

Influence, analysis and perspectives of
use of the dams in flood protection in
Elbe catchment

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Major goals of the DÚ4 a DÚ5 tasks

Historical simulation of time series (1890 -2002)
for two basic types of flow:

- **Natural flow**
- **Flow affected by reservoirs**

Content

- Basis for modelling system setup
- Data
- Model setup, calibration and verification
- Adjustment of reservoir model according to outflow control rules
- Continuous historical simulation of natural flow
- Continuous historical simulation of affected flow by controlled outflow from reservoirs

Model setup basis

- Data availability
- Model for simulation for period 1890-2002
- Hydrological forecasting system of CHMI
- Time step adjustment
- Implementation of new catchments
- Replacement of original rainfall runoff model APIC by Sacramento model
- Recalibration of models in view of 2002 flood

Data

Precipitation

- Daily rainfall data from historical database 1961-2002
- Daily rainfall data from digitalization 1890-1960
- Monthly data

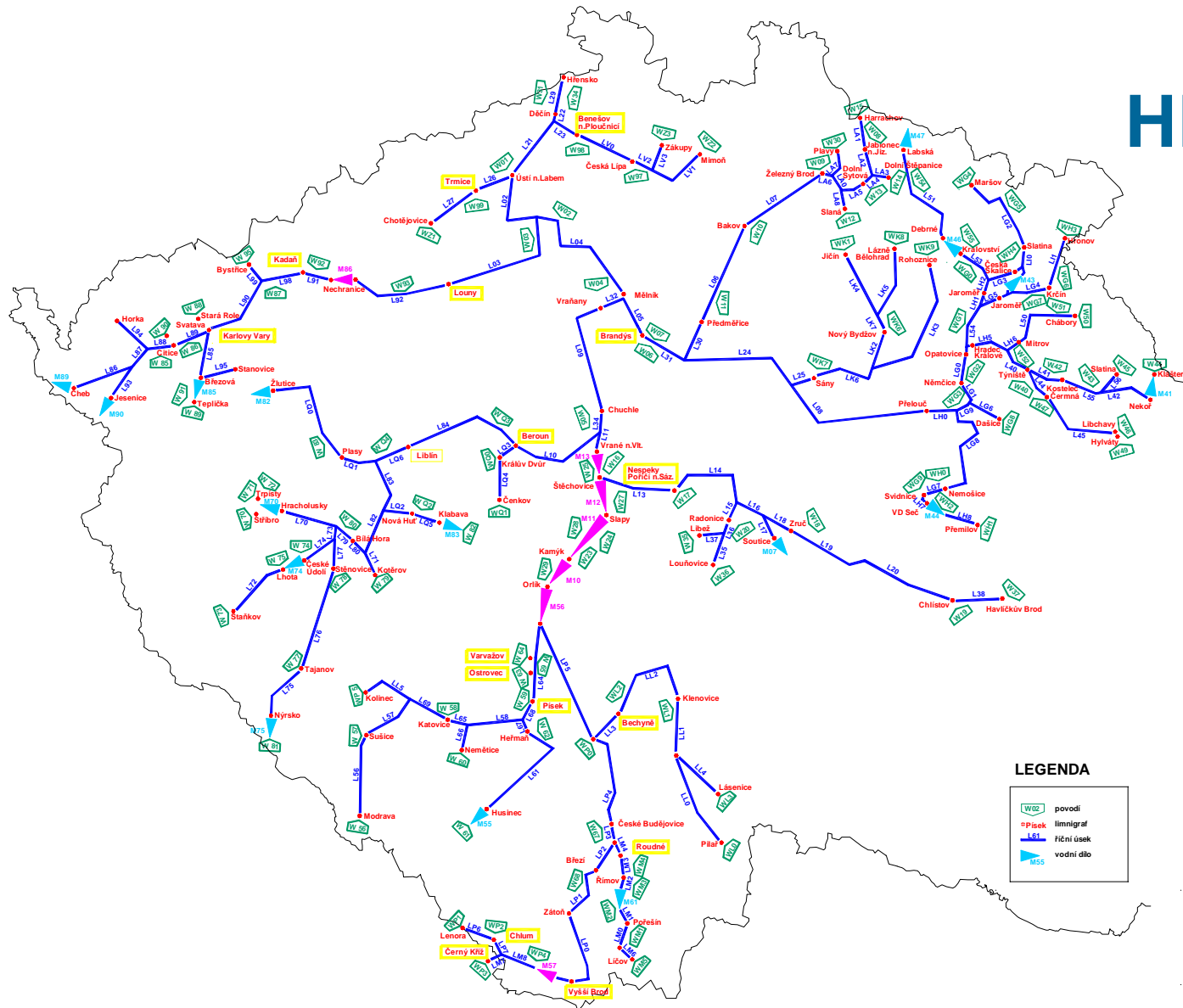
Temperature

- Tmax, Tmin a Tavg => 6-hourly time series
- digitalization Tavg => 6-hourly time series

