HydroEco´2011

3rd International Multidisciplinary Conference on
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#261: NATURE CLOSE TORRENT CONTROL IN ORE MOUNTAINS

Case Study Jindrichovicky Brook Restoration

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BOKU

INTRODUCTION

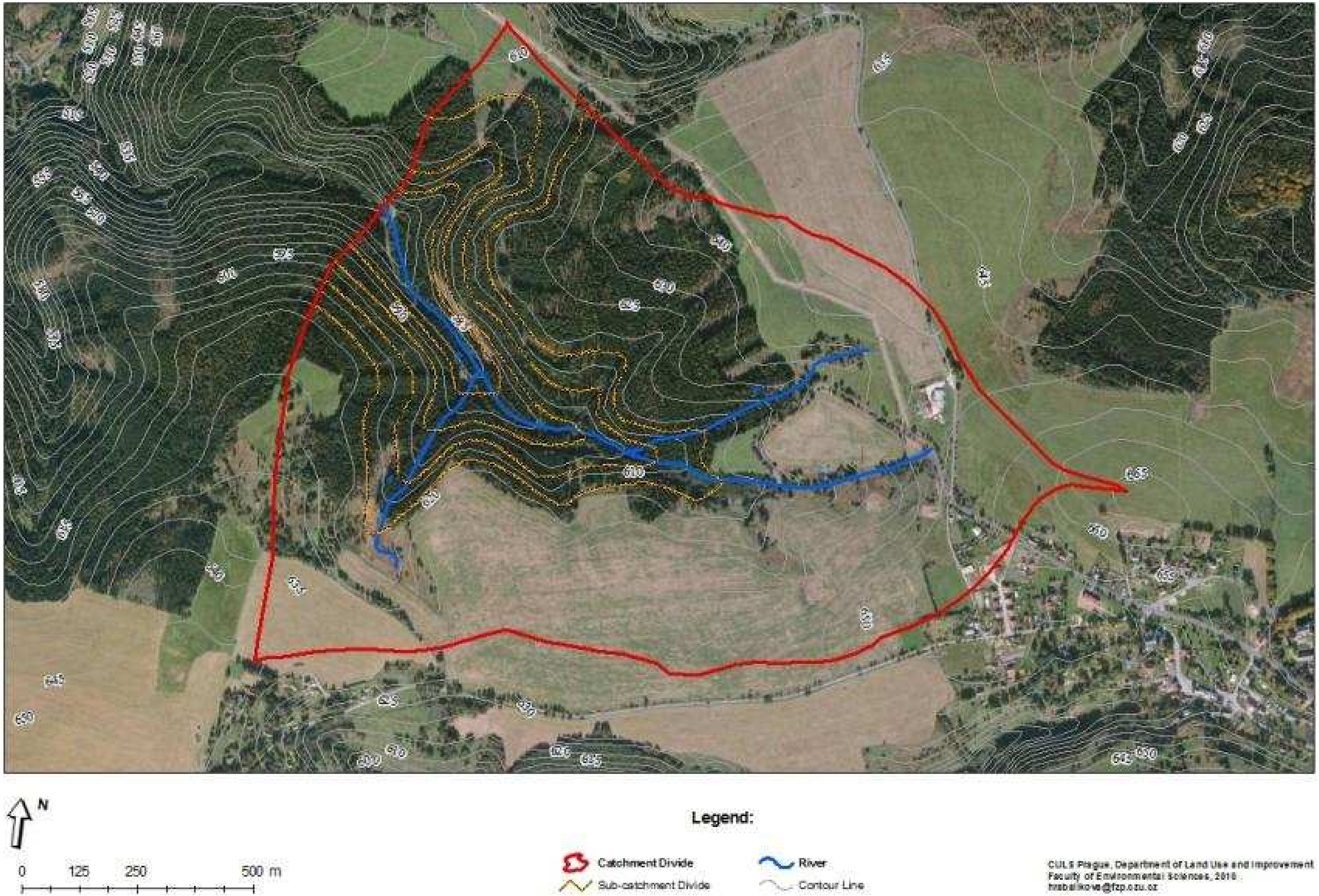
CAN HYDROLOGIC AND HYDRAULIC MODELS BE USED IN TORRENT RESTORATION?

Problems to be solved:

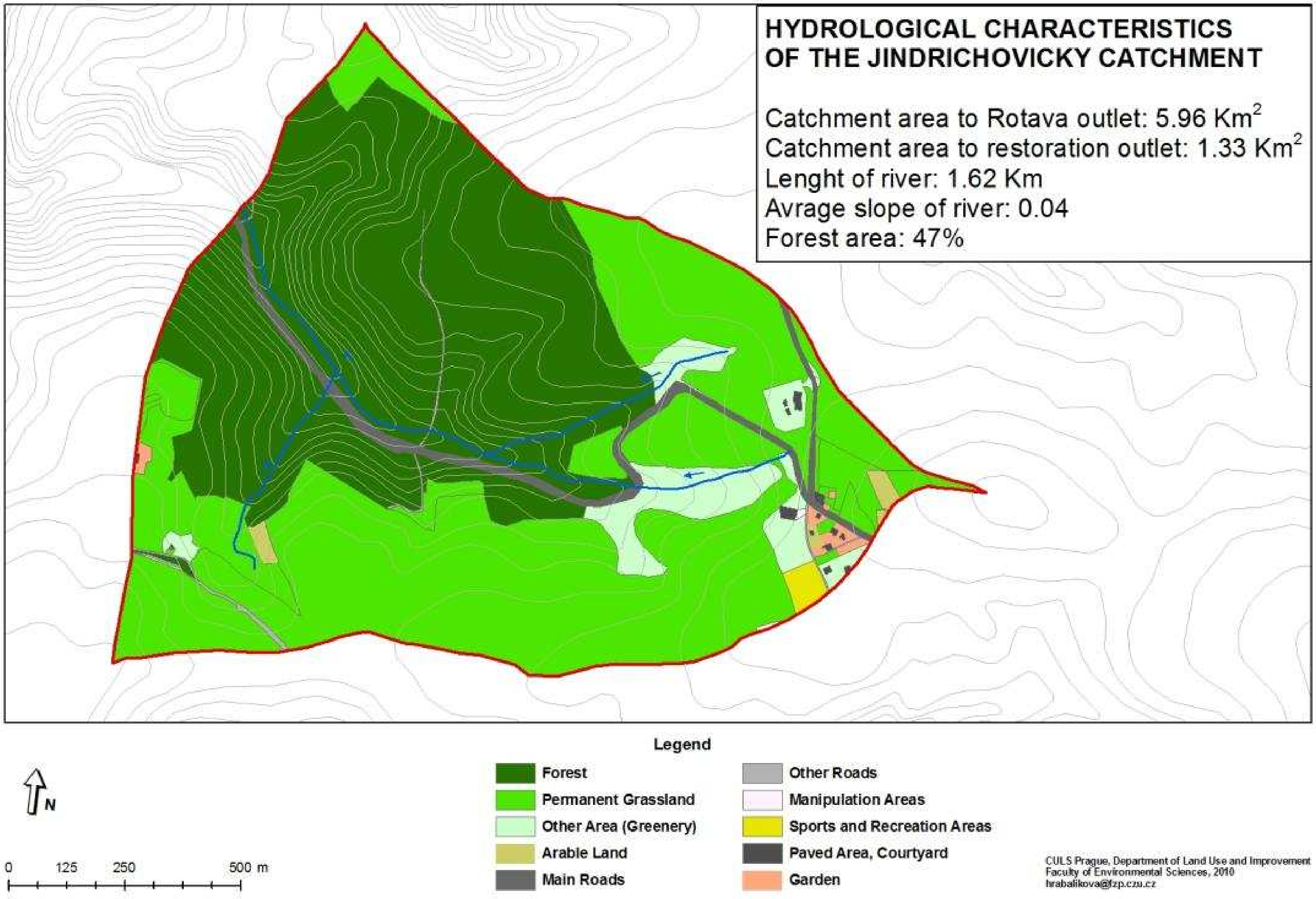
- Discharge capacities in different stream parts:
  - Design rainfall data ($P_{N,t}$): **DES-RAIN Model**
  - Design discharge data (Q_N incl. urbanised areas): **KINFIL Model**
- Channel stability, different morphology (in situation, longitudinal and cross-section profiles): **HEC-RAS, SRH-2D**
- Biodiversity adequate to local environment
- Reparian vegetation to fit to natural site

