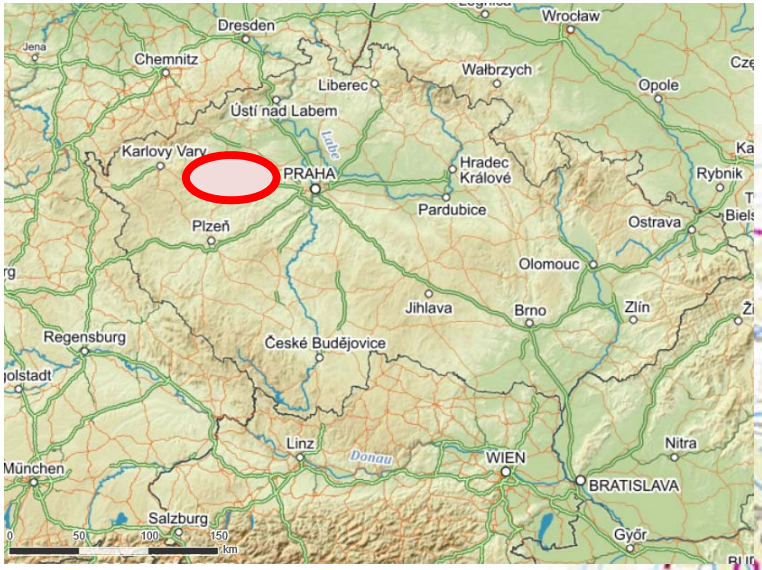
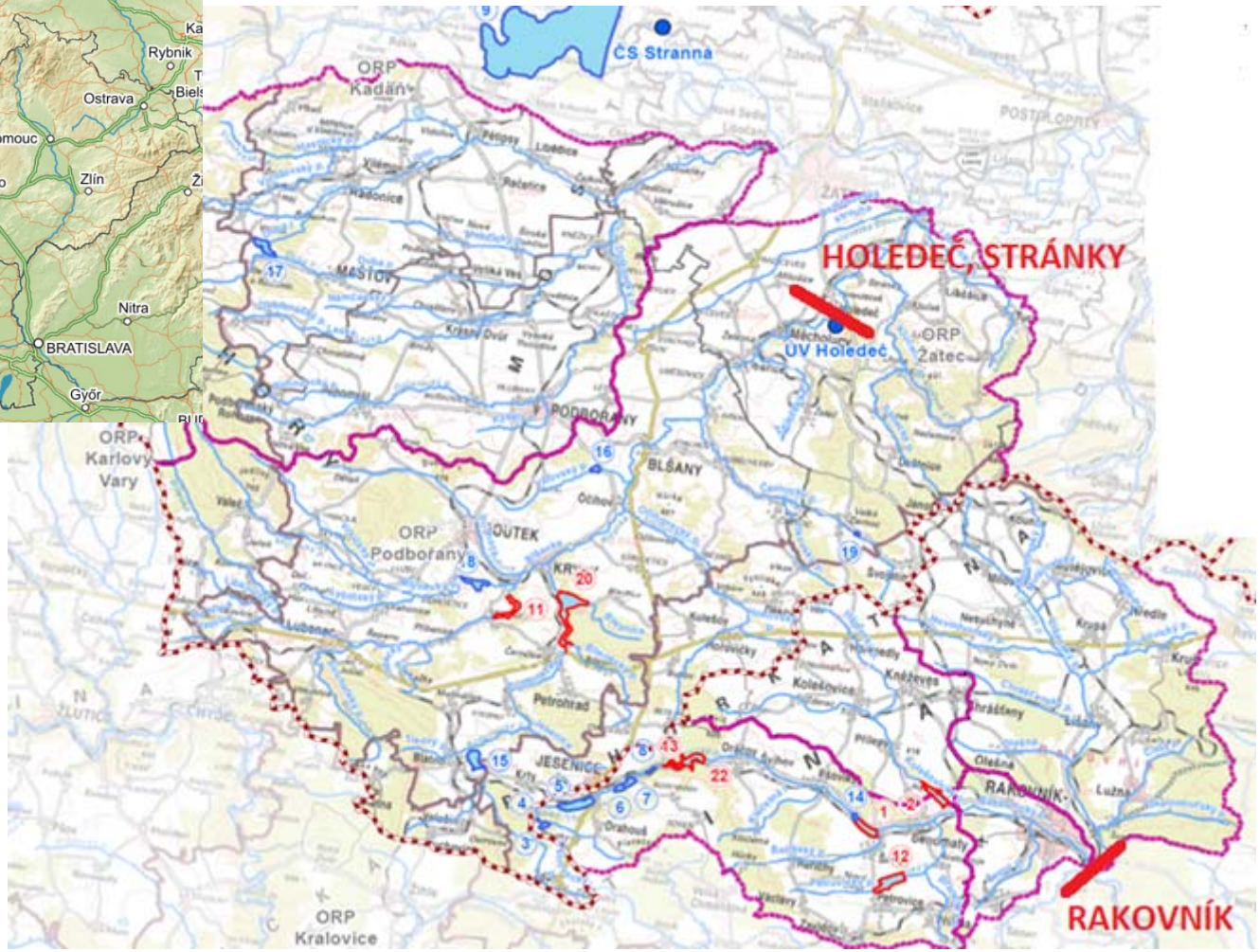
FAKULTA
STAVEBNÍ
ČVUT V PRAZE

Complex water management solution of new reservoirs in the Rakovník Creek basin and the Blšanka River basin and other measures to mitigate the water deficit in the area