Flow data

- Daily data (QD), peak flows (QK) => 6-hourly time series

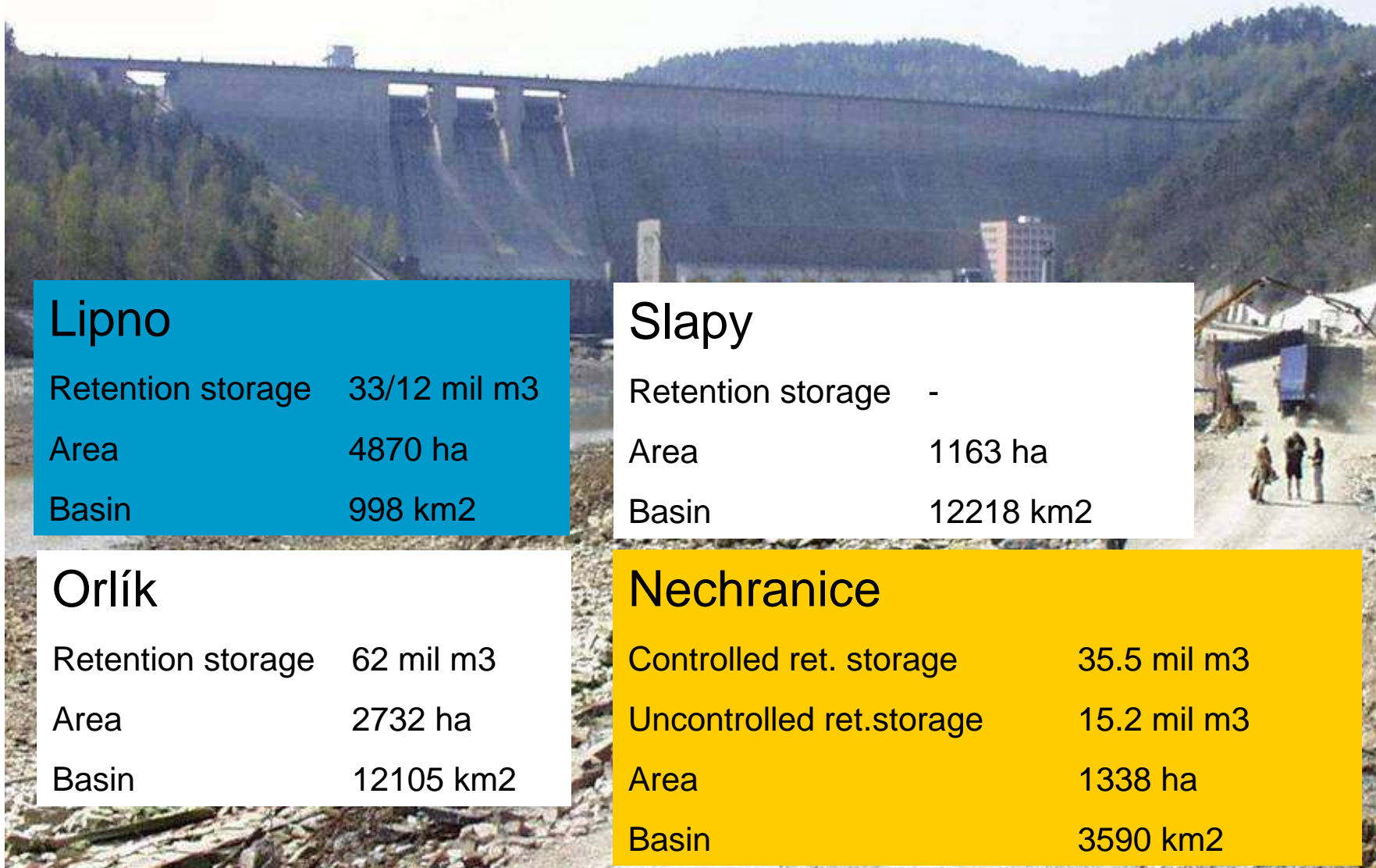
HFS CHMI



LEGENDA

W02	povodí
písek	řiční úsek
M01	vodní dílo

Characteristics of major dams



Lipno

Retention storage	33/12 mil m ³
Area	4870 ha
Basin	998 km ²

Slapy

Retention storage	-
Area	1163 ha
Basin	12218 km ²

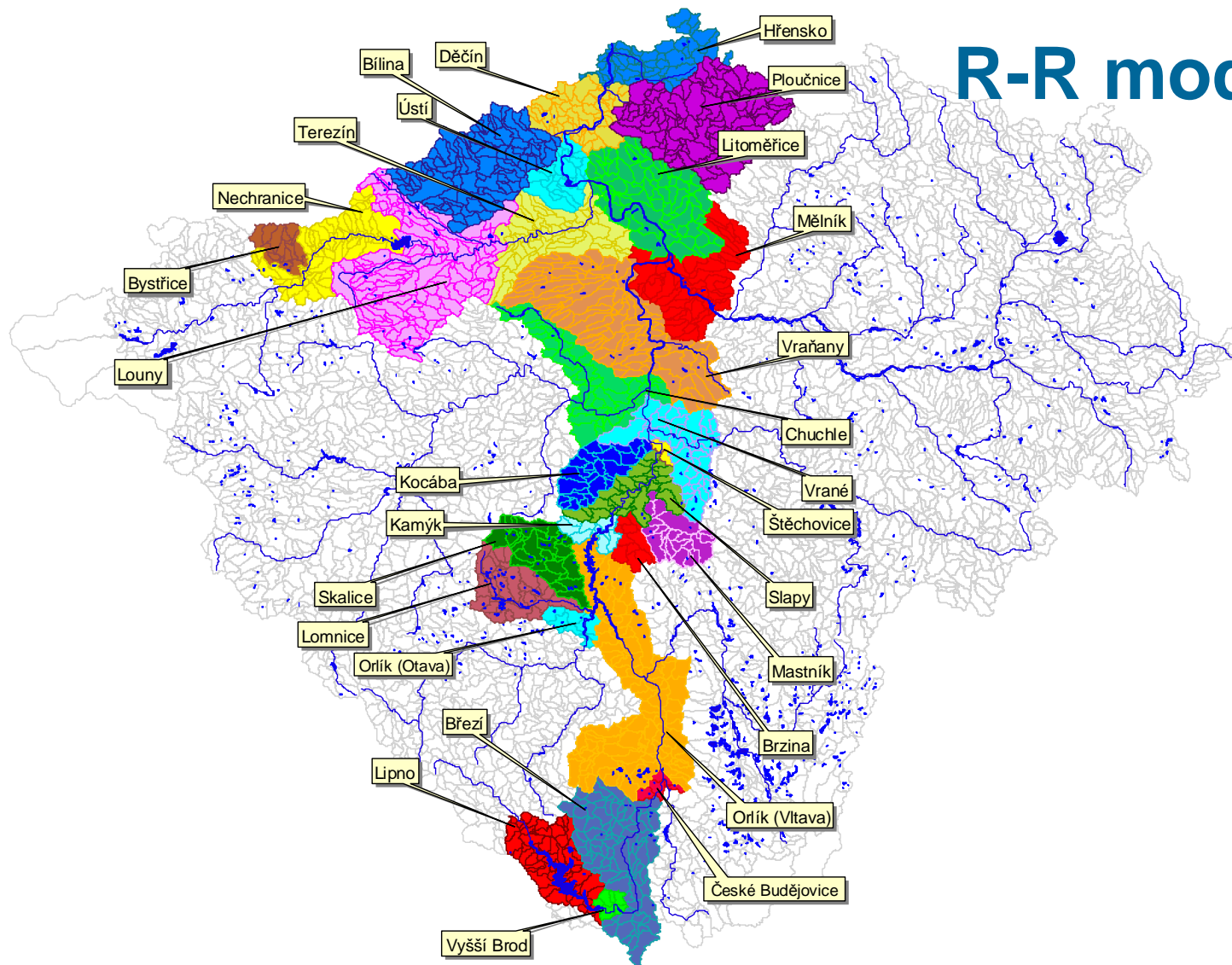
Orlík

Retention storage	62 mil m ³
Area	2732 ha
Basin	12105 km ²

Nechranice

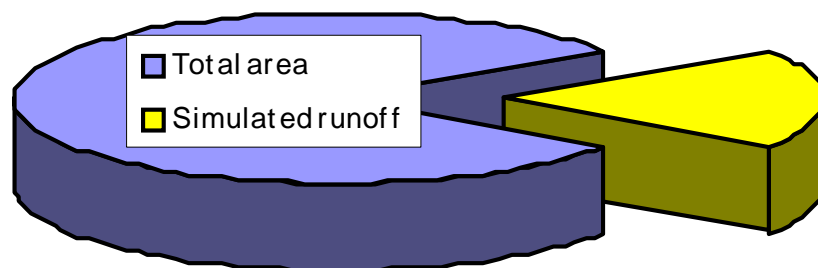
Controlled ret. storage	35.5 mil m ³
Uncontrolled ret.storage	15.2 mil m ³
Area	1338 ha
Basin	3590 km ²

R-R models



Rainfall – runoff models

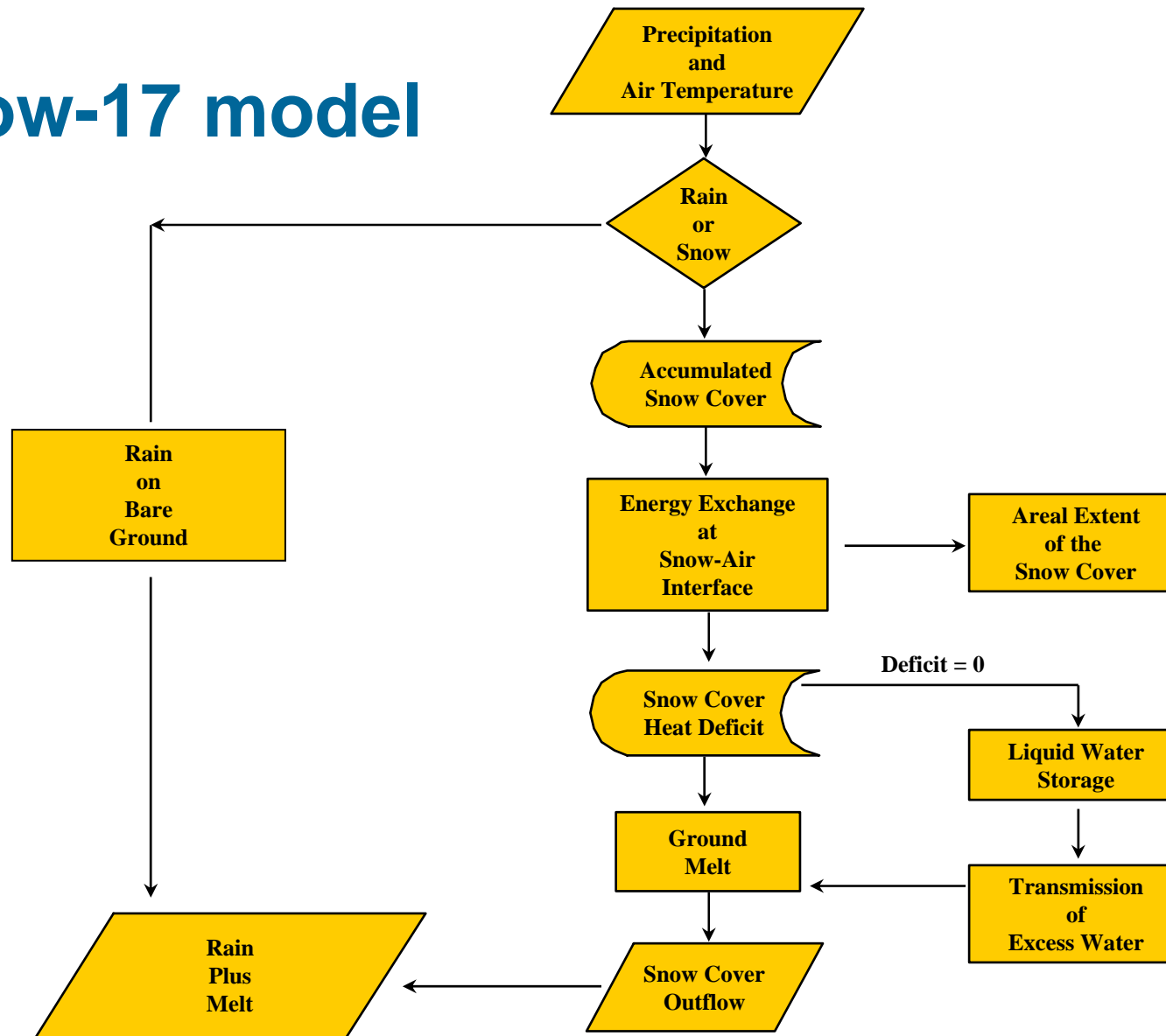
River station	Basin area(km ²)	Area of basin covered by rainfall runoff model("km ²)	% of area of basin covered by rainfall runoff model
Přítok Lipno	998	553	0.55
České Budějovice	2847	1440	0.51
Přítok VD Orlik	12105	2976	0.25
Přítok VD Kamýk	12217	3088	0.25
Přítok VD Slapy	12218	3826	0.31
Přítok VD Štěchovice	12957	3847	0.30
Chuhle	12977	5305	0.41
Vraňany	28048	6633	0.24
Mělník	41824	7298	0.17
Ústí nad Labem	48557	11173	0.23
Hřensko	51392	11890	0.23