Hard regulation measures in the 1970's

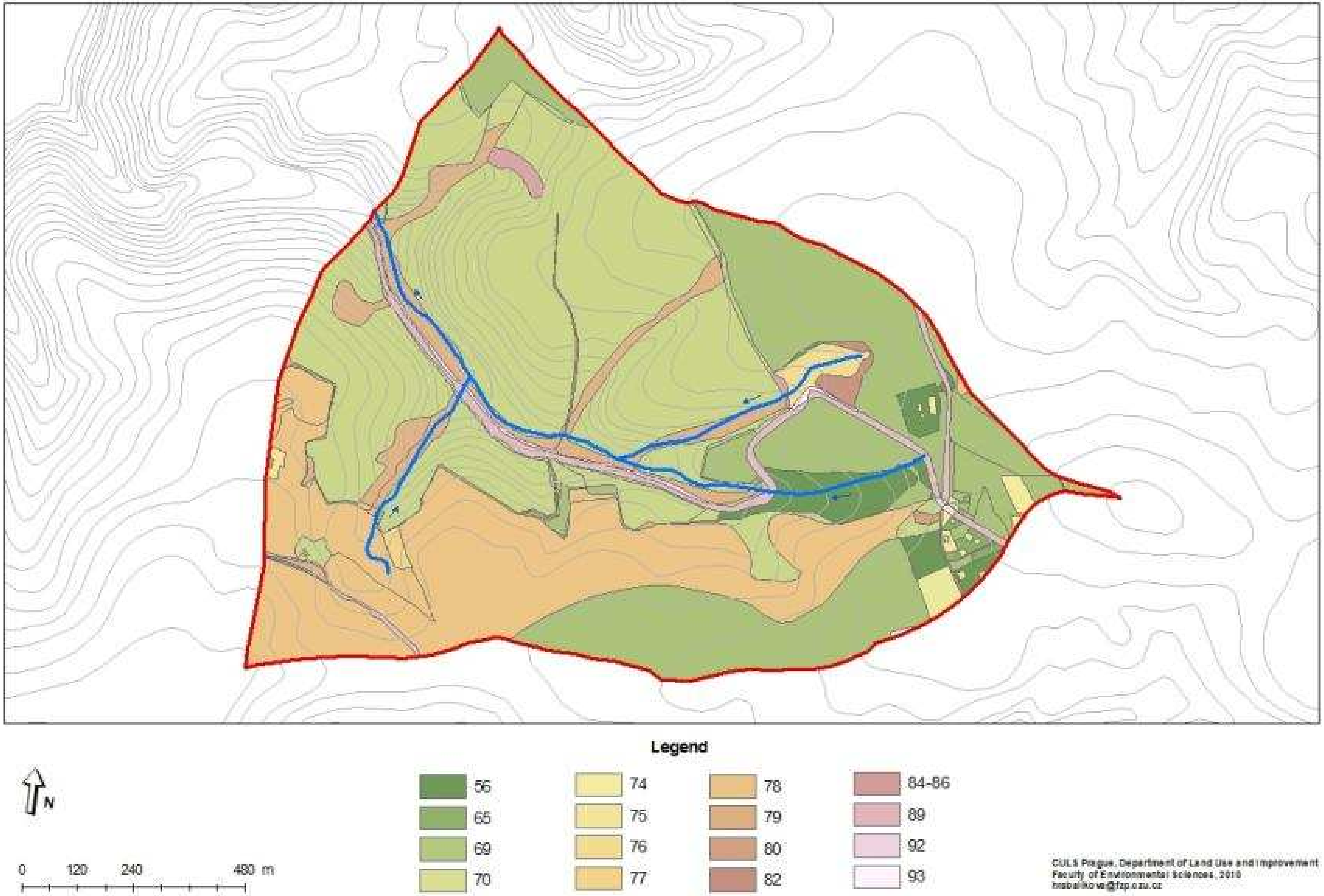
Elevation situation of the catchment



Land use of the catchment



Curve Number (CN) value of the catchment



SELECTION OF DESIGN RAINFALLS

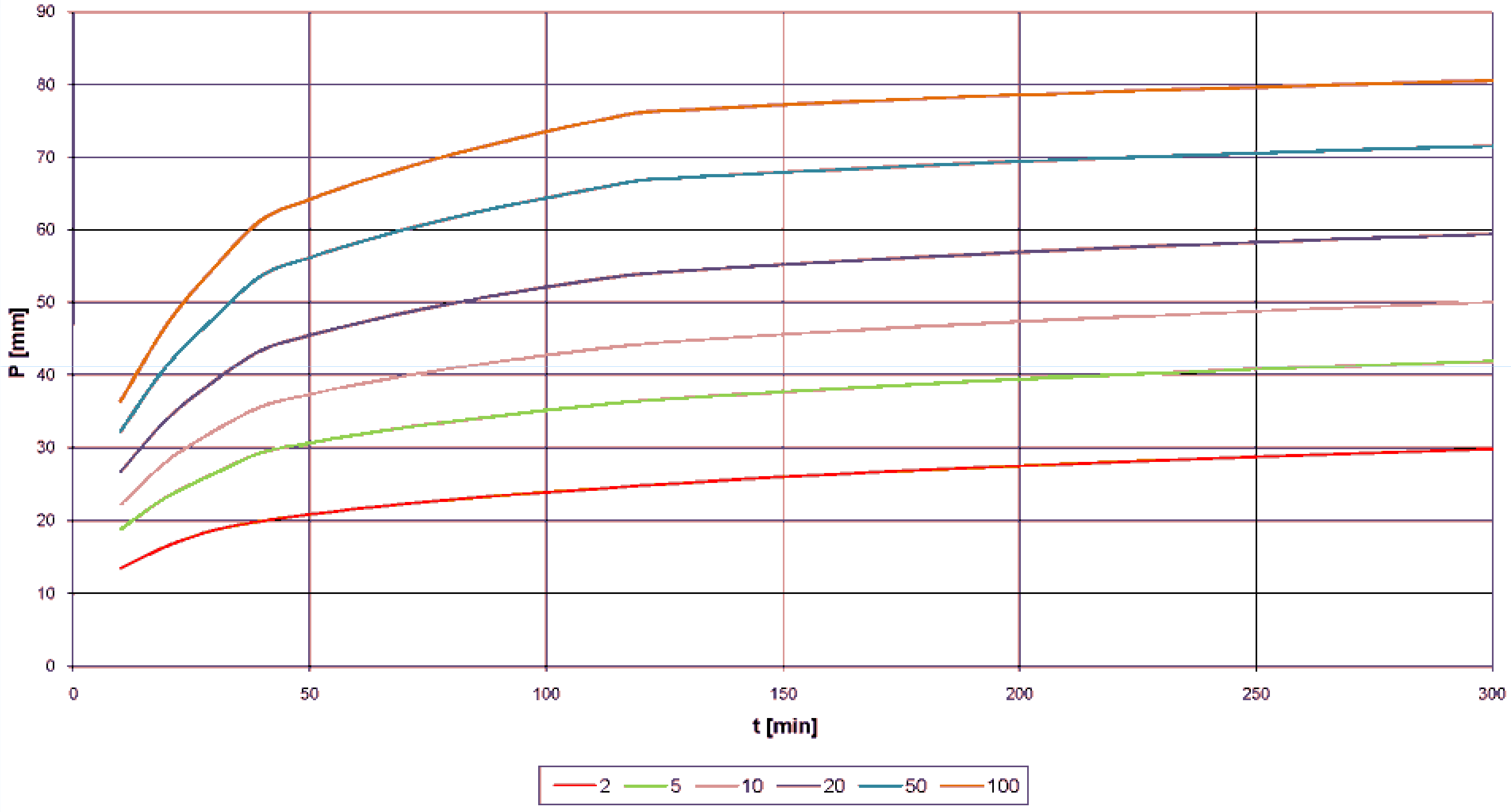
Method of reduction of 1-day maximum rainfall

$$P_{t,N} = P_{1d,N} \cdot a \cdot t^{1-c} \qquad i_{t,N} = P_{1d,N} \cdot a \cdot t^{-c}$$

One-day maximum rainfall $P_{1d,N}$ (mm) at the Jachymov st.

$H_{t,N}$ (mm)							
N (years)/ t (min)	10	20	30	60	90	120	300
2	13.5	16.6	18.7	21.7	23.5	24.9	29.8
5	18.8	23.3	26.4	31.8	34.4	36.4	42.0
10	22.2	28.1	32.4	38.6	41.9	44.3	50.0
20	26.6	34.0	39.2	47.1	51.0	53.9	59.4
50	32.2	41.4	48.0	58.3	63.1	66.9	71.6
100	36.4	47.1	54.9	66.5	72.0	76.2	80.6

Rainfall depths for t_d 10 to 300 min (N=2 to 100 years)



