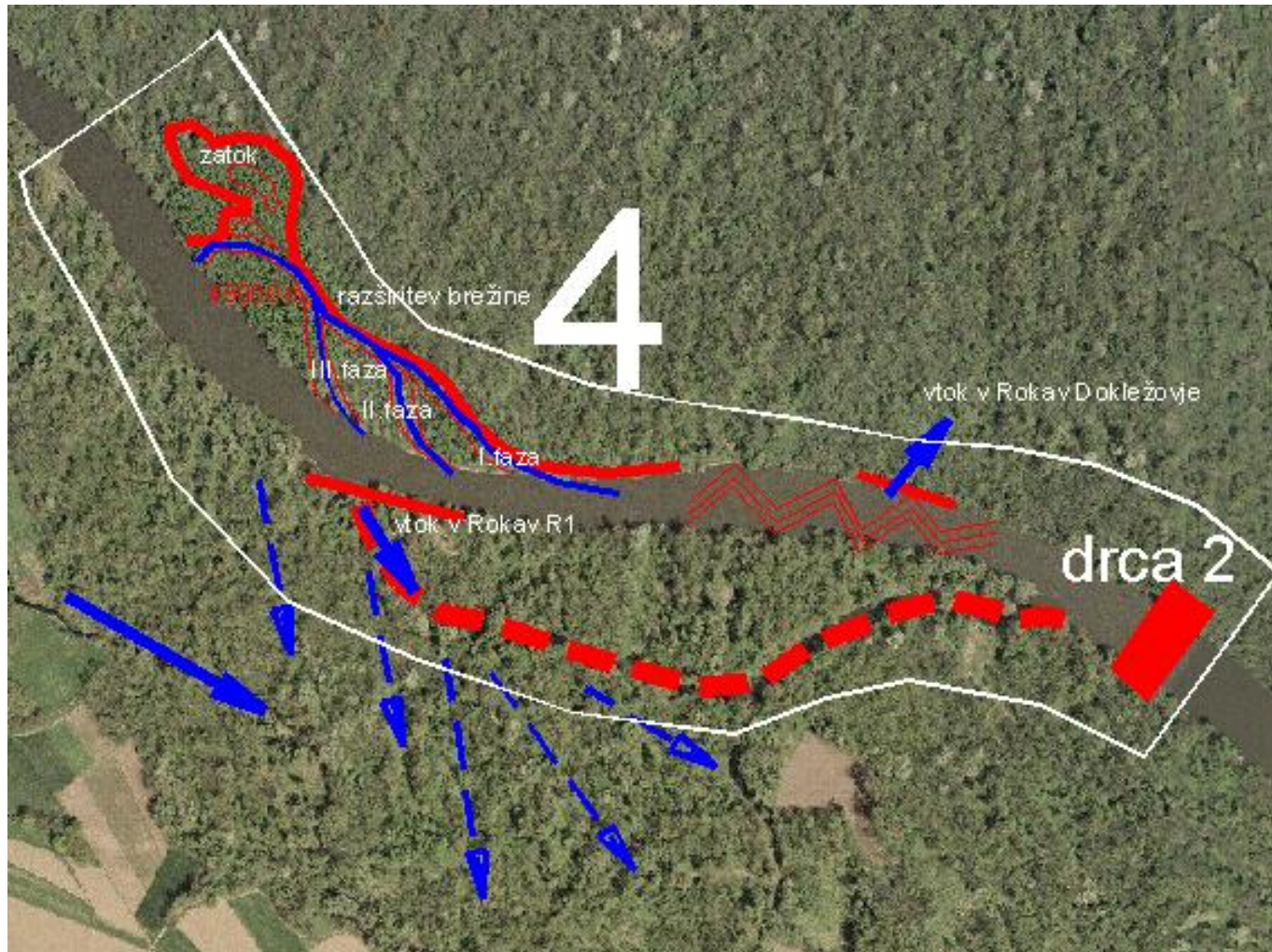
North
 SCALE 1:25000
 project area: 15.2 km²
 the Mura river: 8.3 km



1 in 4: drči/nizka kamnita pragova
 2 in 3: nove stranske struge, odstranitev obrežnih zavarovanj in večji dotoki vode v obstoječe stranske struge/kanale
 5 in 6: odstranitev obrežnih zavarovanj in ponovno povezovanje reke s stranskimi strugami
 7: Razširitev struge in povezava s stransko strugo
 8 - 13: vzdrževanje stranskih strug, mrtvic in poplavnega gozda za ustvarjanje / ohranjanje obrežnih in rečnih habitatov (stoječe vodne cone, počasen vodni tok; odprte vodne površine)