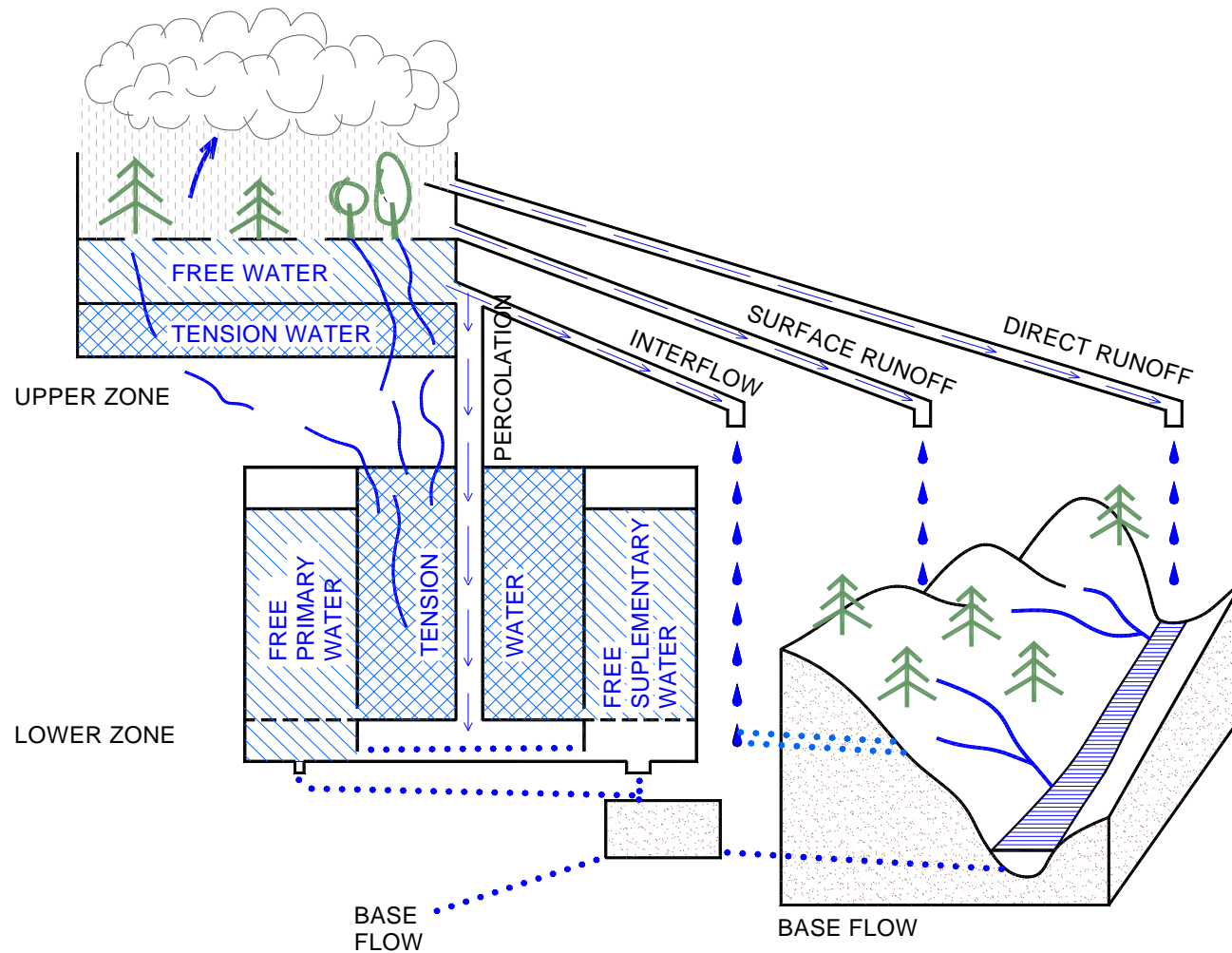
Applied models

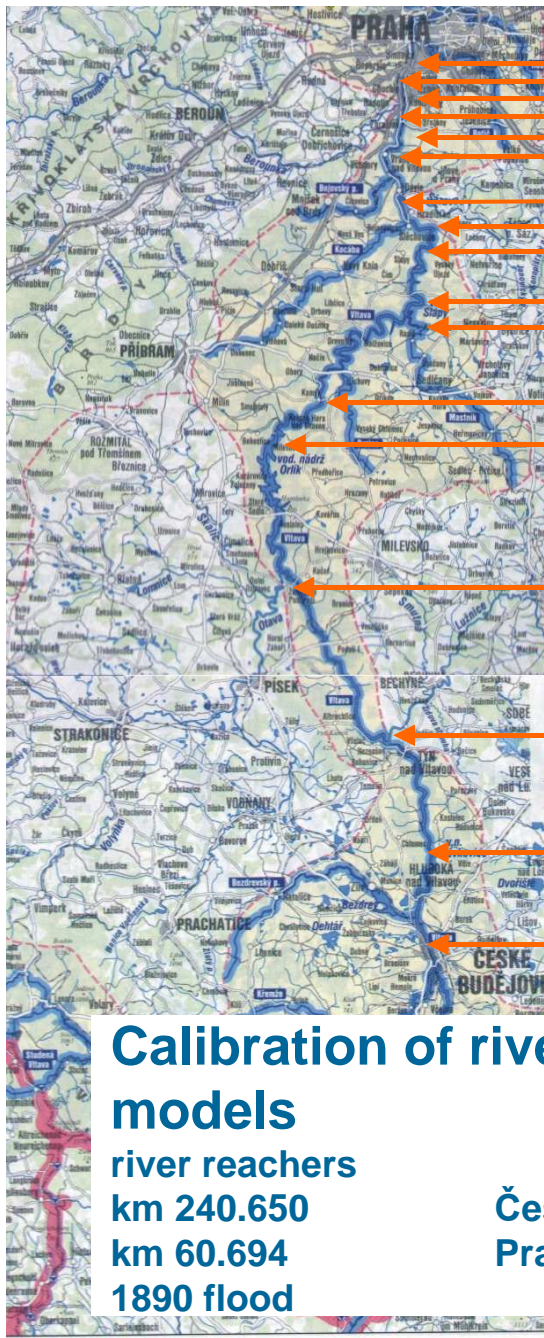
- Snow Accumulation and Ablation Model - SNOW-17 (Andersen)
- Rainfall- runoff model SAC-SMA (Sacramento- Soil Moisture Accounting)
 - Physically-based conceptual model - based on physical concepts that describe water movement through a watershed
 - Two-layer soil model
- River routing model (TDR, Muskingum - Cunge)
- Reservoir model MAN

Snow-17 model



Sacramento model - physically-based conceptual model

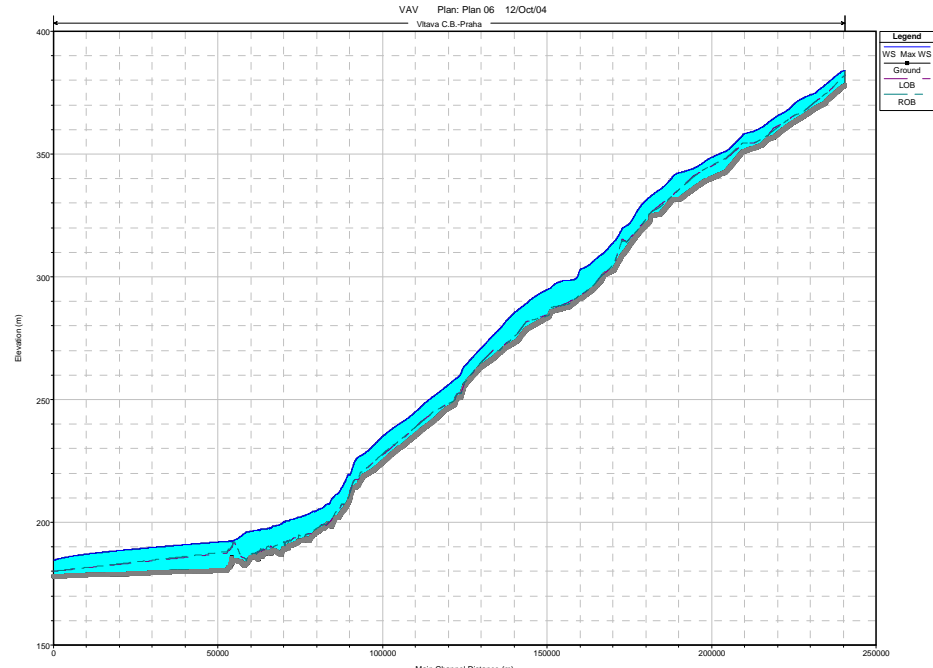
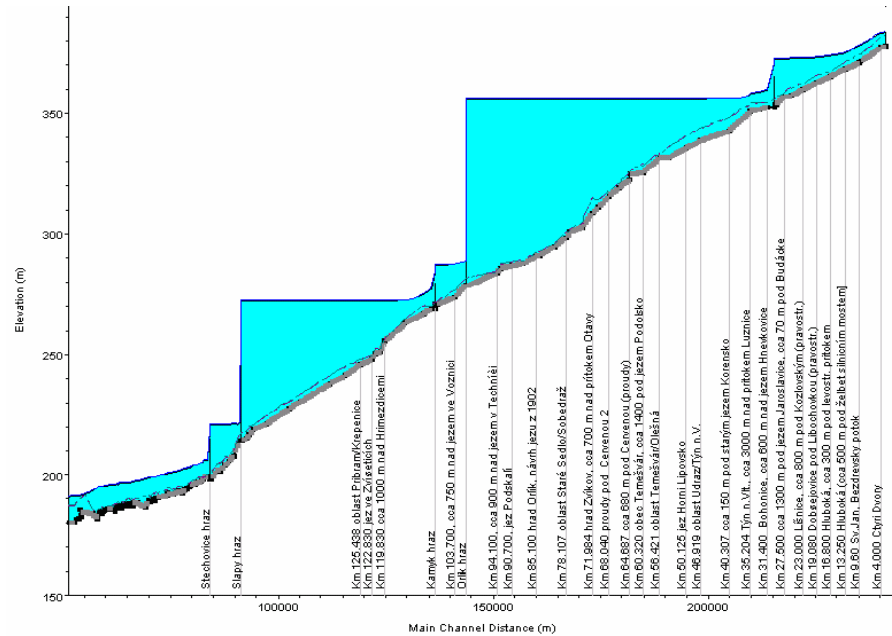