Pavel Fošumpaur, Tomáš Kendík, Karel Březina

Basins of the Rakovník Creek and the Blšanka River





River basin area
Rakovnik Creek:
302 km^2

Blsanka River:
380 km^2

Measures to mitigate droughts in the area

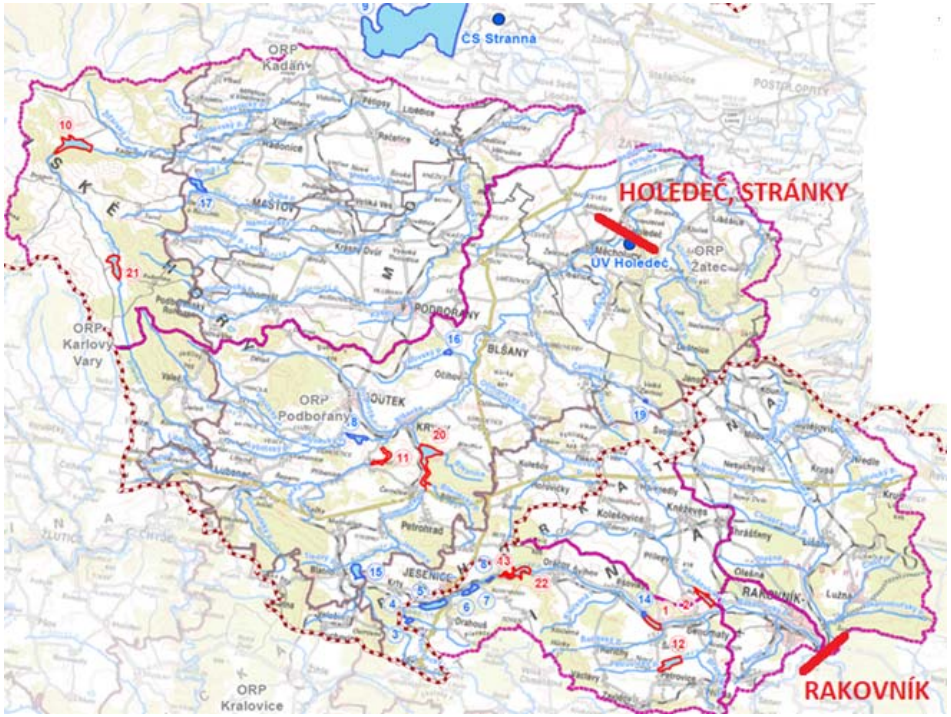
prepared BY	prepared FOR	year	Name of the study/project	Measure
VÚV T.G.M.	NAZV, Mze	01/2012	Možnosti zmírnění současných důsledků klimatické změny zlepšením akumulační schopnosti v povodí Rakovnického potoka (pilotní projekt)	komplex (nádrže a přírodě blízká)
VRV	PVL	01/2014	Studie proveditelnosti vodních nádrží v povodí Rakovnického potoka, I. etapa	komplex (nádrže a přírodě blízká)
VRV	PVL	06/2014	Studie proveditelnosti vodních nádrží v povodí Rakovnického potoka, II. etapa	komplex (nádrže a přírodě blízká)
Envisystem	POH	09/2015	Studie proveditelnosti nádrže na Blšance nad mestem Kryry	VD Mukoděly
VRV	POH	11/2015	Vodní nádrž Hlubocká pila, studie proveditelnosti a investiční záměr	VD Hlubocká pila
SWECO	PVL	08/2016	VD Senomaty - studie proveditelnosti	VD Senomaty
SWECO	PVL	08/2016	VD Šanov - studie proveditelnosti	VD Šanov
SWECO, VRV	PVL, POH	12/2016	Převedení vody z Povodí Ohře do povodí Blšanky a Rakovnického potoka	převod vody z Ohře
PVL, Plzeň		09/2017	Posouzení kompenzačních možností soustavy vodních nádrží na Jesenicku v povodí Rakovnického potoka	Jesenické rybníky
SWECO, VRV	PVL	11/2017	Přírodě blízká opatření v povodí Rakovnického a Kolešovického potoka (VD Senomaty a VD Šanov)	přírodě blízká opatření
SWECO, VRV	POH	11/2017	Studie proveditelnosti vodní nádrže Kryry na Podvineckém potoce	VD Kryry + převod vody z Ohře
SWECO	PVL	04/2018	VD Šanov - DUR. Dokumentace pro vydání rozhodnutí o umístění stavby	VD Šanov
SWECO	PVL	04/2018	VD Senomaty - DUR. Dokumentace pro vydání rozhodnutí o umístění stavby	VD Senomaty

- The measures were mostly proposed separately
- The aim of the study is to assess benefits of these measures as a system
- Cooperation of individual measures

Layout of the Presentation

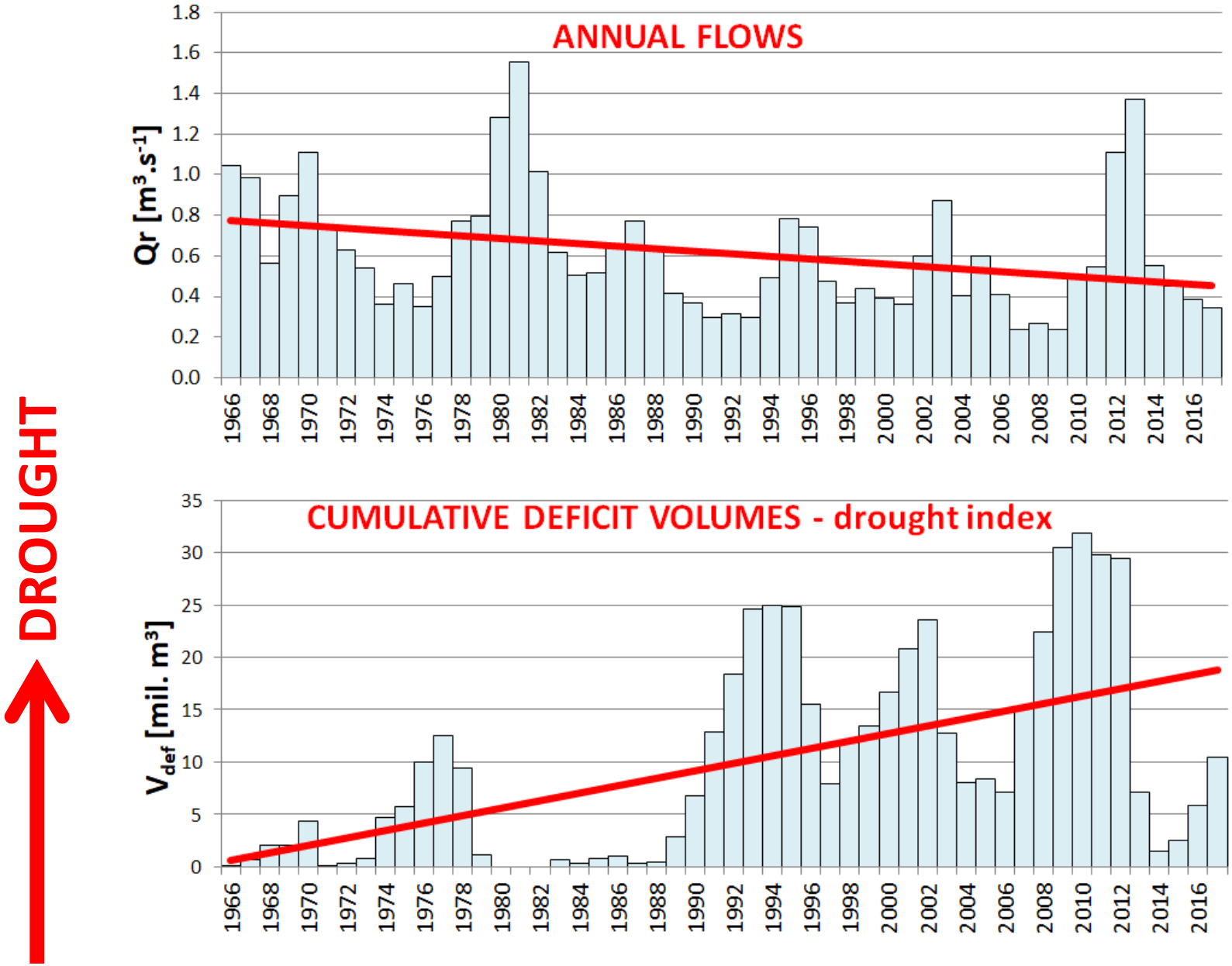
- Hydrological data
- Water demands
- Technical measures and their combinations
- Complex water management solution
- Application of natural measures