MODEL KINFIL – PRINCIPLES

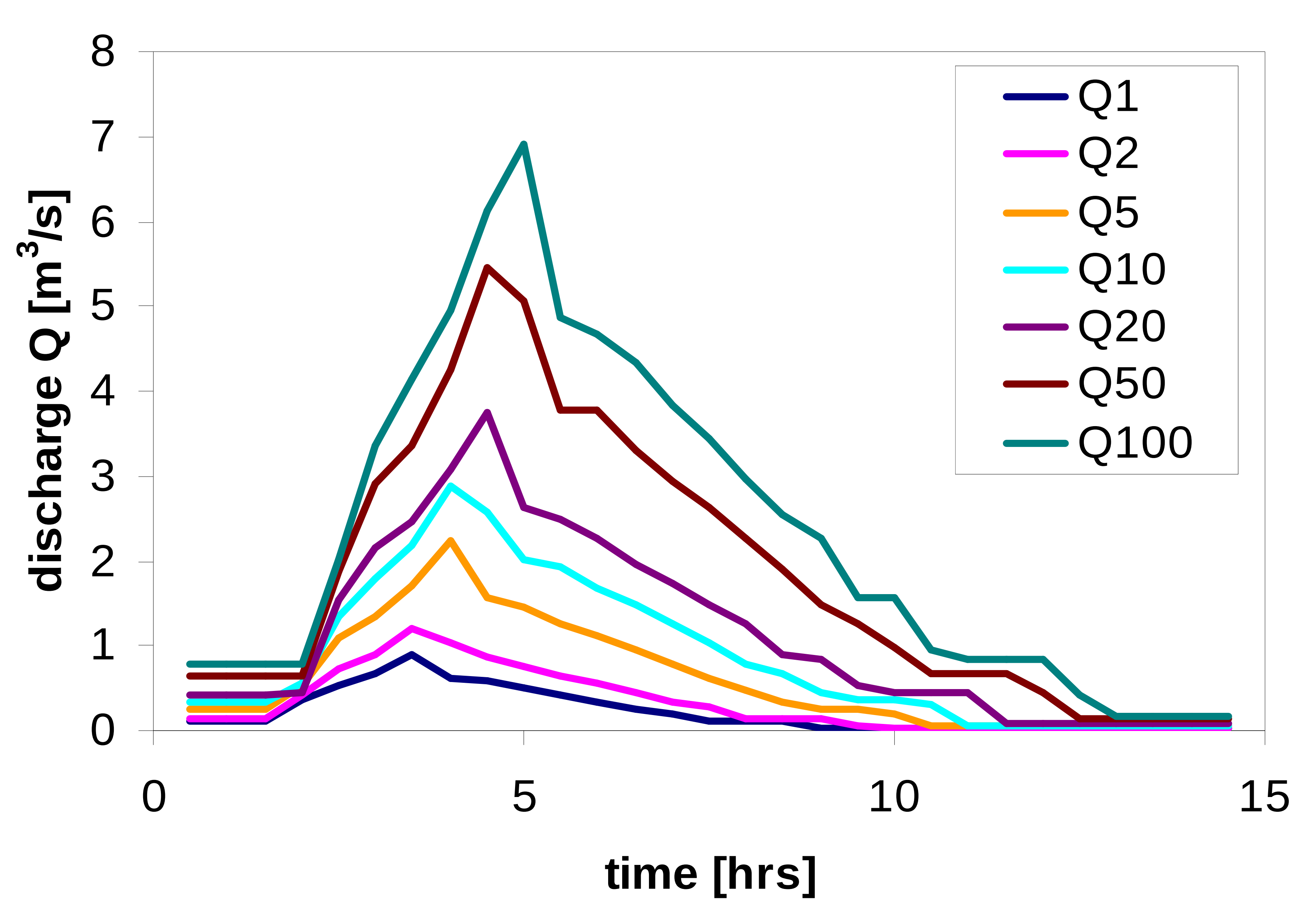
INFIL Part

- Infiltration computation:
  - Green Ampt (and Morel-Seytoux)
- Storage suction factor
- Ponding time

KINFIL Part

- Computation of flow on slopes using kinematic wave computation:
  - (Lax-Wendroff numerical scheme)

DESIGN HYDROGRAPHS - Jindrichovicky Brook



HYDRAULIC MODELS USED

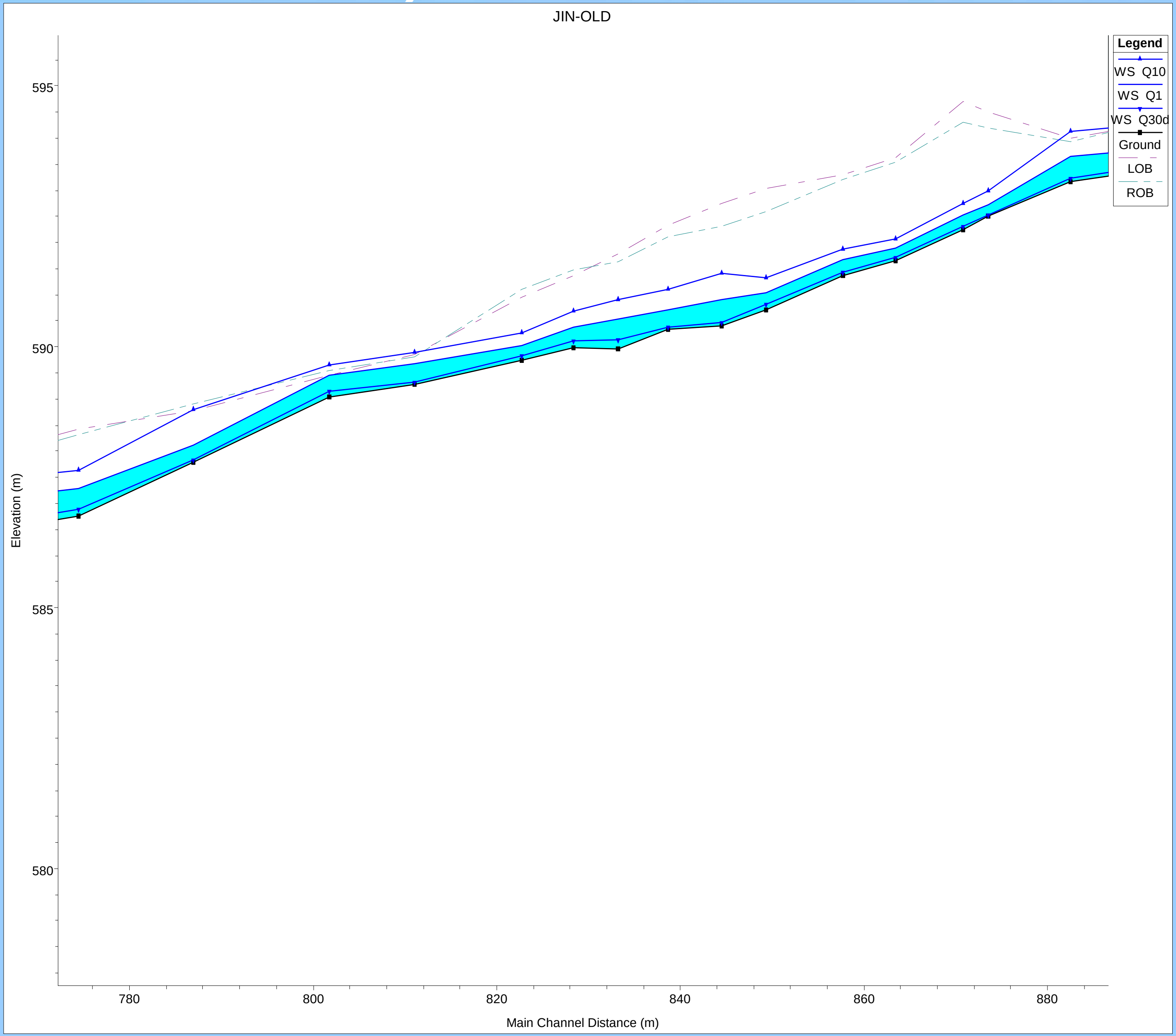
HEC-RAS 1D

- Steady flow,
- non-uniform,
- too many cross-section profiles needed,
- Supercritical flow (unstable solution).