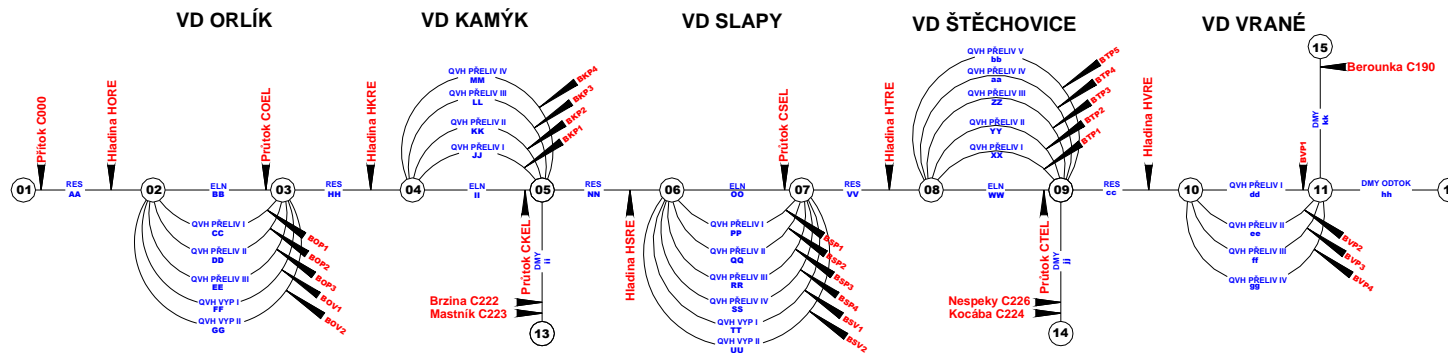
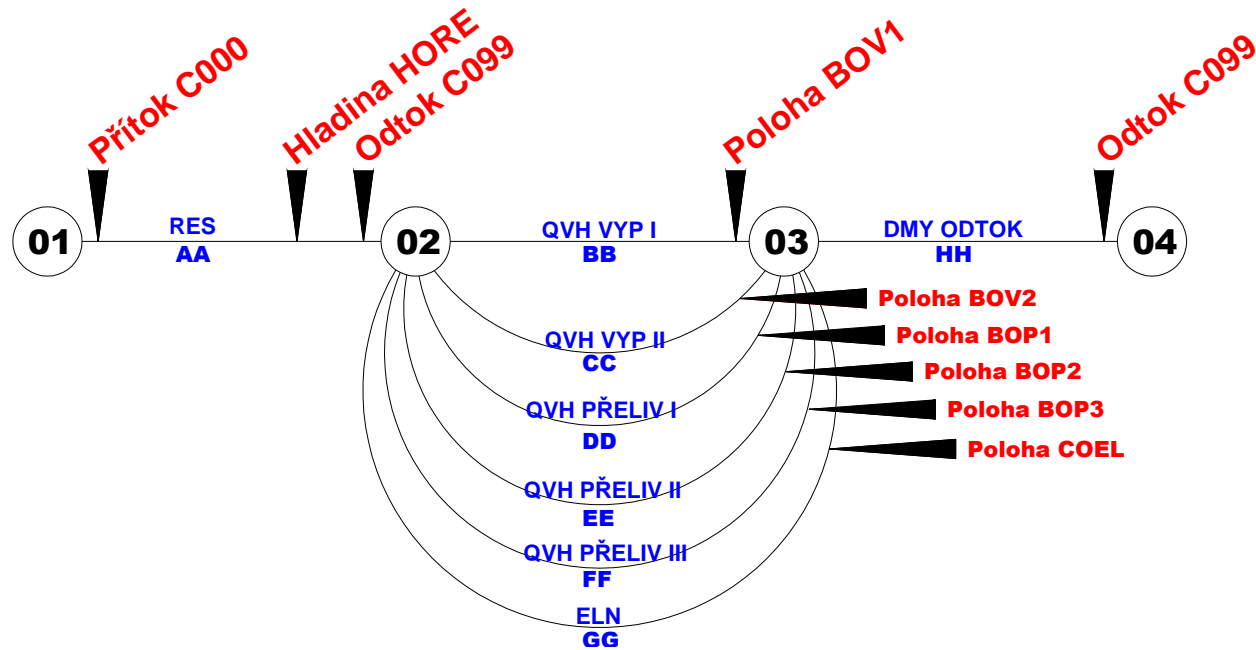
- Praha Helmovský jez (fiktivní závěrový pf) Km 53.694
- Praha Šítkovský jez Km 53.694
- Chuchle Km 60.694
- Berounka přítok Km 63.1547
- Zbraslav Km 65.694
- Vrané n.Vlt. Km 72.092
- Sázava přítok Km 78.360
- Kočába přítok Km 82.200
- Stěchovice hráz Km 83.594
- Slapy hráz Km 91.794
- Mastník přítok Km 105.220
- Kamýk hráz Km 135.600
- Orlík hráz Km 143.600
- Otava přítok Km 172.720
- Lužnice přítok Km 209.495
- Hněvkovice hráz Km 213.313
- České Budějovice měření Km 240.650
(horní uzávěrový profil modelu)

Calibration of river routing models
 river reachers
 km 240.650
 km 60.694
 1890 flood