Hydrology

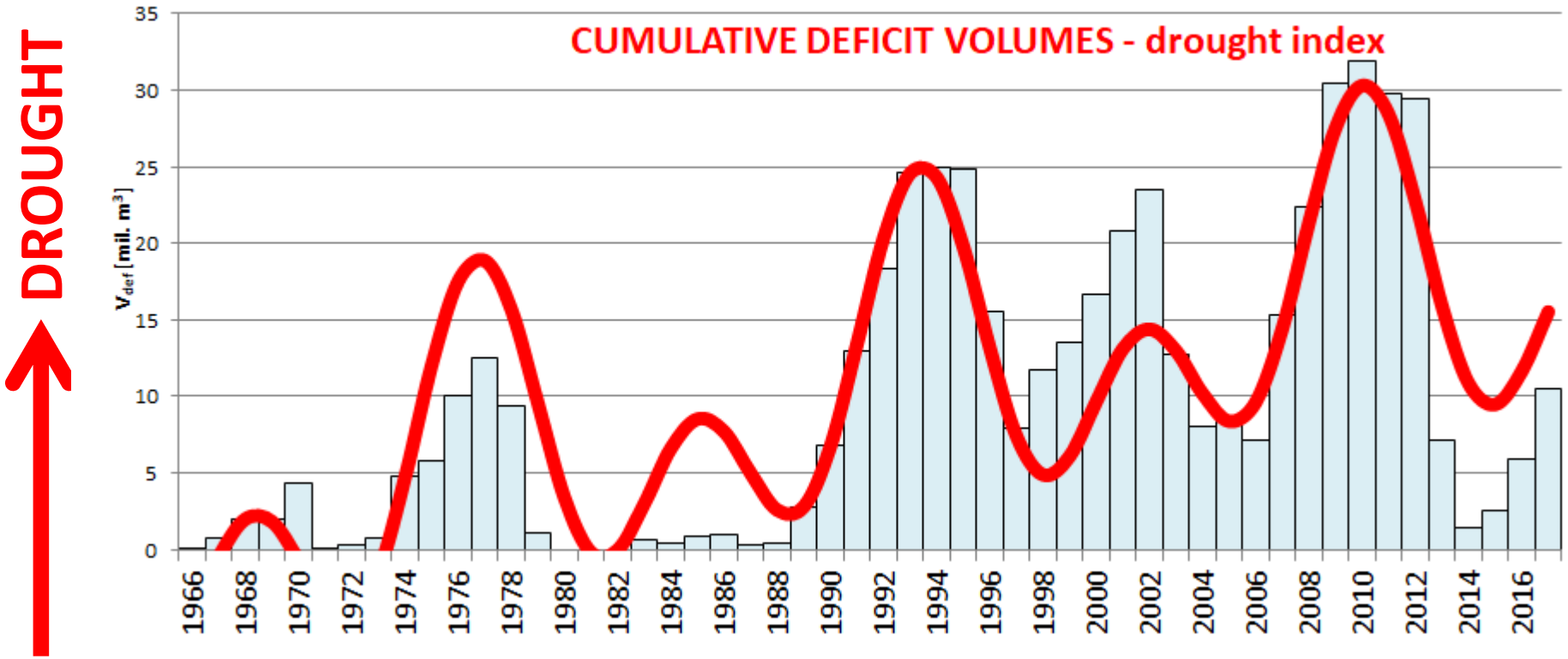


- Time series of daily flows:
  - Rakovník: 1966 - 2017 (52 let)
  - Holedeč, Stránky: 1968 – 2017 (50 let)
- Advantages of daily flow series
  - Water transfer, real time operation, reliability of water demand and minimum flows in rivers