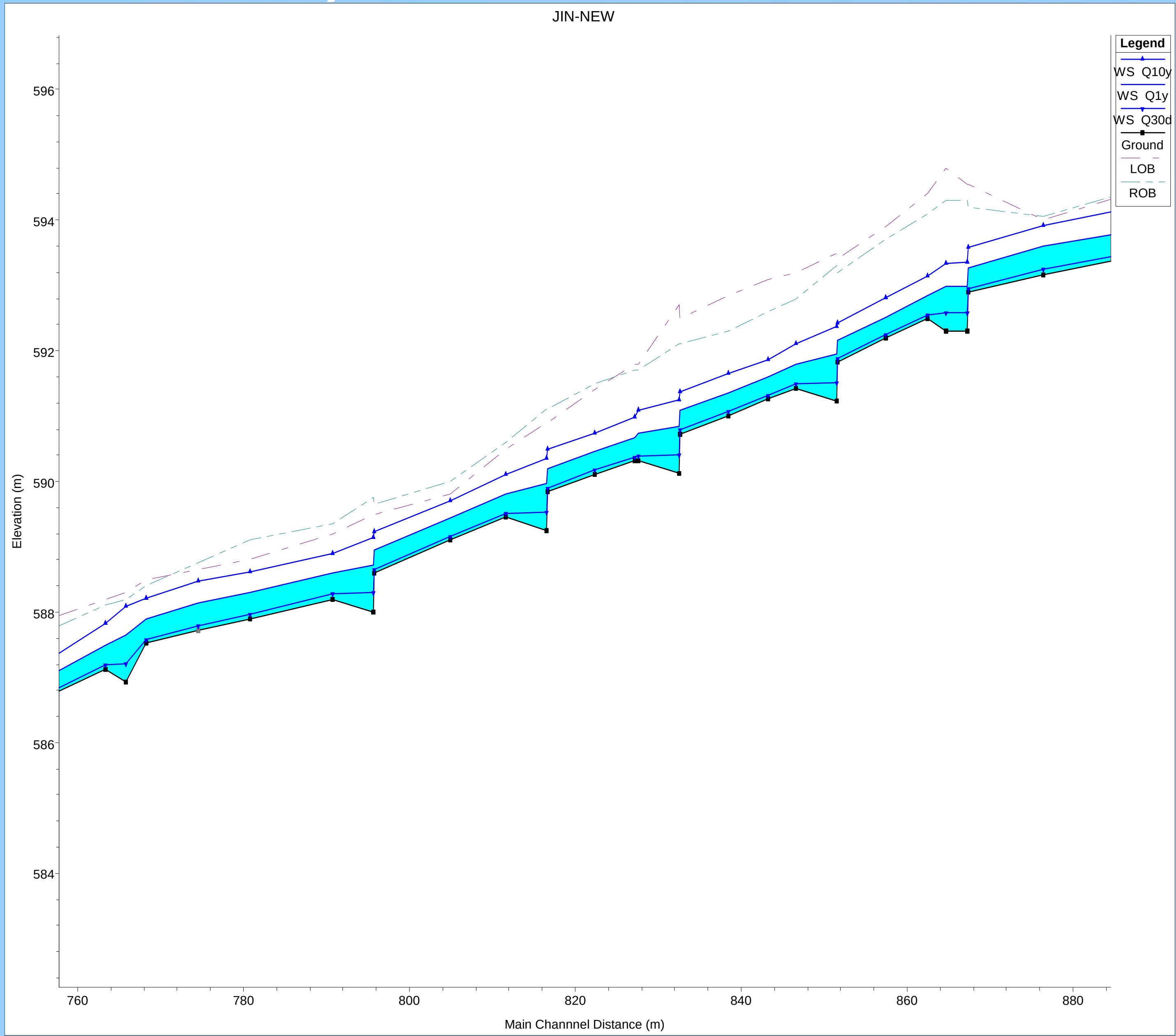
SRH 2D

- Unsteady flow
- less number of profiles:
  - Depth,
  - Velocity,
  - Froude number,
  - Shear stress
- Better possibility to describe morphologic profile situation when needed.

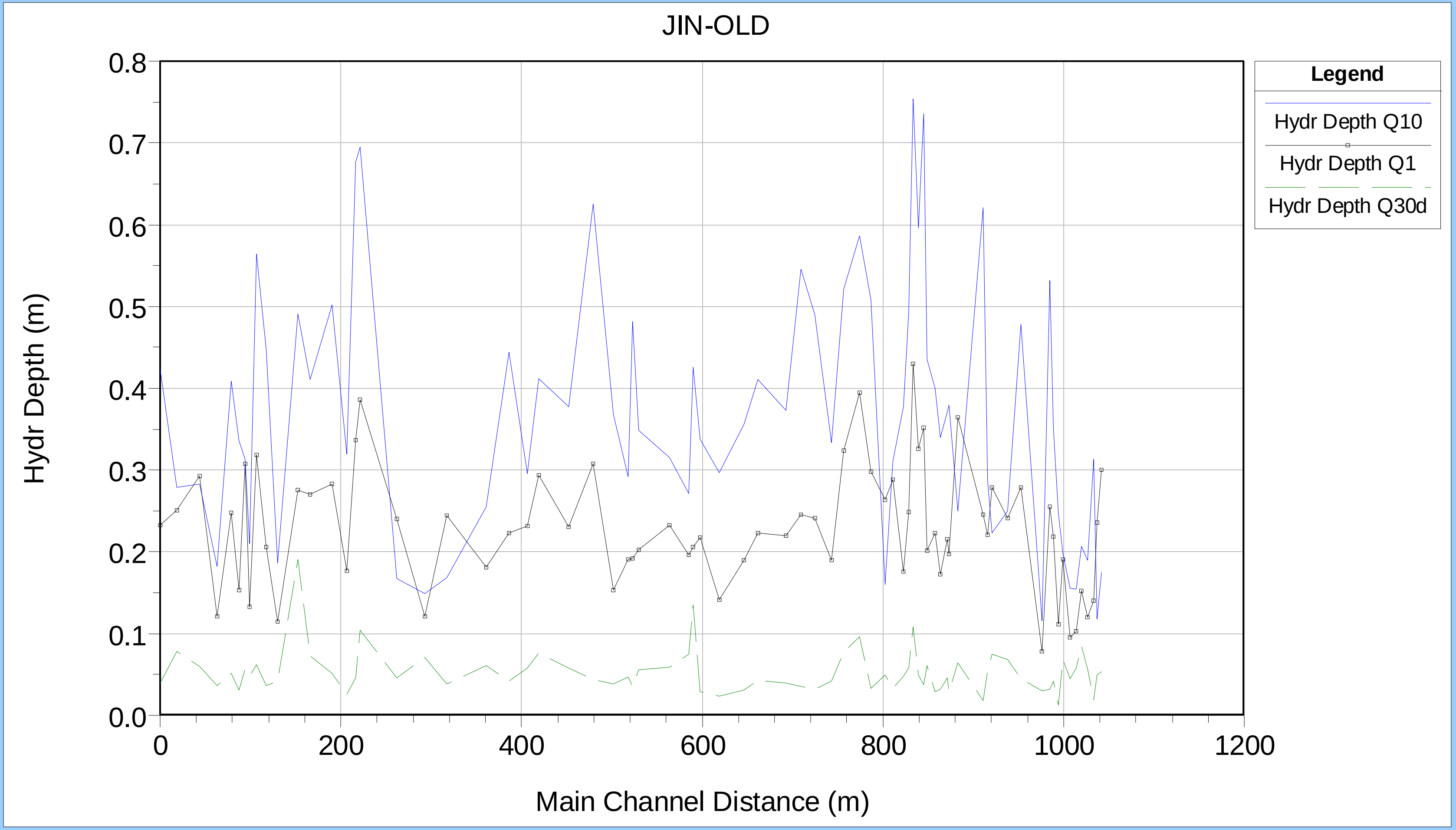
LONGITUDINAL PROFILE, former channel (1970's) (on the selected reach)