České Budějovice
Praha

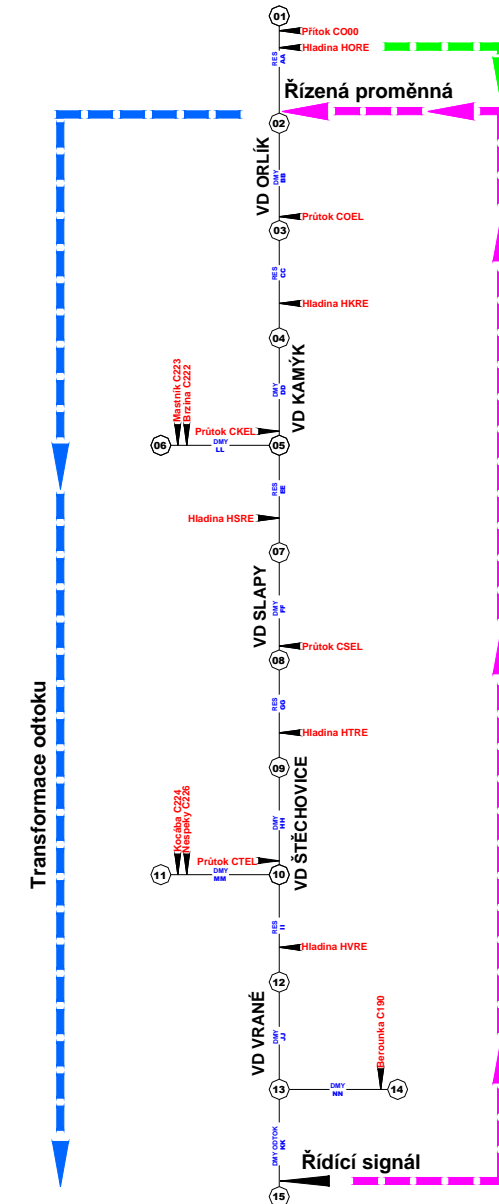


Reservoir model

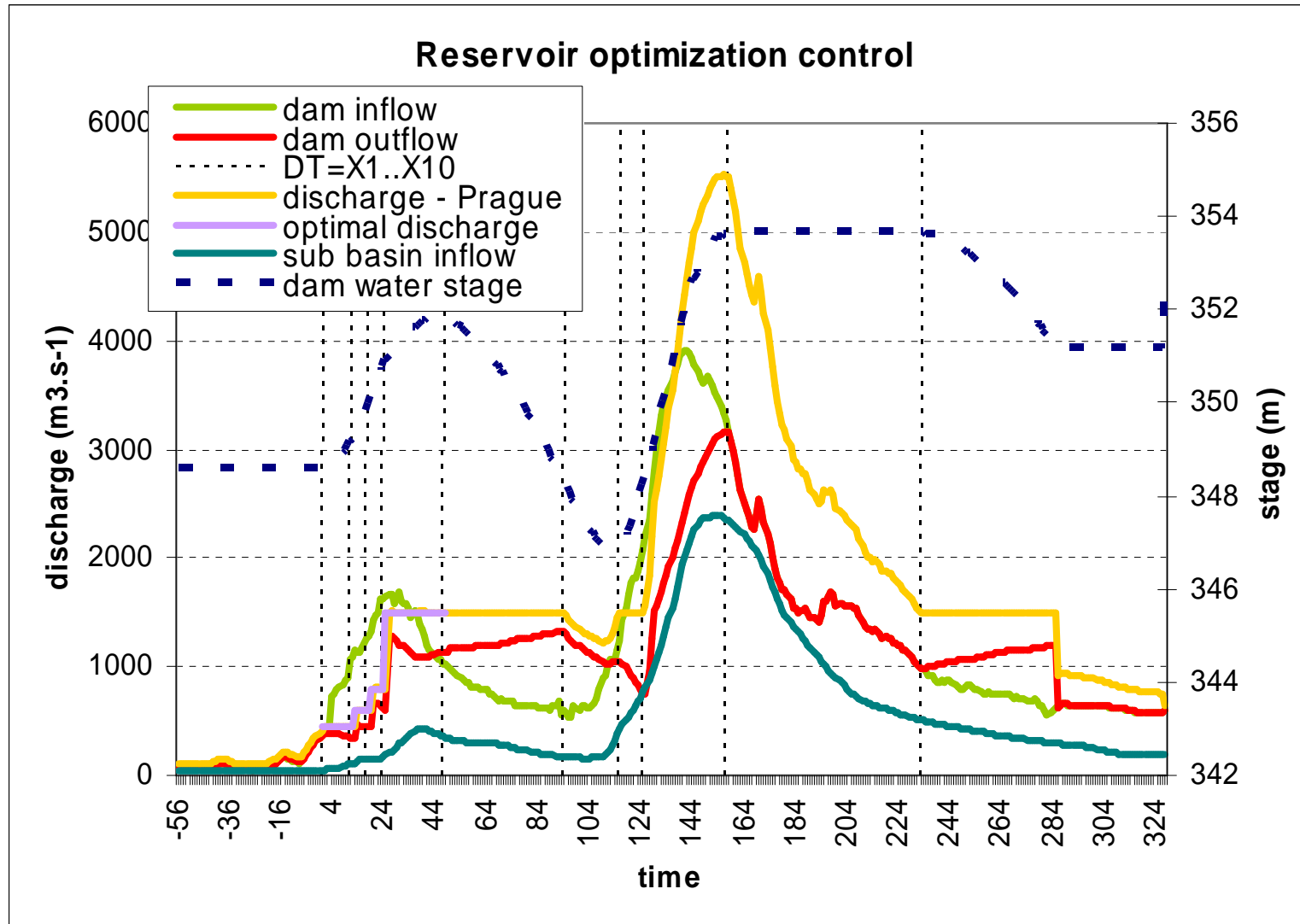


Optimization of cascade of reservoirs

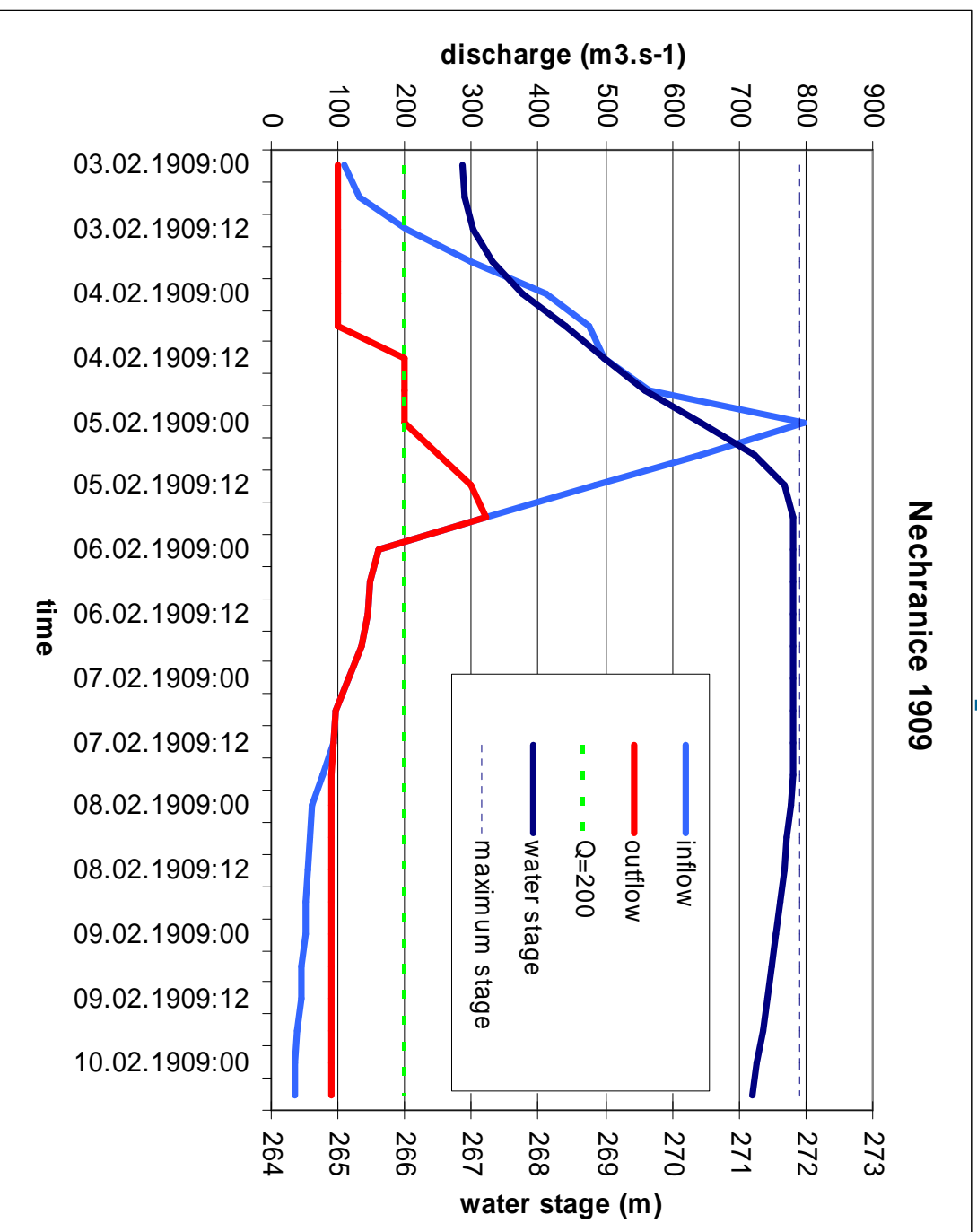
Od	Interval	Čas celkem	Profil	Průtok
00:00	12:00	12	Chuchle	≤ 450
			Slapy	≤ 300
12:00	6:00	18	Chuchle	≤ 600
			Slapy	≤ 600
18:00	6:00	24:00	Chuchle	≤ 800
24:00	24:00	48:00	Chuchle	≤ 1500
48:00			Chuchle	více 1500