Station: Rakovník/Rak. Creek

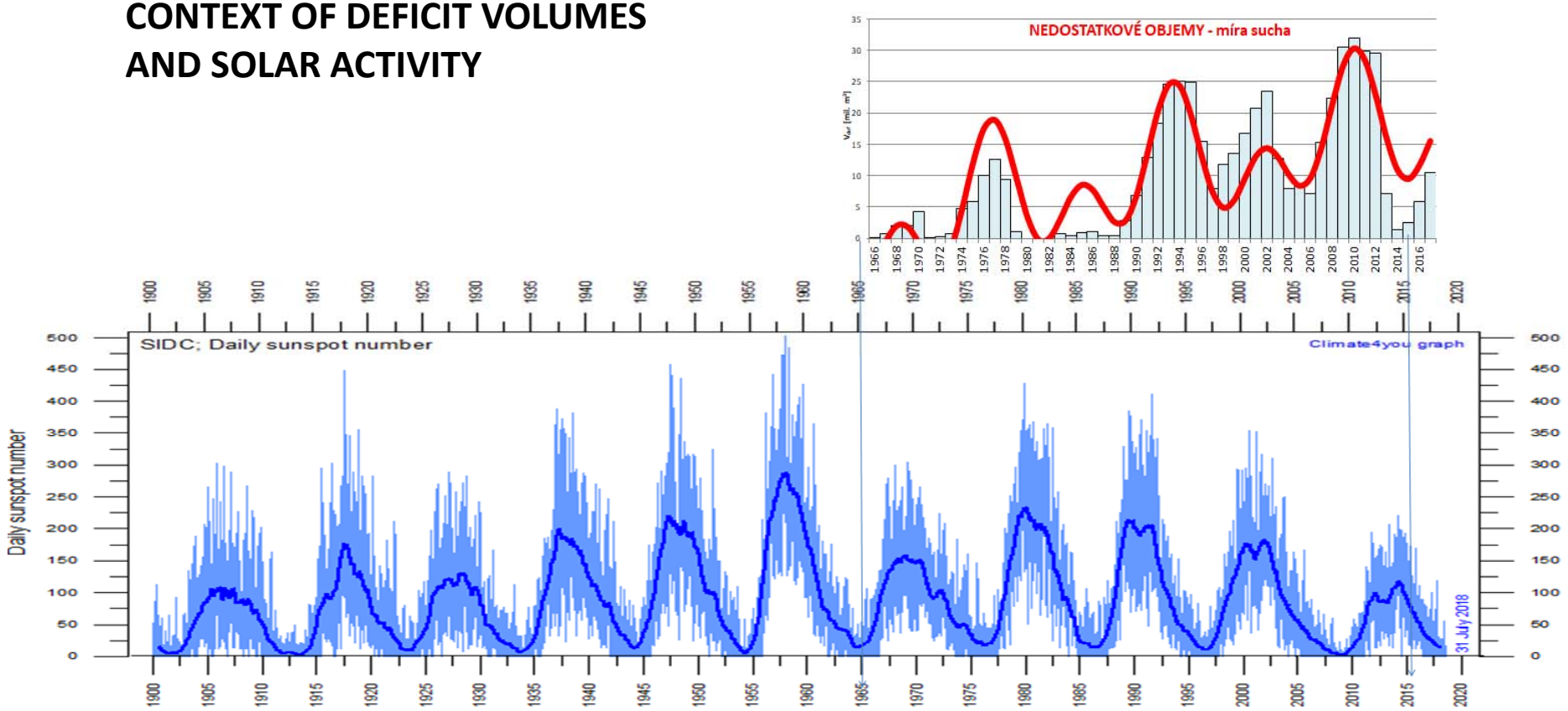


Station Rakovník/Rak. potok

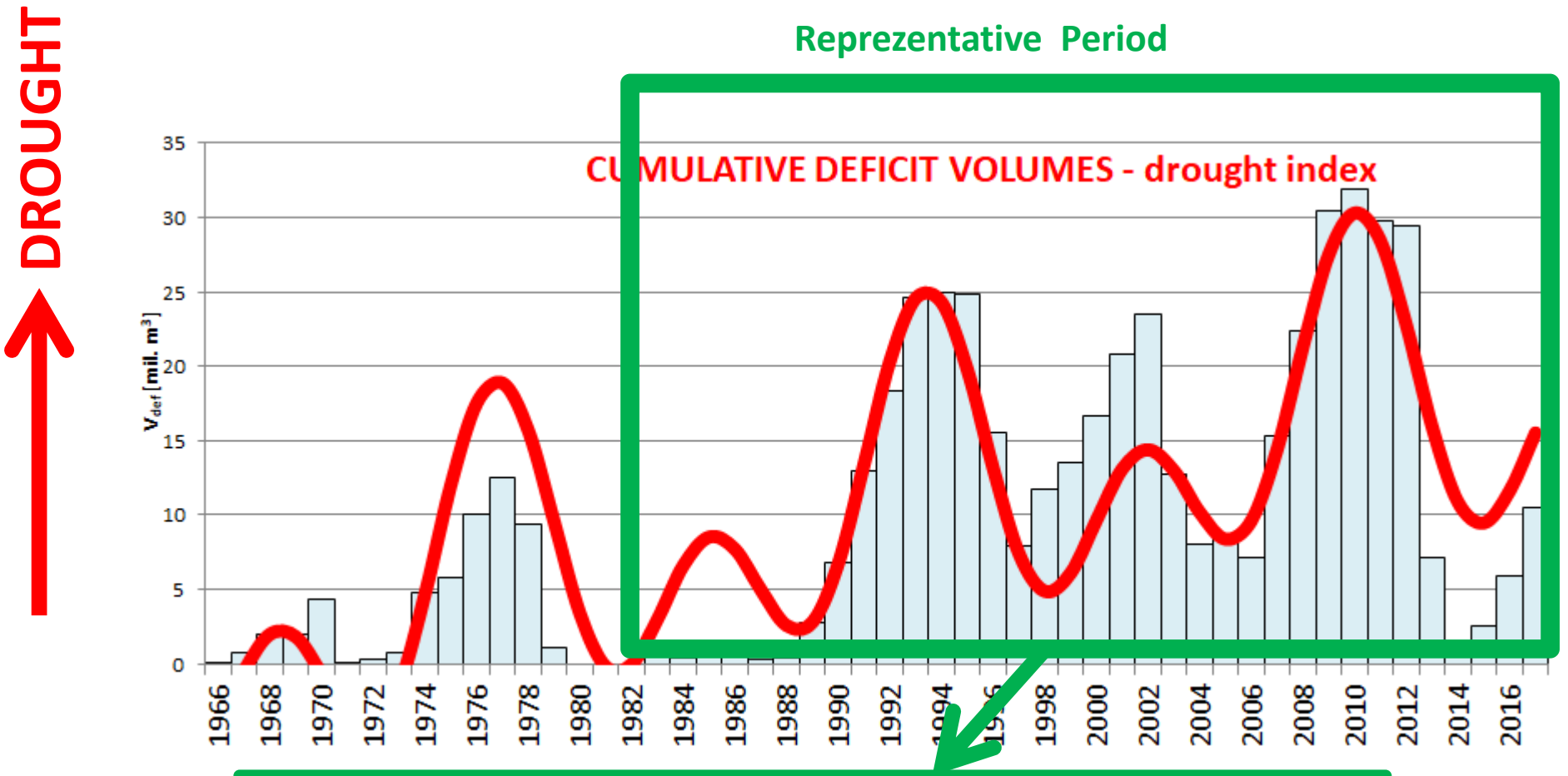


- Dry periods are related to solar activity - the same period,
- Future developments are also affected by warming - a difficult forecast

CONTEXT OF DEFICIT VOLUMES AND SOLAR ACTIVITY

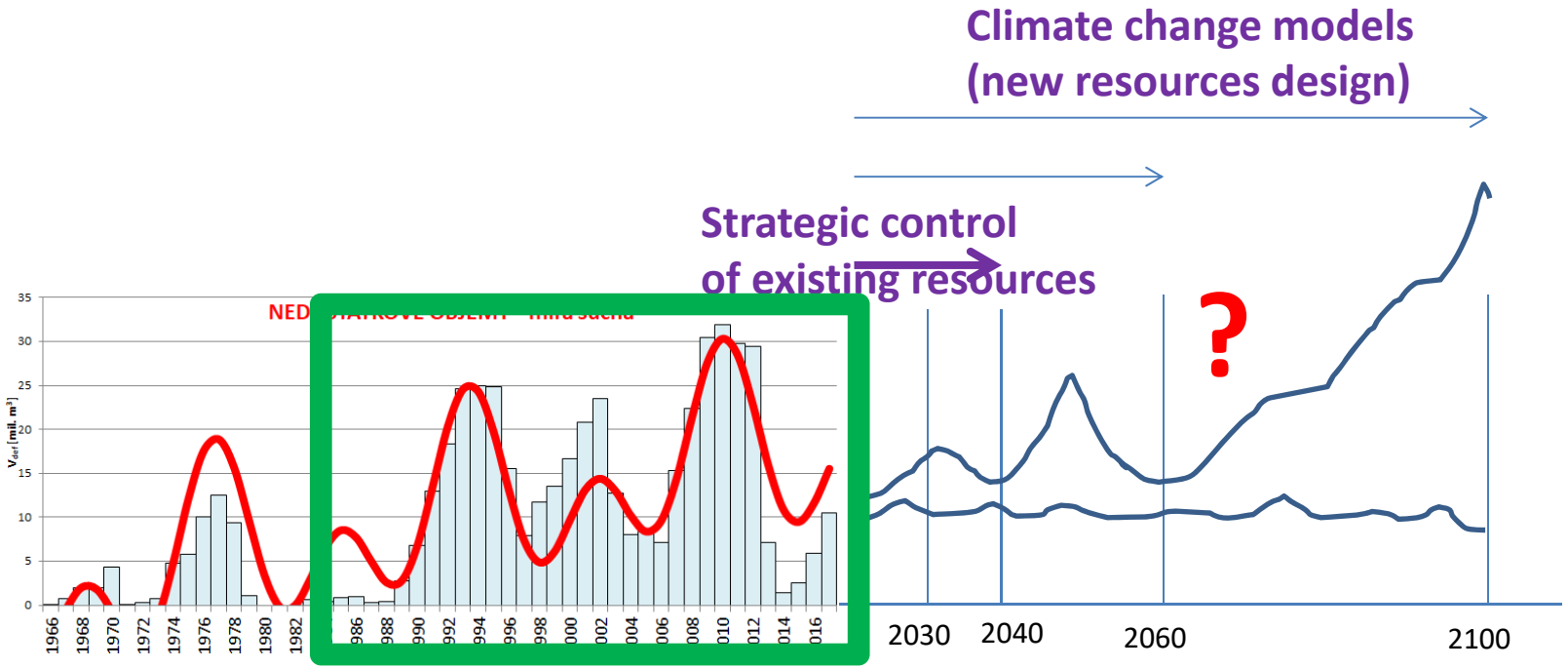


A Selection of Representative Period



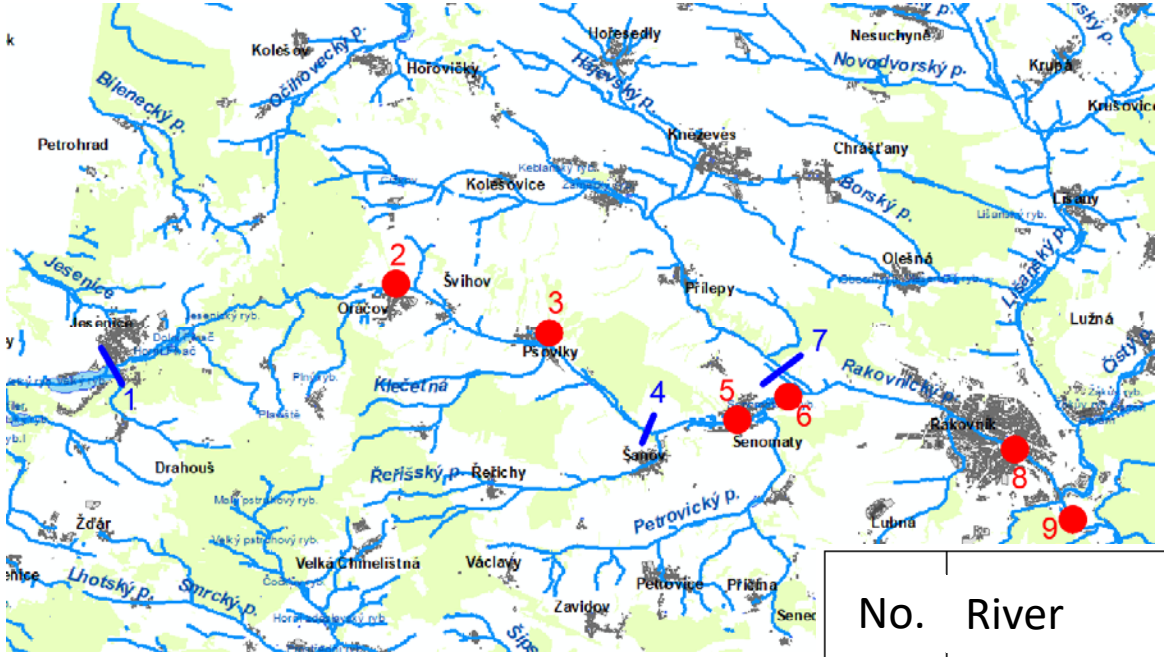
- period 1981 – 2017 was used for water management solution,
- Daily step of solution
- Compliance with the practice of the Czech Hydrometeorological Institute for the selection of representative period

Future development?