1 and 4: stone riffles (low weir)
 2 and 3: new side channel and bank opening – inflow to existing side channel
 5 and 6: bank revetments removal and side channel reconnection
 7: Extension of the riverbed and connection with the side channel
 8 – 13: side channles, oxbow lakes and flood forest maintenance to create/sustain riparian habitats (standing water zones; slow water flow; open water surfaces)





- odstranitev obrežnega zavarovanja (razširitev brežin/struge), nov rokav „Dokleževje“) in prepustitev sukcesiji;
- povezava struge z rokavom “R1” (do Besnice);
- Drča spodaj (dvig gladine ob nizkih vodah)

-
- removal of the bank revetments (widening of the channel/bank); new side channel „Dokležovje“ and leaving it to succession;
 - riverbed connection with side channels "R1,, (to link with the existing „Besnica“);
 - stone riffle downstream to rise water level at low flow discharges;



Bunčani, Rokav „R0“
March 2009, June 2009, April 2010



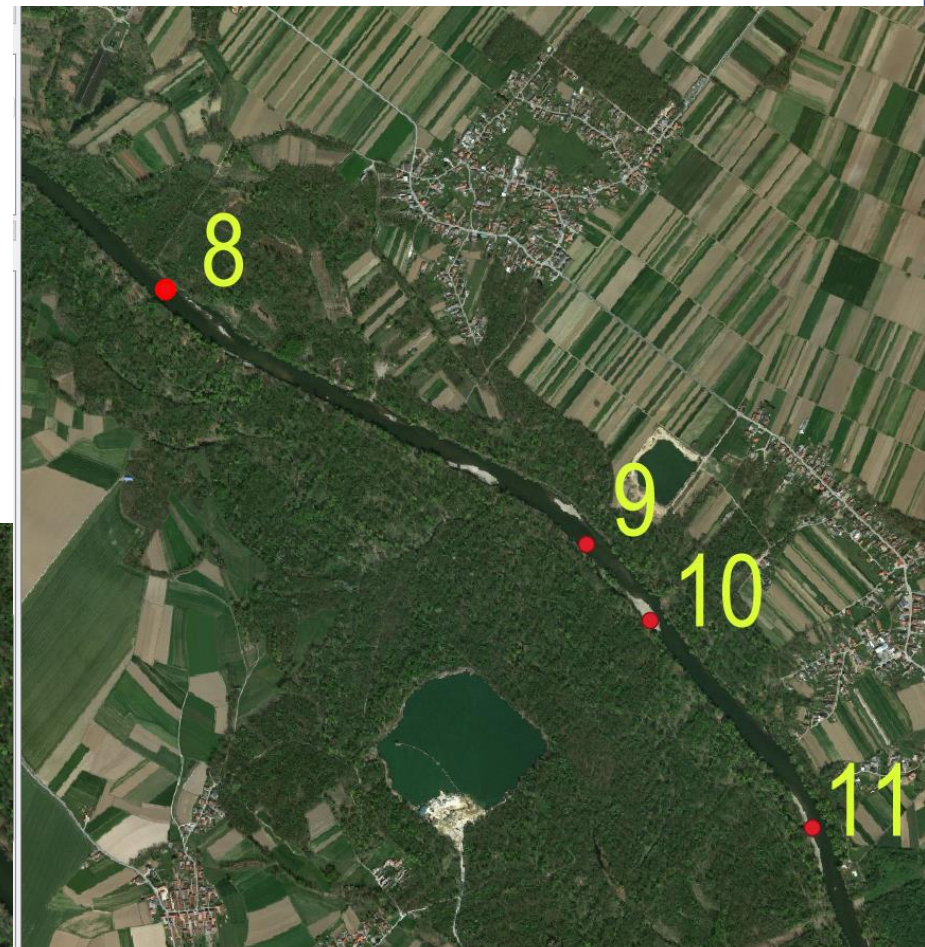
Dokležovje, Bank revetments
removal; new side channel;