Optimized outflow



Nechranice dam - optimized outflow



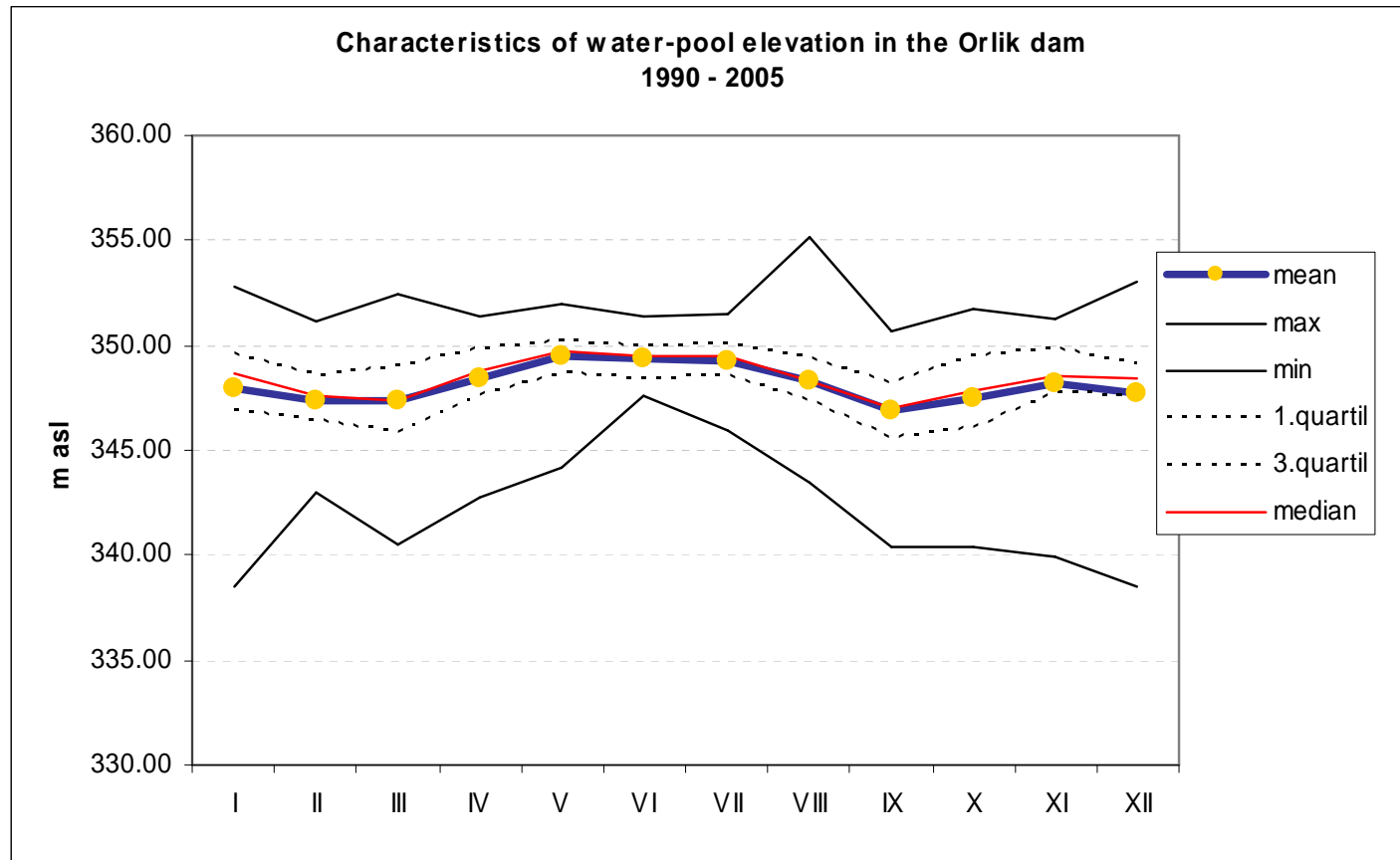
Interactive control centre

AL-Manipulace										
Nádrž			Průtok (n-1)	Průtok (n)	Hladina (n-1)	Hladina (n)	Nastavení (n-1)	Nastavení (n)	Vstupy (n-1)	Vstupy (n)
Čas			03.09 03:00	03.09 04:00	03.09 03:00	03.09 04:00	03.09 03:00	03.09 04:00	03.09 03:00	03.09 04:00
VD Orlík	AA	RES - P	1098	1170	390.06	390.07	-	-	1097.50	1170.00
		RES - O	590	650	390.06	390.07	-	-		
elektrárna	BB	ELN	0	0	-	-	-	-	0.00	0.00
odtok Orlík	CC	REL	590	650	-	-	-	Qmax= 14692.39	590.00	650.00
VD Kamýk	DD	RES - P	590	650	290.00	290.00	-	-		
		RES - O	590	650	290.00	290.00	-	-		
elektrárna	EE	ELN	0	0	-	-	-	-	0.00	0.00
odtok Kamýk	FF	REL	590	650	-	-	-	Qmax= -999.00	590.00	650.00
VD Slapy	GG	RES - P	730	800	280.02	280.02	-	-		
		RES - O	640	700	280.02	280.02	-	-		
elektrárna Slapy	HH	ELN	0	0	-	-	-	-	0.00	0.00
odtok Slapy	II	REL	640	700	-	-	-	Qmax= -999.00	640.00	700.00
VD Štěchovice	JJ	RES - P	640	700	229.83	229.83	-	-		
		RES - O	640	700	229.83	229.83	-	-		
elektrárna	KK	ELN	0	0	-	-	-	-	0.00	0.00
odtok Štěchovice	LL	REL	640	700	-	-	-	Qmax= 7306.99	640.00	700.00
VD Vrané	MM	RES - P	821	893	135.51	134.32	-	-		
		RES - O	830	890	135.51	134.32	-	-		
odtok Vrané	NN	REL	830	890	-	-	-	Qmax= -999.00	830.00	890.00
celkový odtok	OO	DMY	992	1050	-	-	-	-		
prítok Slapy	PP	DMY	-140	-150	-	-	-	-	-50.60	-55.80
prítok Vrane	QQ	DMY	-181	-193	-	-	-	-	-18.40	-20.00
prítok Beroun	RR	DMY	-162	-160	-	-	-	-	-161.67	-160.00