- For strategic management for 10 to 20 years - take advantage of a representative period
- For long-term prediction - models of climate change
- Uncertainty of Climate Models ???

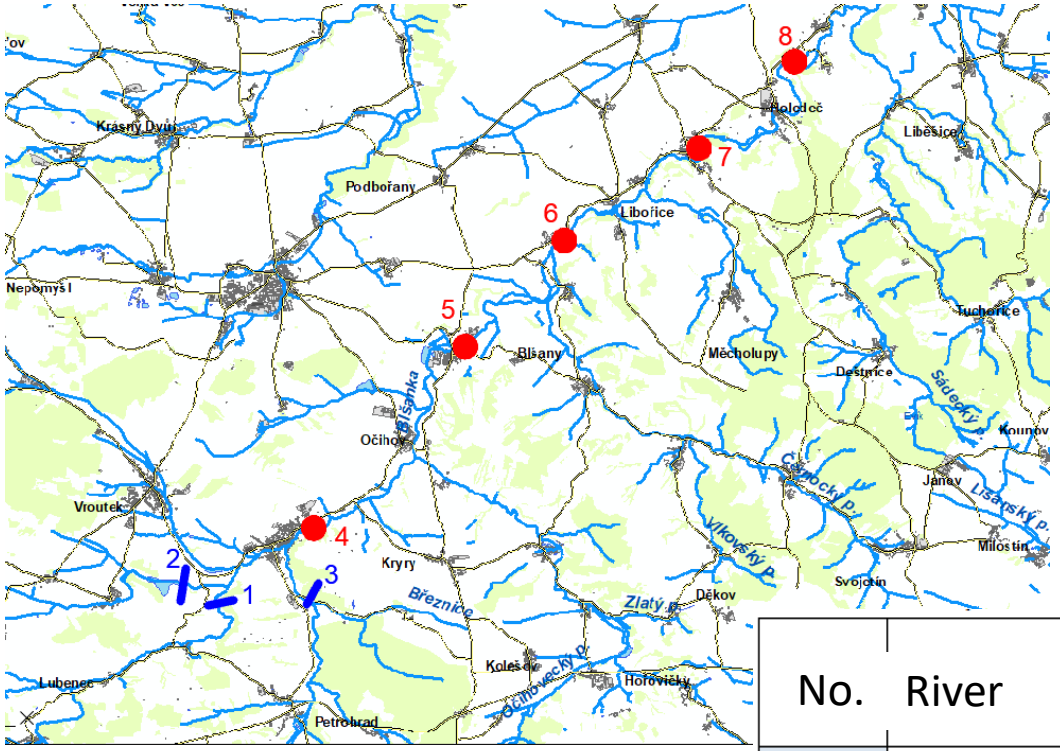
Rakovnický Creek - flow series preparation



- Hydrometric measurements in period 2008 – 2018
- Hydrological analogy
- Hydrological studies by VÚV, T.G.M., v.v.i.

No.	River	Profile	Area [km2]	Mean annual flow [l/s]
1	Rakovnický potok	Velký rybník	9.713	17.0
2	Rakovnický potok	Oráčov	27.850	48.7
3	Rakovnický potok	Pšovlky	36.110	65.7
4	Rakovnický potok	VD Šanov	50.400	94.7
5	Rakovnický potok	Senomaty nad Petrovickým p.	65.210	122.5
6	Rakovnický potok	Senomaty pod Petrovickým p.	90.245	171.5
7	Kolešovický potok	VD Senomaty	51.900	42.9
8	Rakovnický potok	Rakovnický nad Lišanským	163.530	233.6
9	Rakovnický potok	LGS Rakovník bez ČOV	302.120	507.5

Blšanka River - flow series preparation



- Hydrometric measurements in period 2008 – 2018
- Hydrological analogy
- Hydrological studies by VÚV, T.G.M., v.v.i.

No.	River	Profile	Area [km2]	Mean annual flow [l/s]
1	Blšanka	VD Mukoděly	65.60	177.1
2	Mlýnecký potok	VD Vidhostice	43.60	135.0
3	Podvinecký potok	VD Kryry	85.60	171.0
4	Blšanka	LGS Kryry	221.90	531.6
5	Blšanka	Blšany	284.60	643.9
6	Blšanka	Liběšovice	341.97	745.4
7	Blšanka	Měcholupy	363.56	783.2
8	Blšanka	LGS Stránky	380.30	800.8

Water Demand

Thorough survey of current and prospective status:

- The current water withdrawal serves predominantly for irrigation and makes 18 $l.s^{-1}$ in Rakovnik area and the 20 $l.s^{-1}$ in Blšanka area in the vegetation season.
- The discharge into surface water is usually carried out in the form of drainage from WWTPs and it is dominantly the water taken from the groundwater subsystem.
- Discharge into surface water significantly exceeds the amount of withdrawals from the surface water subsystem. As a result, groundwater withdrawals currently supply the surface water subsystem.
- Prospective studies predict a significant increase in water demand for irrigation in the future.

Water demands for hop irrigation

- It is based on detailed analysis (12/2016)

skupina chmelnic	plocha	potřeba za vegetační období	potřeba za 1.5. až 31.8.	**potřeba za 1.4. až 20.8.**
	[ha]	[tis. m^3]	[$l.s^{-1}$]	[$l.s^{-1}$]
Blšanka	**1177.174**	**1765.76**	**166.15**	**143.92**
dolní Blšanka	402.292	603.44	56.78	49.18
střední Blšanka	586.541	879.81	82.79	71.71
horní Blšanka	188.341	282.51	26.58	23.03
Rakovnický p.	**841.670**	**1262.51**	**118.80**	**102.90**
Kolešovický p.	411.343	617.01	58.06	50.29
Lišanský p.	430.327	645.49	60.74	52.61