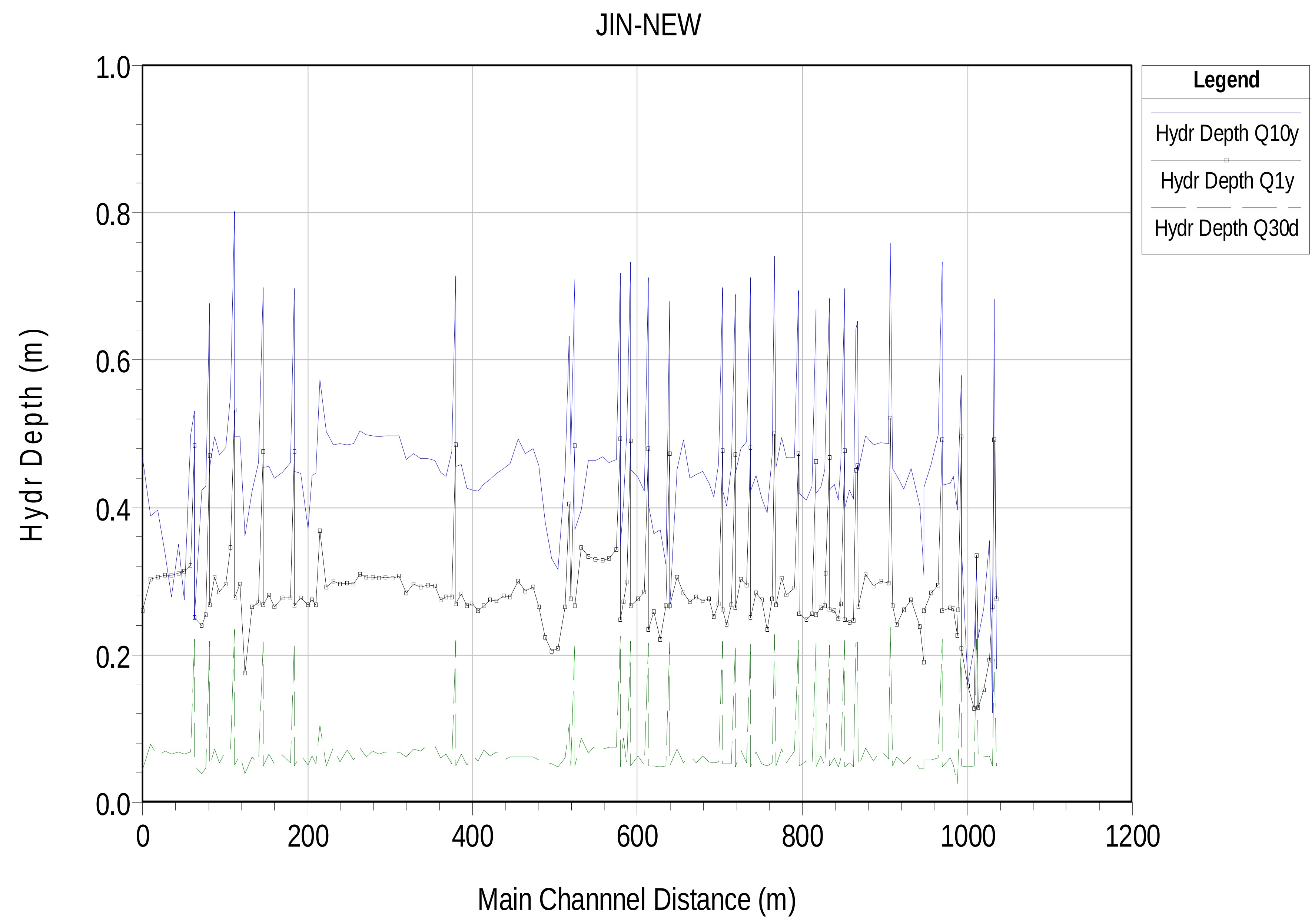
LONGITUDINAL PROFILE, new channel (2008) (on the same reach)



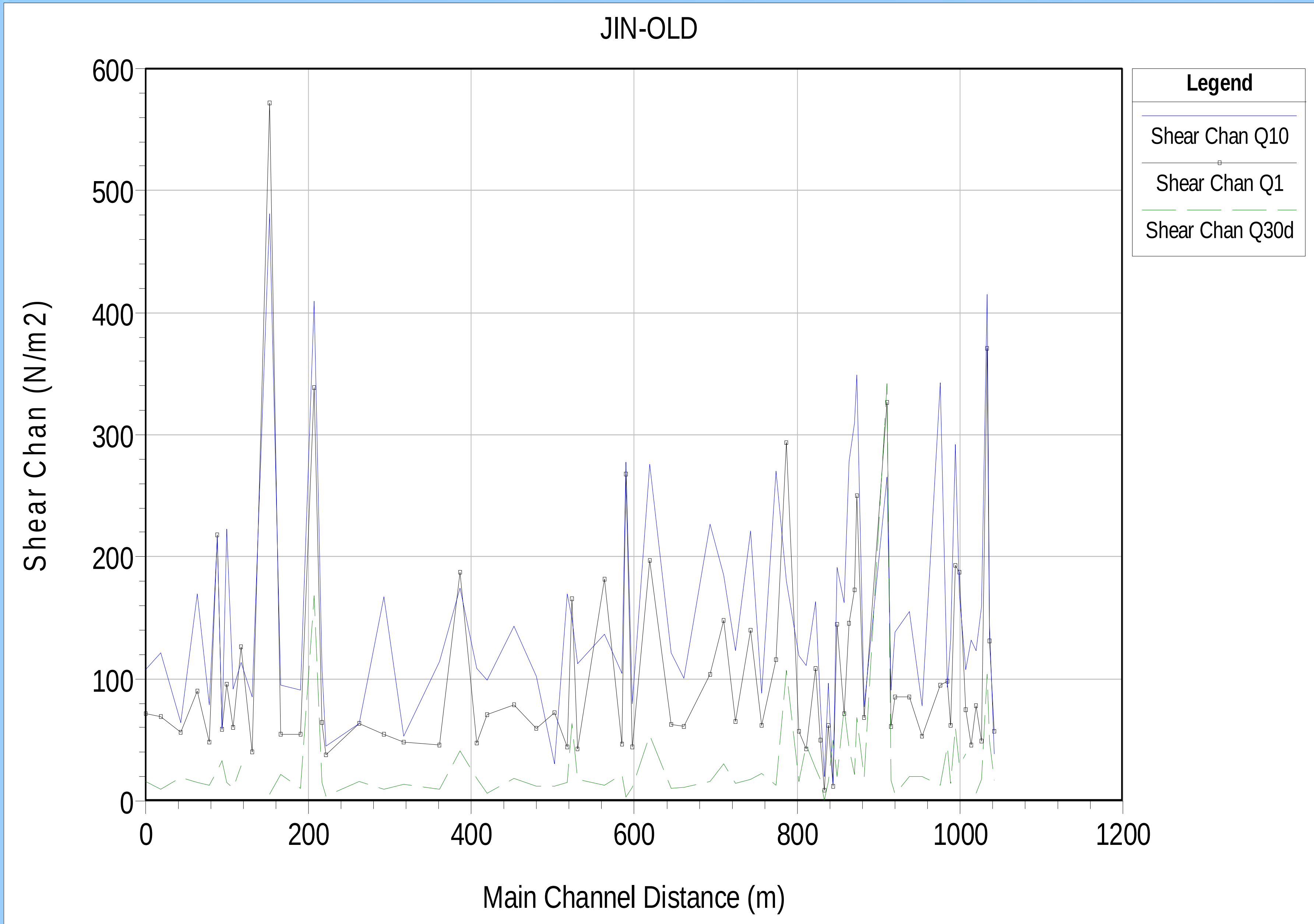
HYDRAULIC DEPTHS for Q_{30d}, Q_{1y}, Q_{10y} former channel