Časová hladina: 25. Změnit na:
 Auto simulace

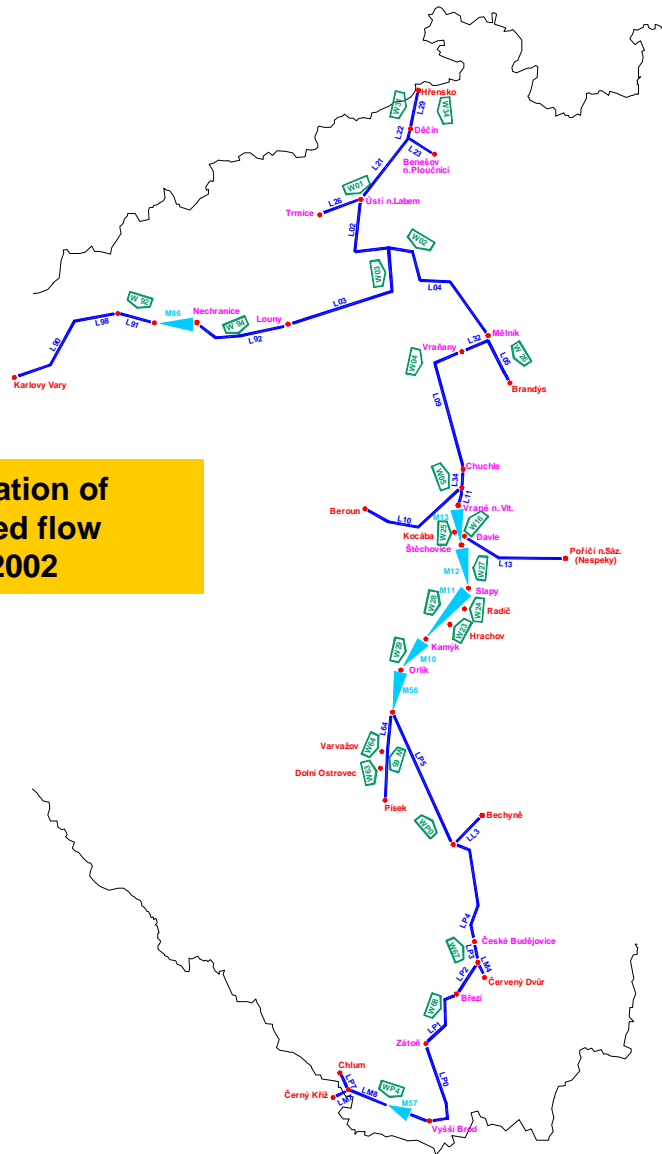
Status 16.12.2004 22:47

Initial conditions

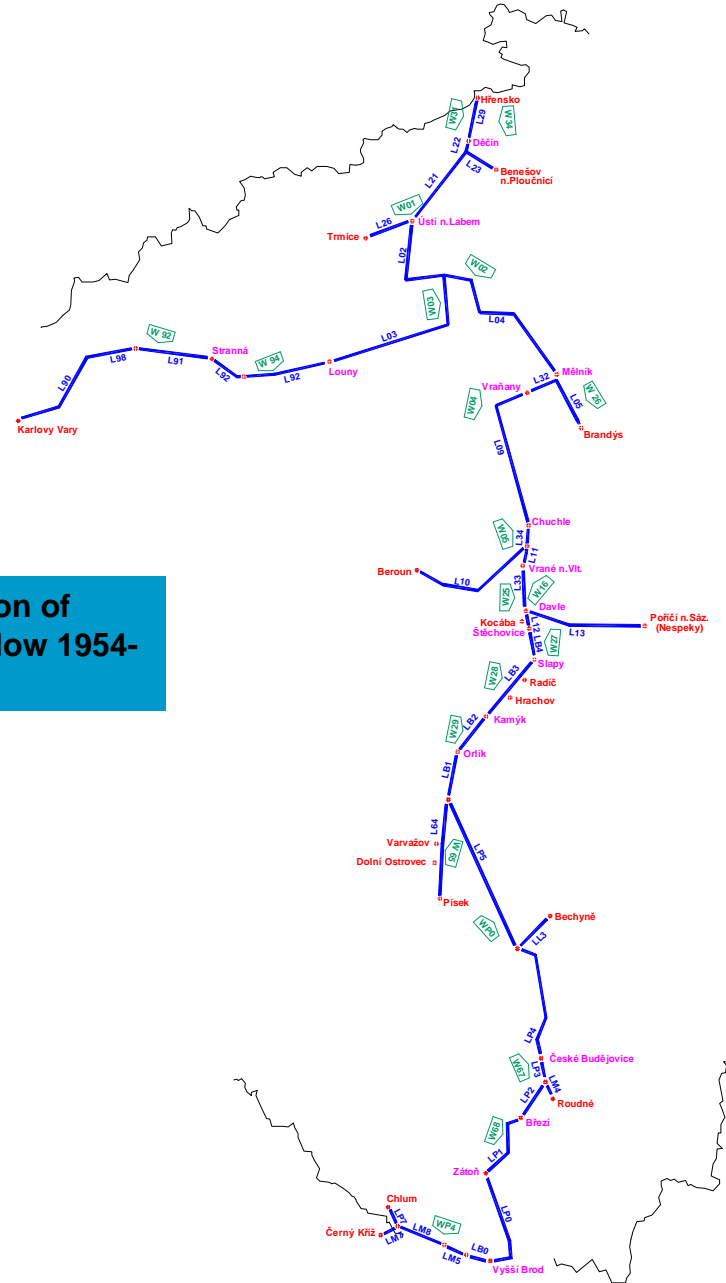


Alternatives of simulations

ALTERNATIVE	TYPE OF SIMULATION	PERIOD
Scheme 1	NATURAL FLOW	1969-2002
Scheme 2	NATURAL FLOW	1954-1969
Scheme 3	NATURAL FLOW	1890-1954
Scheme 4	AFFECTED FLOW	1954-2002
Scheme 5	AFFECTED FLOW	1890-1954