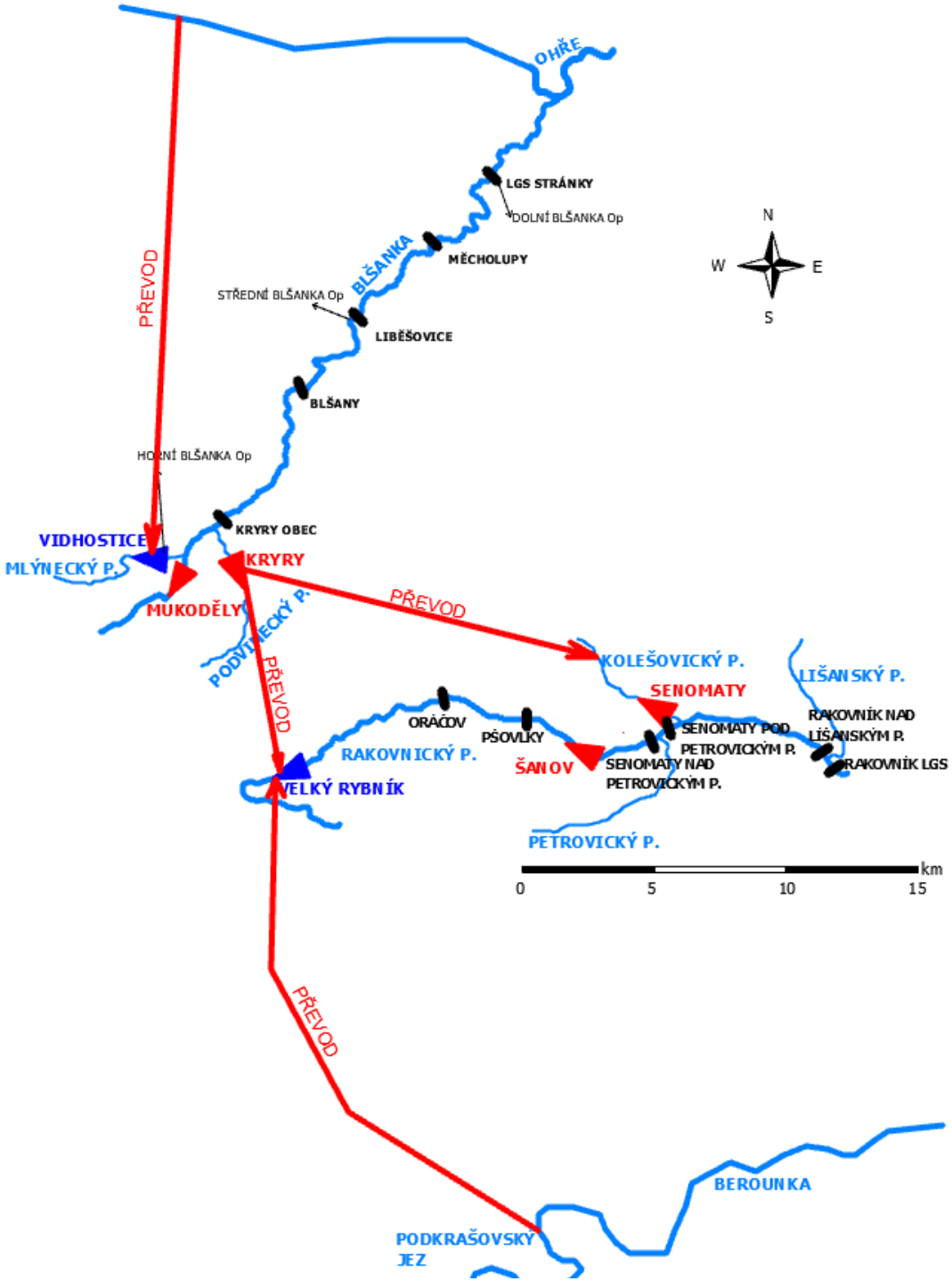
SWECO

VRV

The interest of the hop producers in water was declared by **Union of Hops Growers of the Czech Republic**

Minimum residual flow maintenance (MQ)

- MQ must be secured under the reservoirs and under water withdrawals
- MQ is related to hydrological regime – it should be in accordance to actual data
- MQ is considered in two variants:
  - The current methodological guideline,
  - Proposed methodological approach



Technical measures
- new reservoirs
- water transfers

Hs	Hz	Hmax	Vs	Vz
[m n. m.]	[m n. m.]	[m n. m.]	[m3]	[m3]
le DÚR:				
348.00	**349.00**	349.85	388 45	**201 408**
335.20	**336.20**	337.03	346 05	**199 573**
- maximalistická varianta:				
345.24	**349.00**	349.85	50 00	**539 900**
332.45	**336.20**	337.03	37 00	**508 700**
318.00	**324.90**	325.69	31 610	**860 510**
313.00	**319.85**	321.27	3 500	**606 000**
310.80	**323.80**	325.40	107 564	**6 233 622**

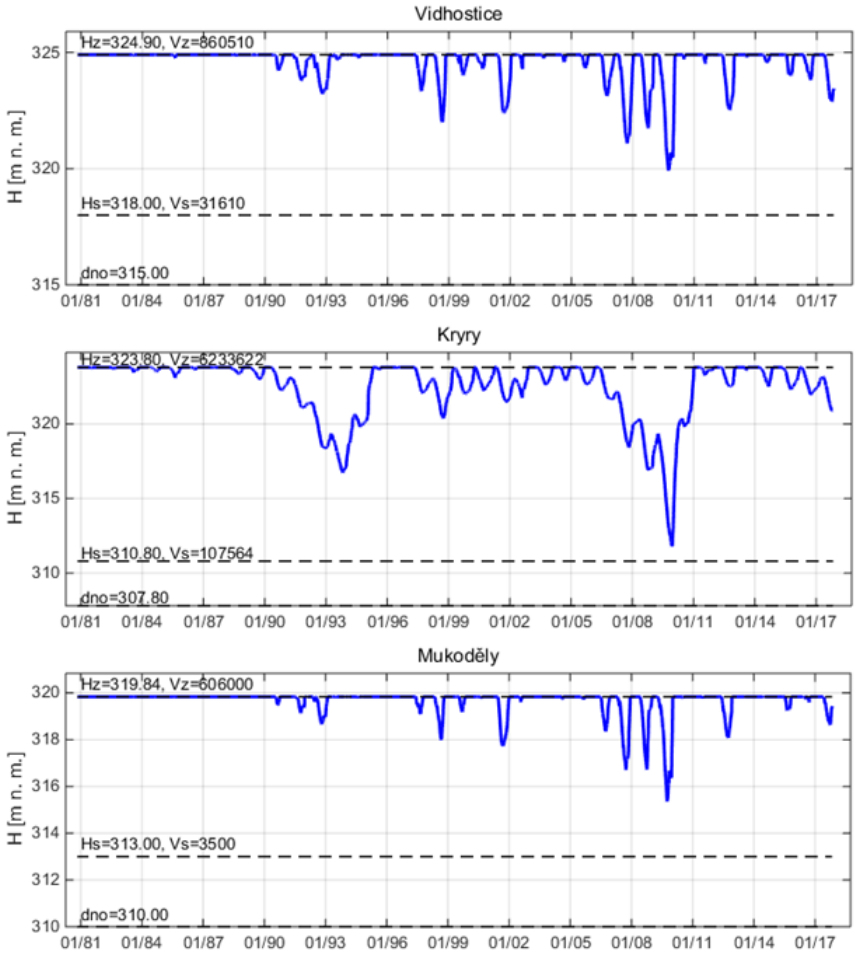
Storage capacity

- Solved in many variants
- System of water management measures
- Required pumped quantities
- Reliability of water supply
- Climate change scenarios