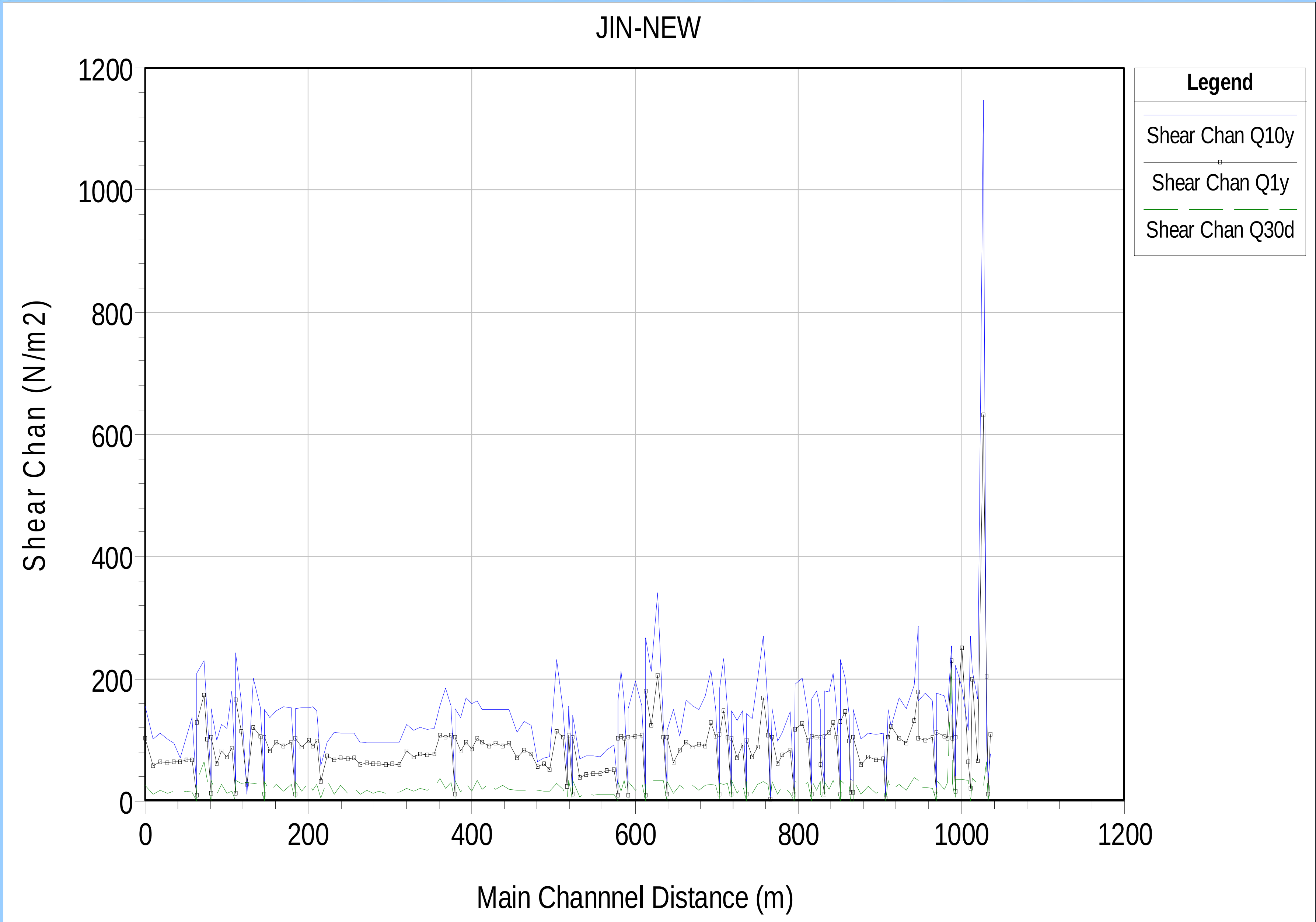
HYDRAULIC DEPTHS for Q_{30d}, Q_{1y}, Q_{10y} new channel