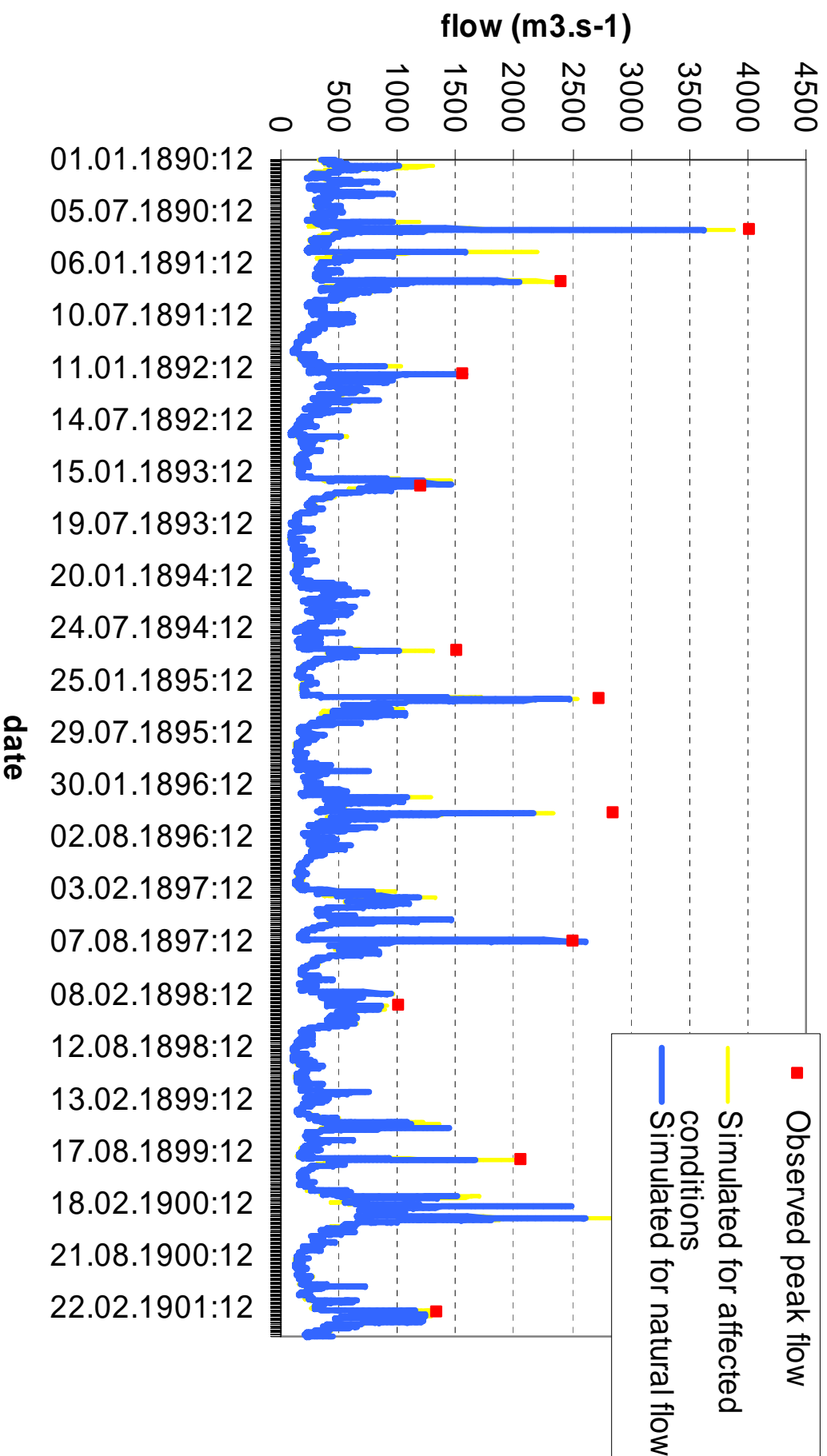


Simulation of affected flow 1954-2002

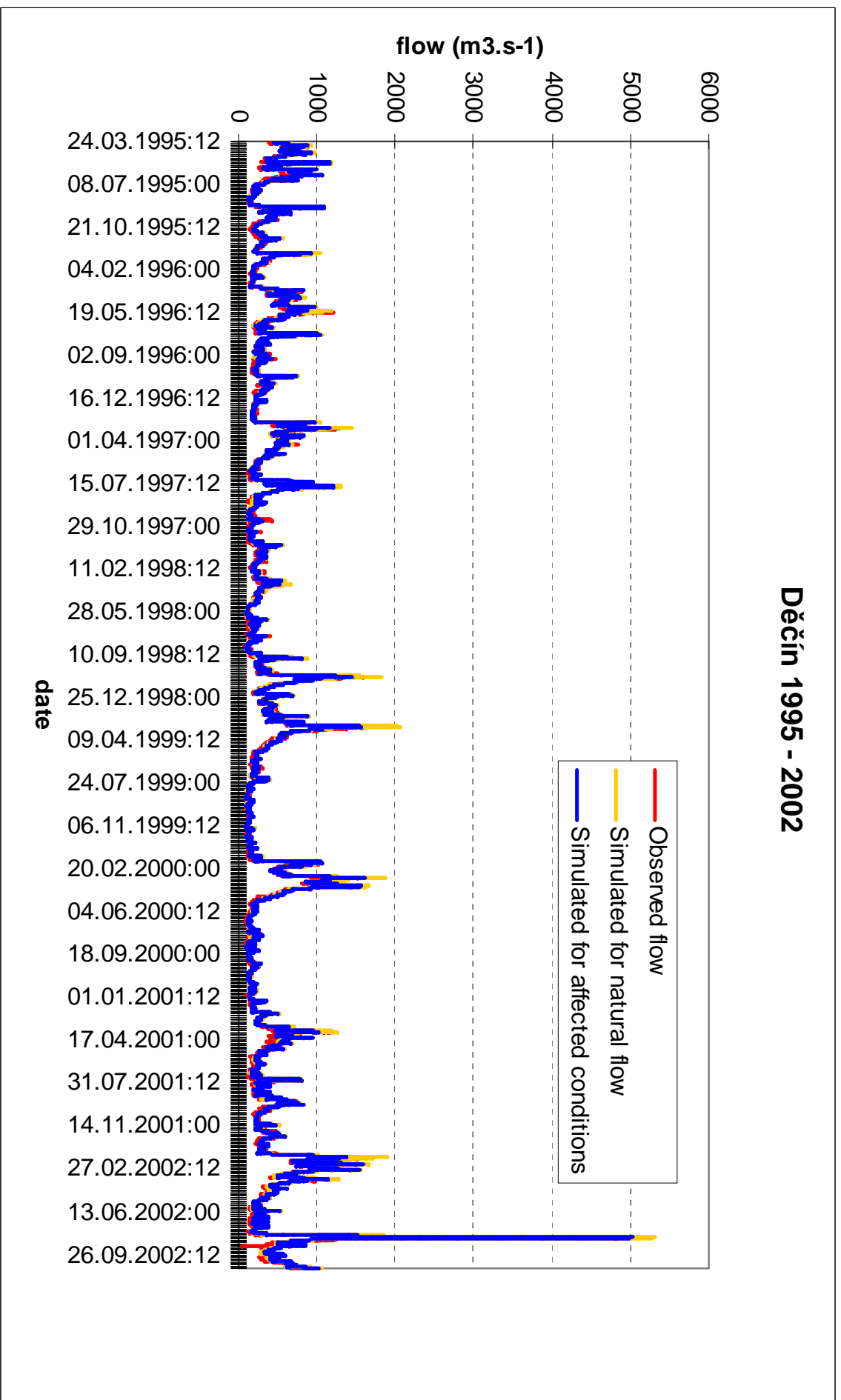


Simulation of natural flow 1954-1969

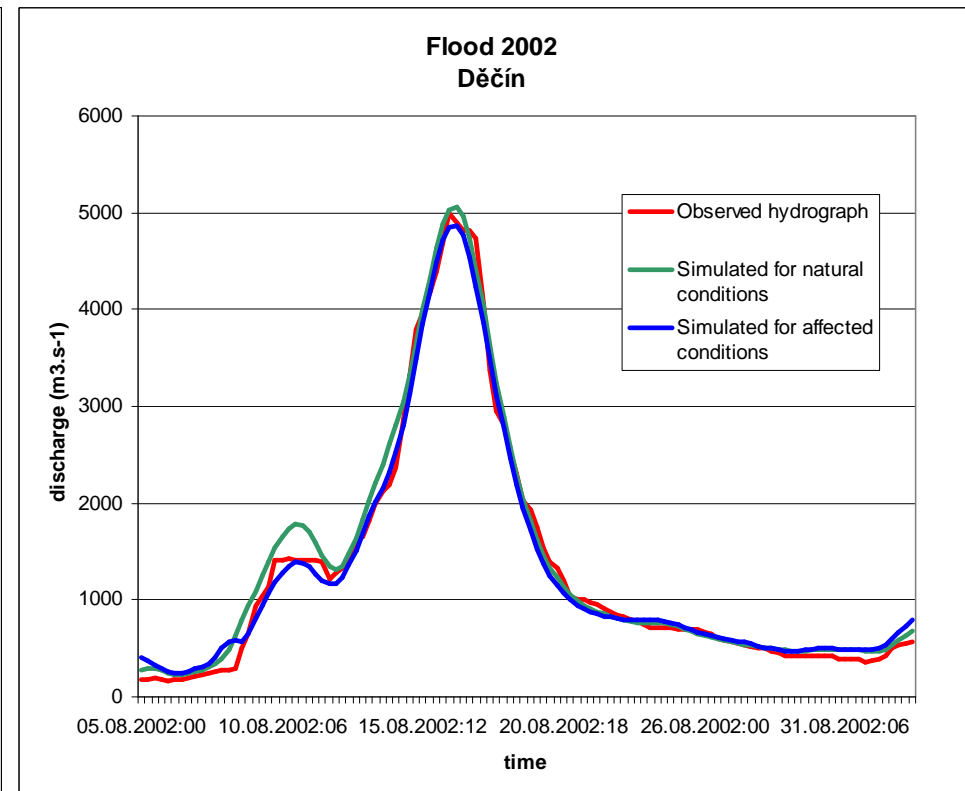
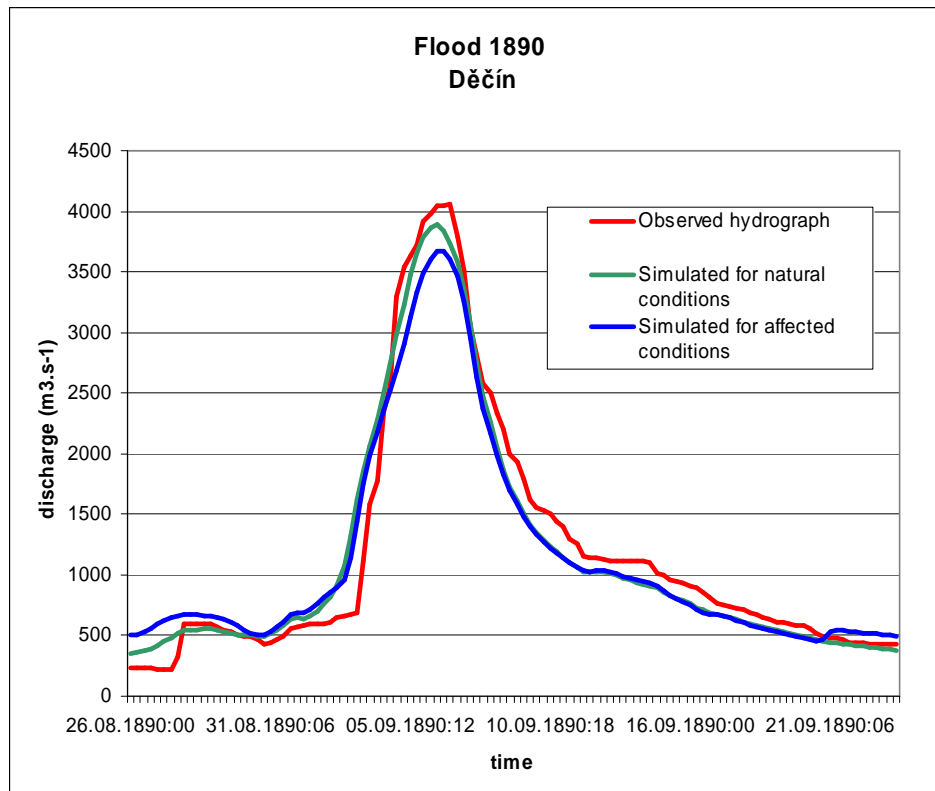
Děčín 1890 - 1901



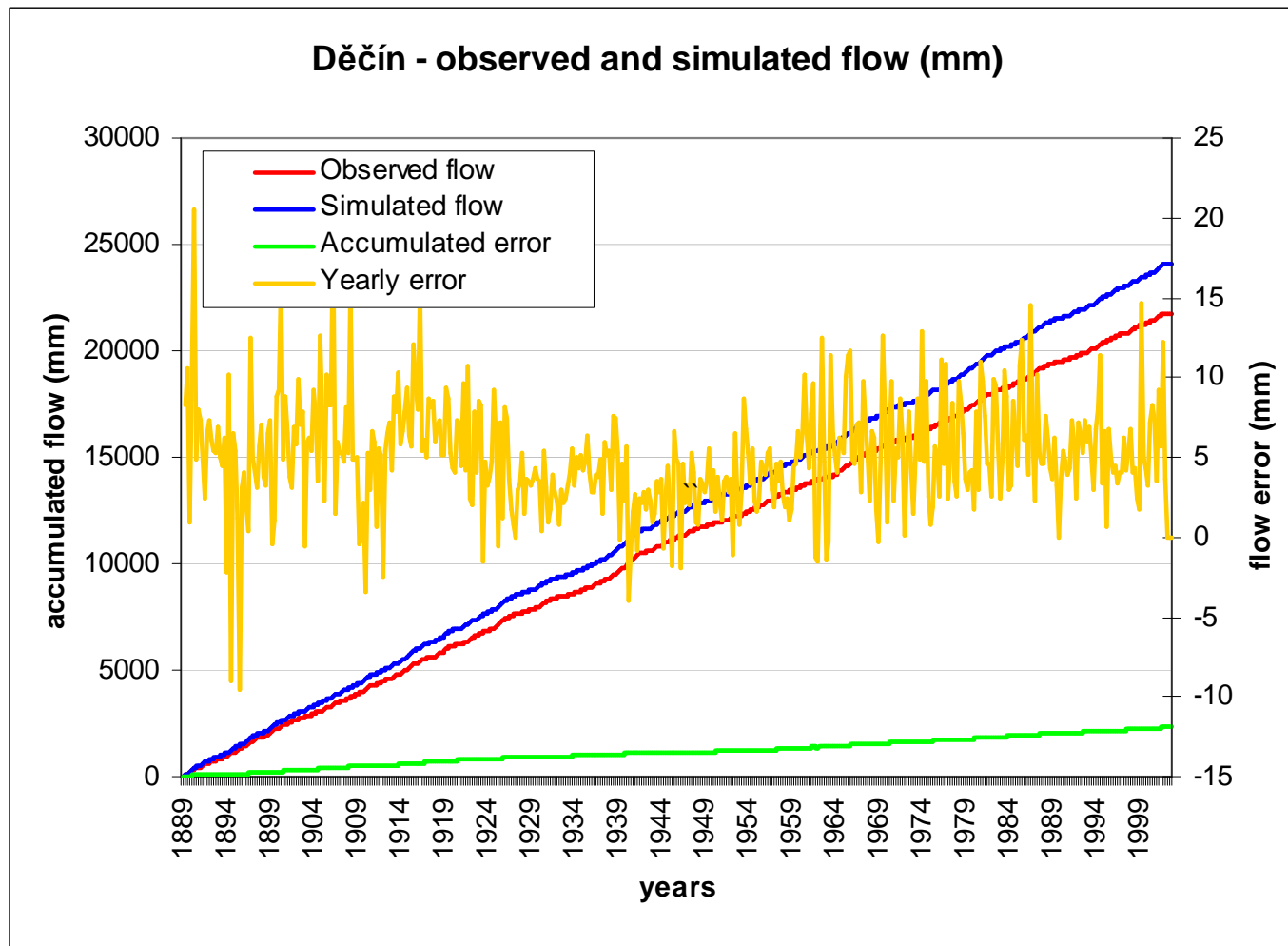
Děčín 1995 - 2002



Detailed flood hydrographs



Statistics



Conclusions

- Hydrological modeling system was made
- Simulations of historical floods were provided for further processing

Thanks for your attention