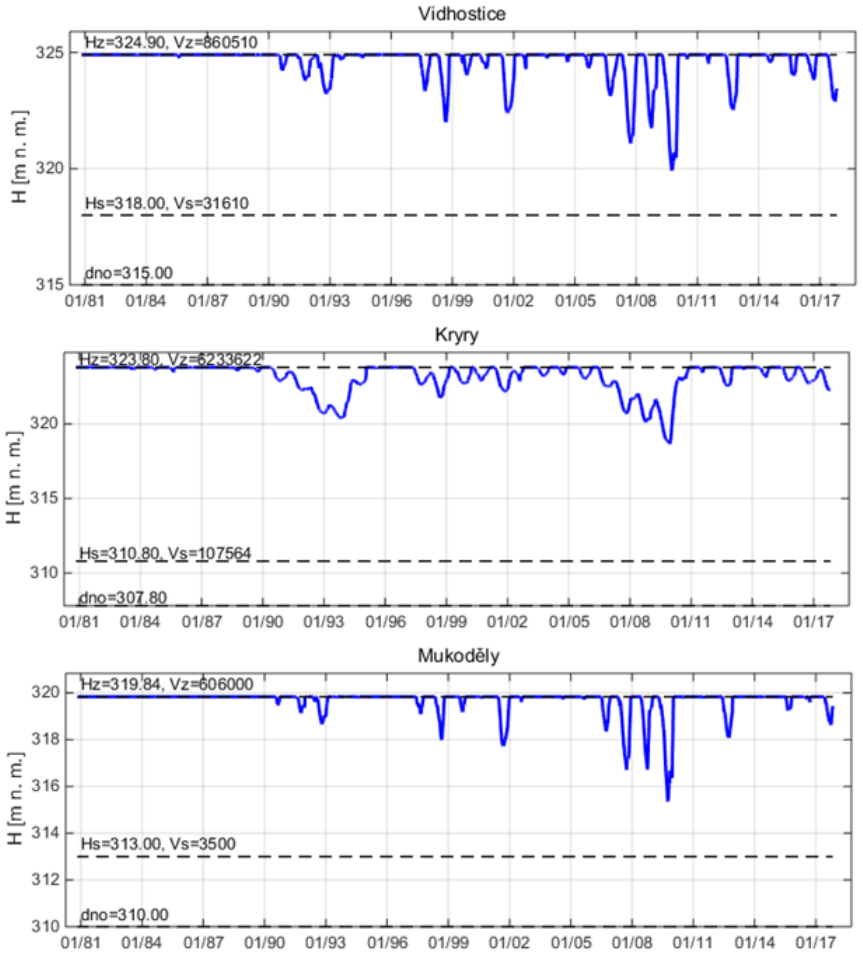
Variants evaluation

- Course of water level in reservoirs
- Reliability of water supply
- Reliability of minimum flow rates in rivers

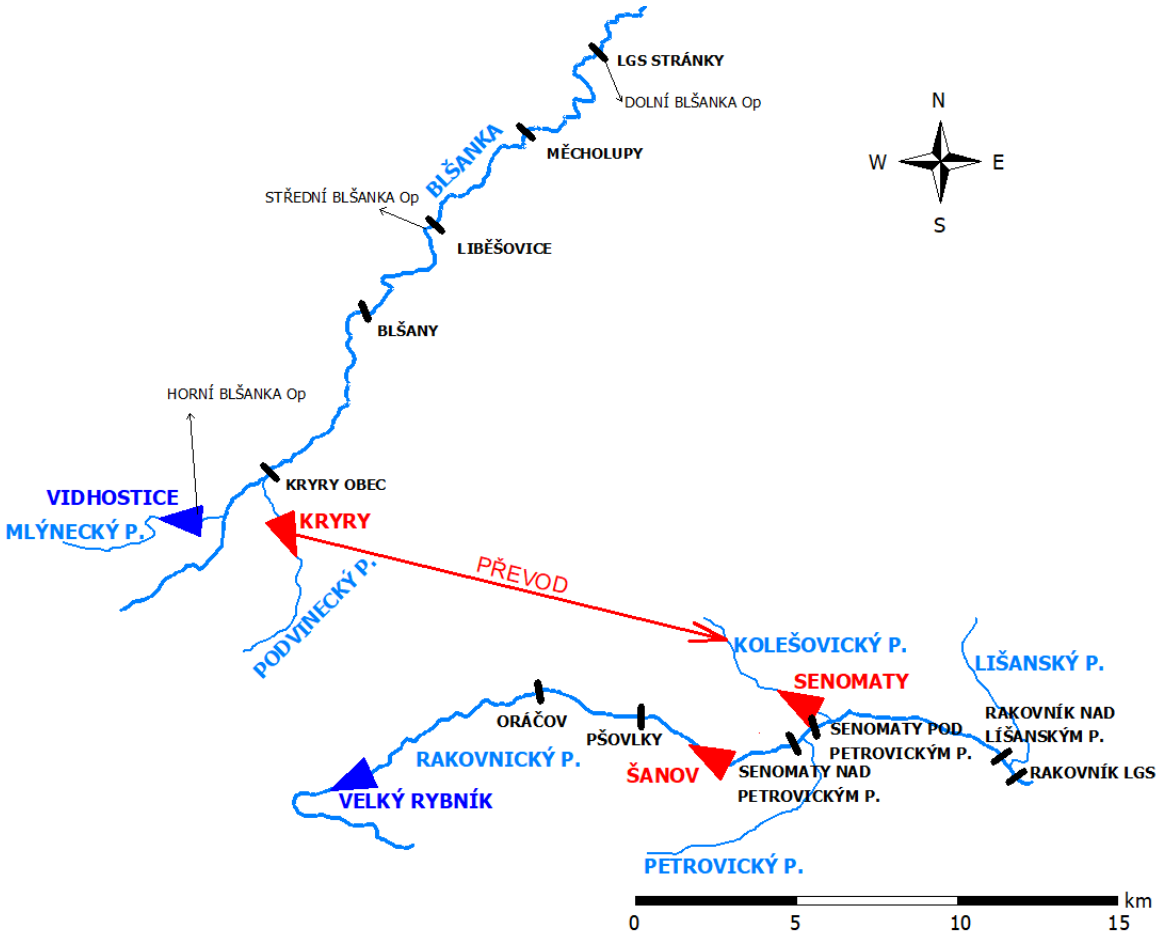
P1-1 kolísání hladin nádrží na Rakovnicku dle DUR



P1-2 maximální využití nádržních prostorů nádrží na Rakovnicku



Current climate conditions

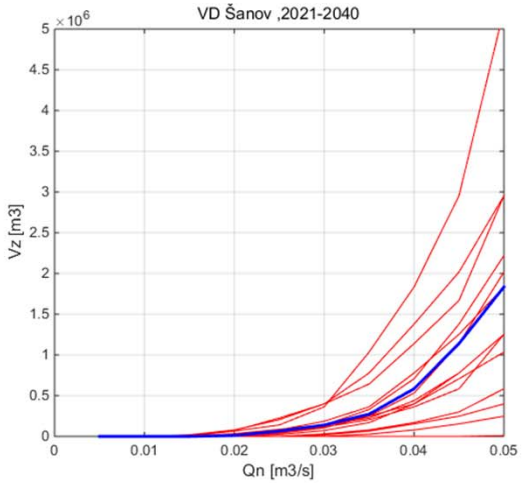


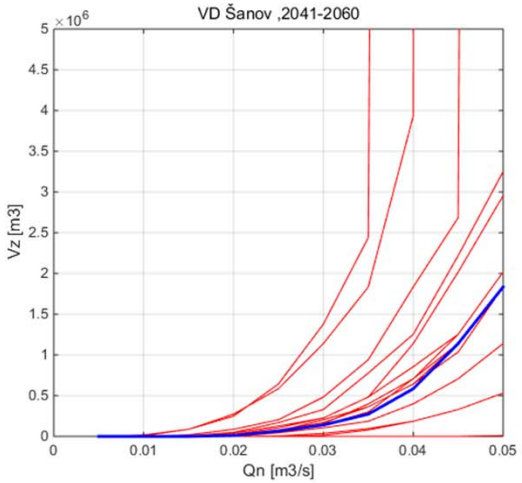
Measures:

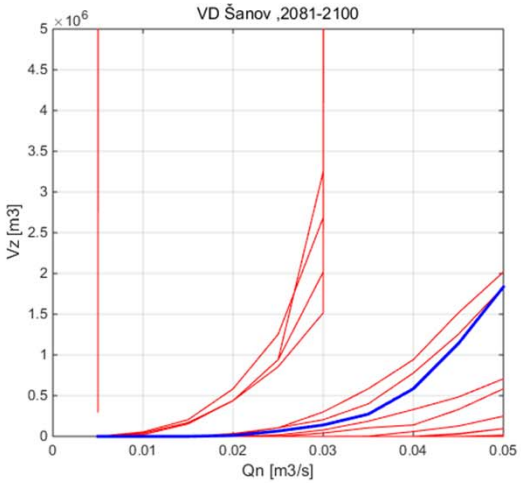
- reservoir Kryry,
- reservoir Šanov and reservoir Senomaty