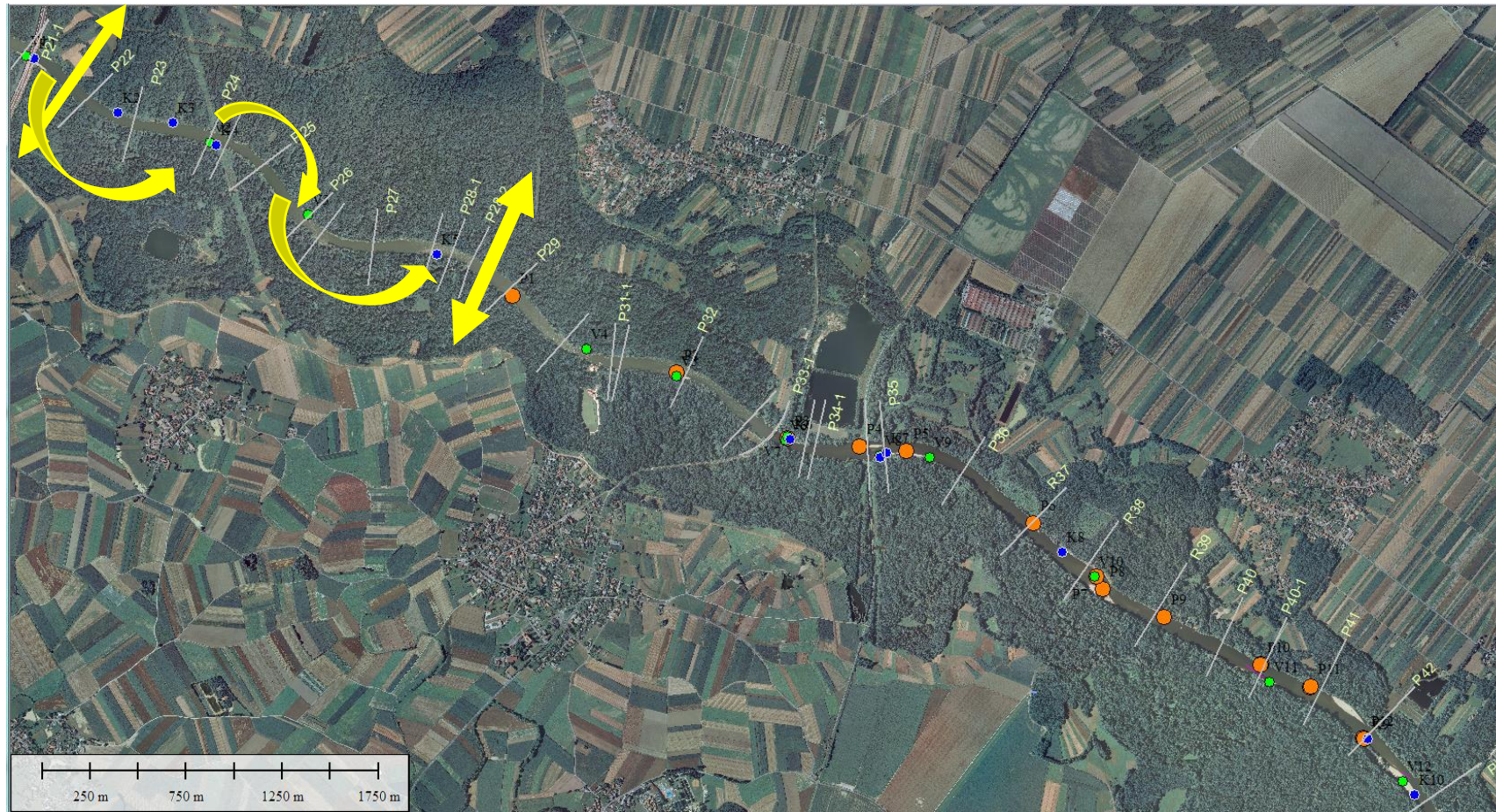
Stone riffle, Bunčani



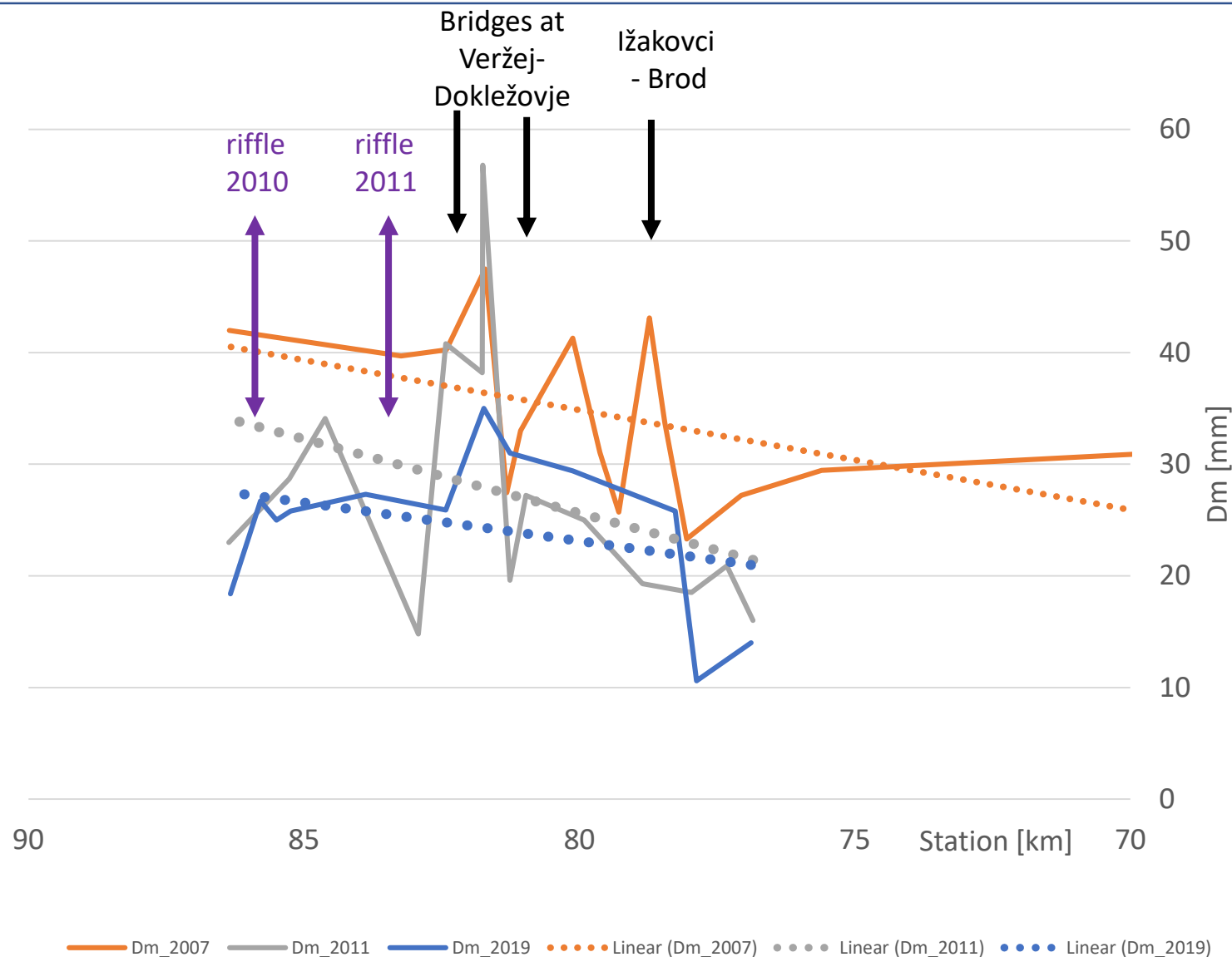
SUCCESS MEASURED BY ECOLOGICAL MONITORING AND CHANGES IN MORPHODYNAMICAS

gravel bars, eroded river banks, geometry of profile, bed load granulometry





MEDIUM GRAIN SIZE (Dm) along the river (10 km)



SREDNJE ZRNO (Dm) vzdolž reke se je znižal:

- Večji delež finejših zrn proda na dnu struge.
- Signal, da se dno struge zvišuje.

MEDIUM GRAIN SIZE (Dm) along the river is reduced:

- Larger share of finer sediments on the channel bottom.
- Signal that channel bed is rising.

Conclusions:

- Hydrology – Morphology: strictly related properties and strong interaction!
- Studied with **hydraulic properties** and physics of **sediment flow**.
- If river bank stabilizing objects are partly removed and water level at low flows are slightly raised with stone riffles (constantly submerged weirs), we can expect morphological more natural river phenomena and stabilization of the riverbed.

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THANK YOU!

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REPUBLIKA SLOVENIJA
MINISTRSTVO ZA OKOLJE IN PROSTOR
DIREKCIJA REPUBLIKE SLOVENIJE ZA VODE



Das Land
Steiermark
→ Wasserwirtschaft