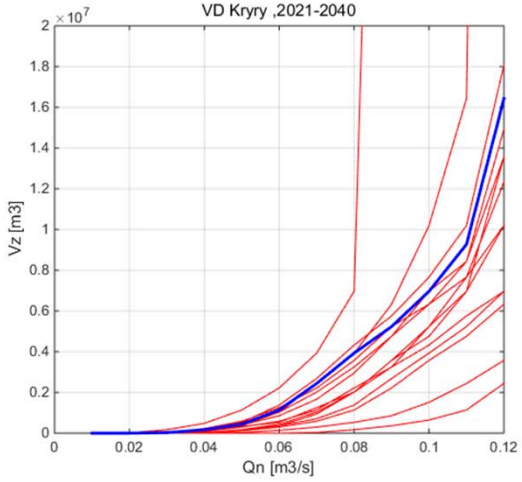
- Water transfer from Kryry to Senomaty

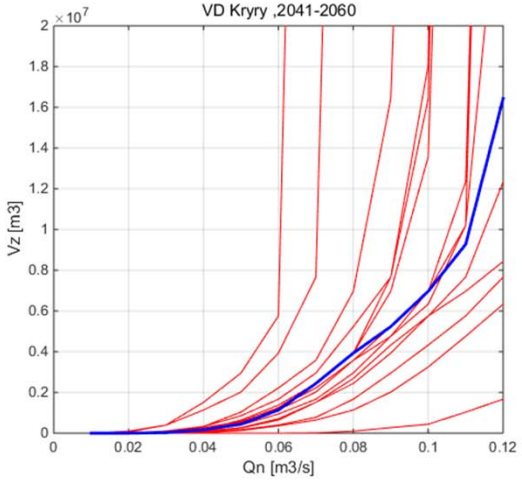
Conditions Affected by Climate Change

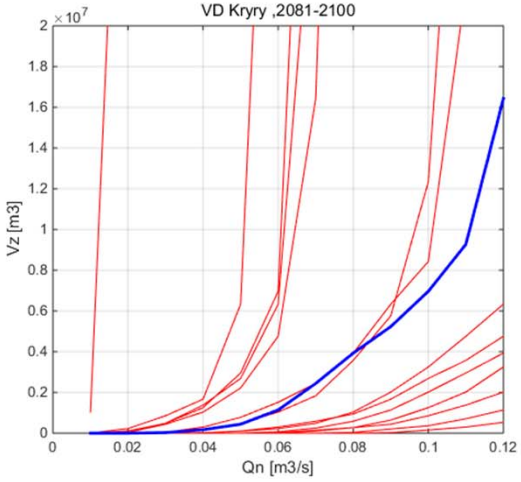






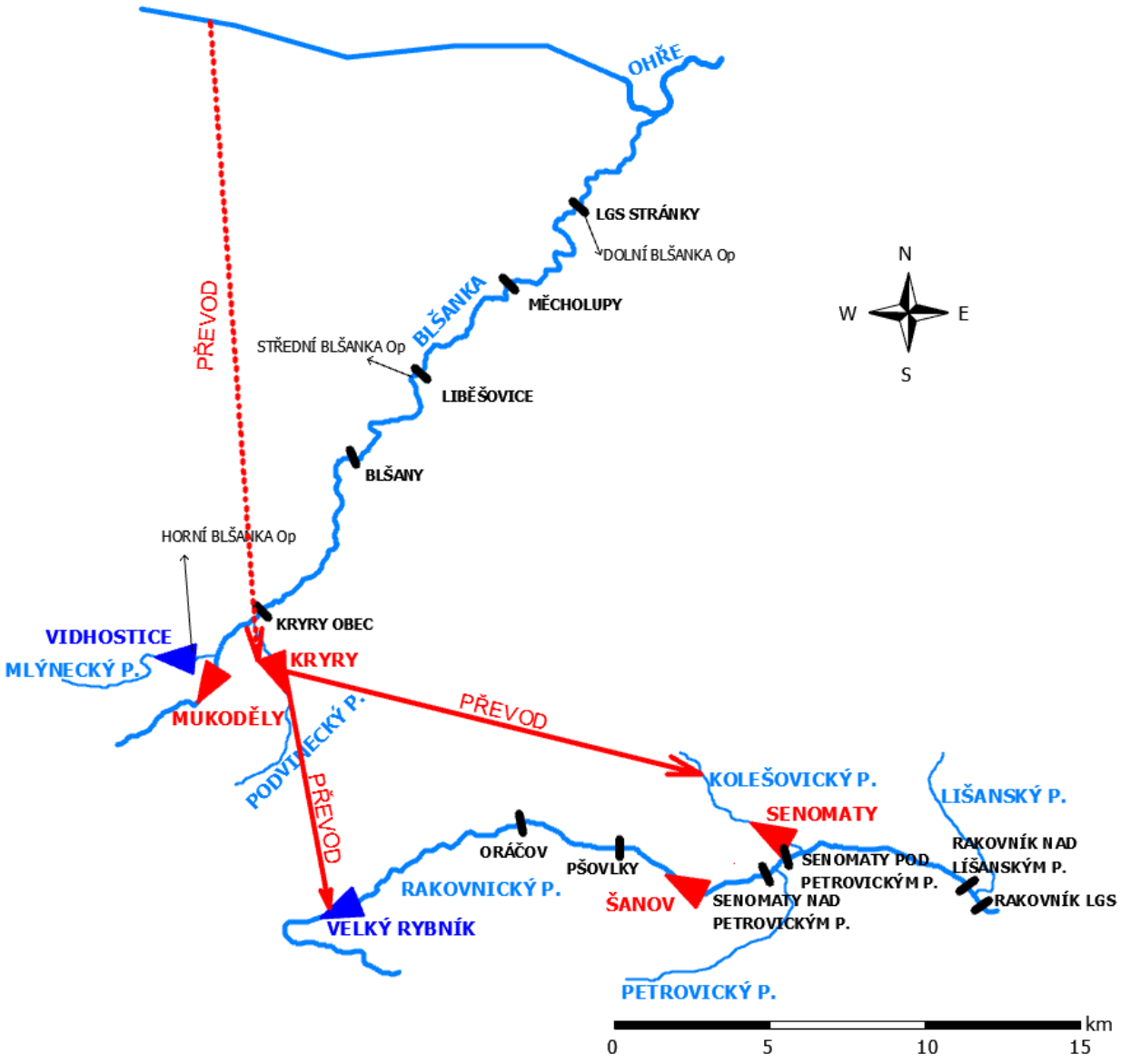






- Great uncertainty of the impacts of climate change
- Selection of the most probable climatic model (Climate Model HadRM_Q0 developed by Met Office Hadley Center, UK).

Conditions Affected by Climate Change



Measures:

- reservoir Kryry,
- reservoir Mukoděly,
- reservoir Šanov and reservoir Senomaty
- Water transfer from Kryry to Senomaty a Velký Jesenický Pond

- Water transfer from Ohře River or Berounka River

Assessing the impact of nature-friendly measures

Detailed analysis (11/2017):

- revitalization and renaturation of small watercourses,
- measures to reduce erosion,
- measures to reduce point sources of pollution,
- measures for better disposal of waste water,
- measures to manage rainfall,
- measures to improve land retention during floods,
- reconstruction of existing small water reservoirs and sediment removal.

-> The quantitative impact on water supply for the customer is small

-> The qualitative influence is significant:

  - reduction of sediment transport to reservoirs,
  - elimination of eutrophication processes in reservoirs.

CONCLUSIONS

- The study contributed to a significant revision of hydrological data and water demands,
- The study comprehensively evaluated the impact of individual measures to solve the deficit conditions in the basin of Rakovník Creek and Blšanka River,
- The results were also prepared for the likely development of climate change.