SHEAR STRESS for Q_{30d}, Q_{1y}, Q_{10y} former channel

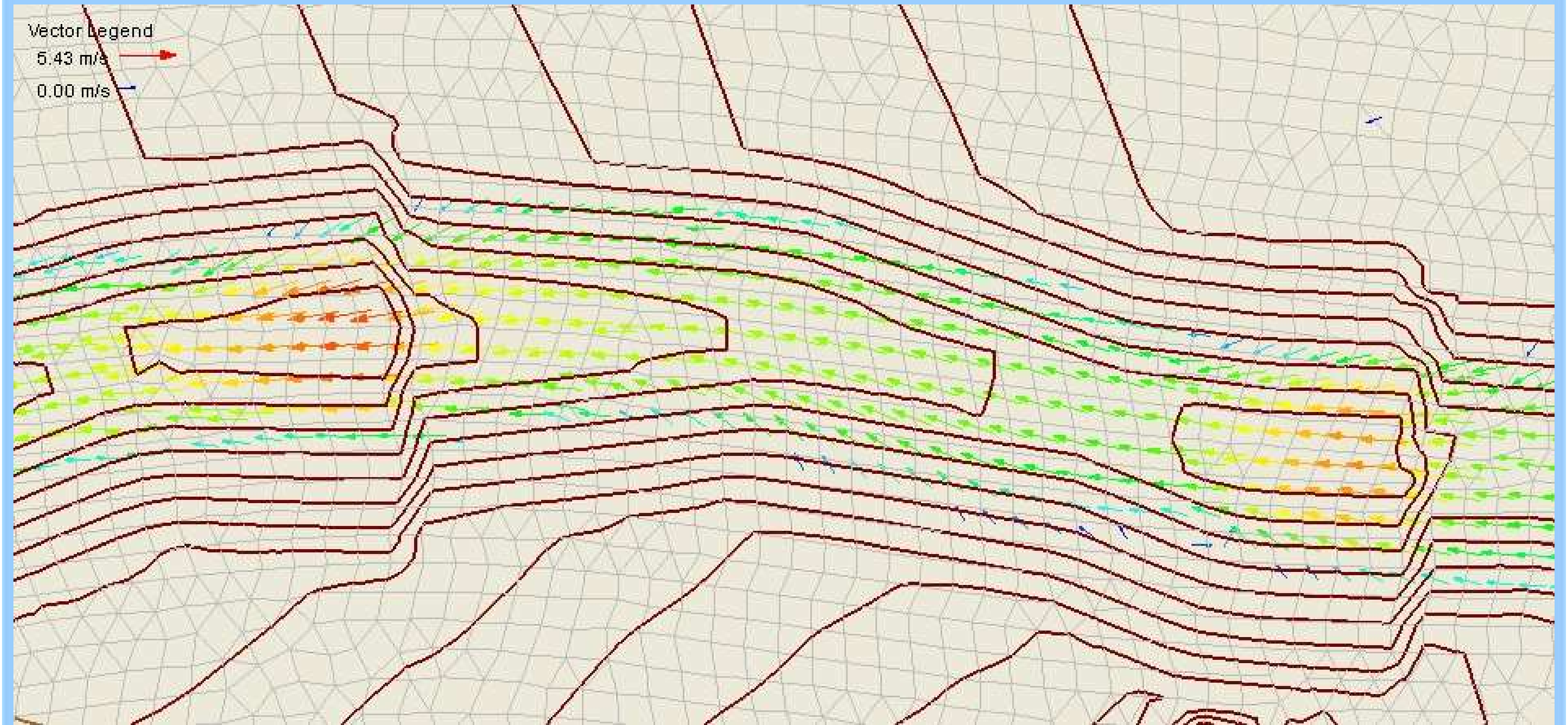


SHEAR STRESS for Q_{30d}, Q_{1y}, Q_{10y} new channel

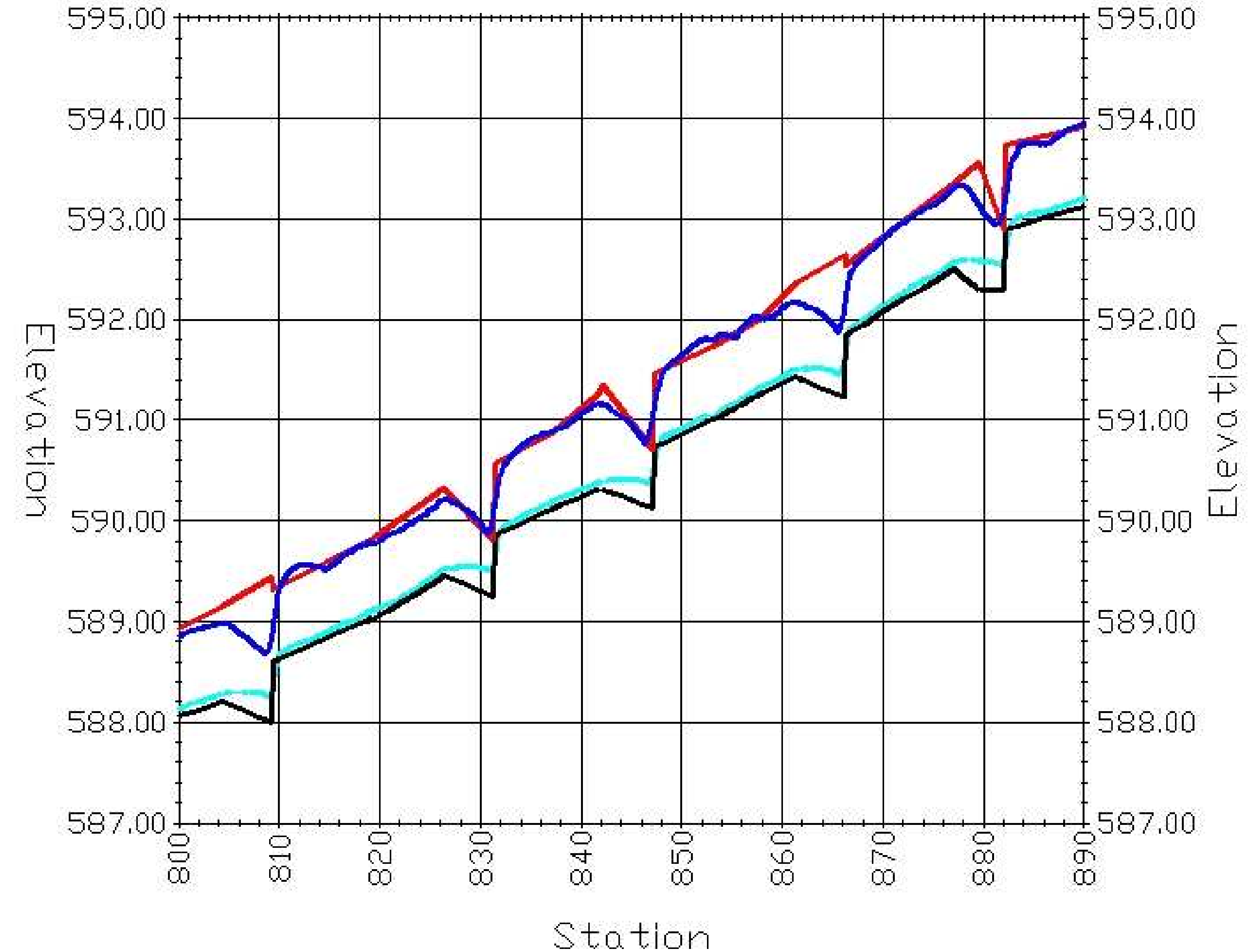


VELOCITY VECTORS – Q_{50} (SRH 2D)

(heterogeneity of velocities)



LONGITUDINAL PROFILE – Q_{30d}, Q_{50} (SRH 2D, HEC-RAS)



COMPARISON OF SELECTED PARAMETERS FOR OLD and NEW CHANNELS for various discharges

Selected Data	Hydr.Depth (m)	Velocity (m/s)	Shear Stress (Pa)	Volume (1000 m^3)
Q_{30day}	[1]0,05 / [2]0,15	0,8 / 0,4	40 / 10	0,04 / 0,1
Q_{1year}	0,25 / 0,35	2,5 / 1,5	140 / 40	0,5 / 0,7
$Q_{10years}$	0,4 / 0,55	3,8 / 2,0	200 / 80	1,25 / 1,7

[1] OLD

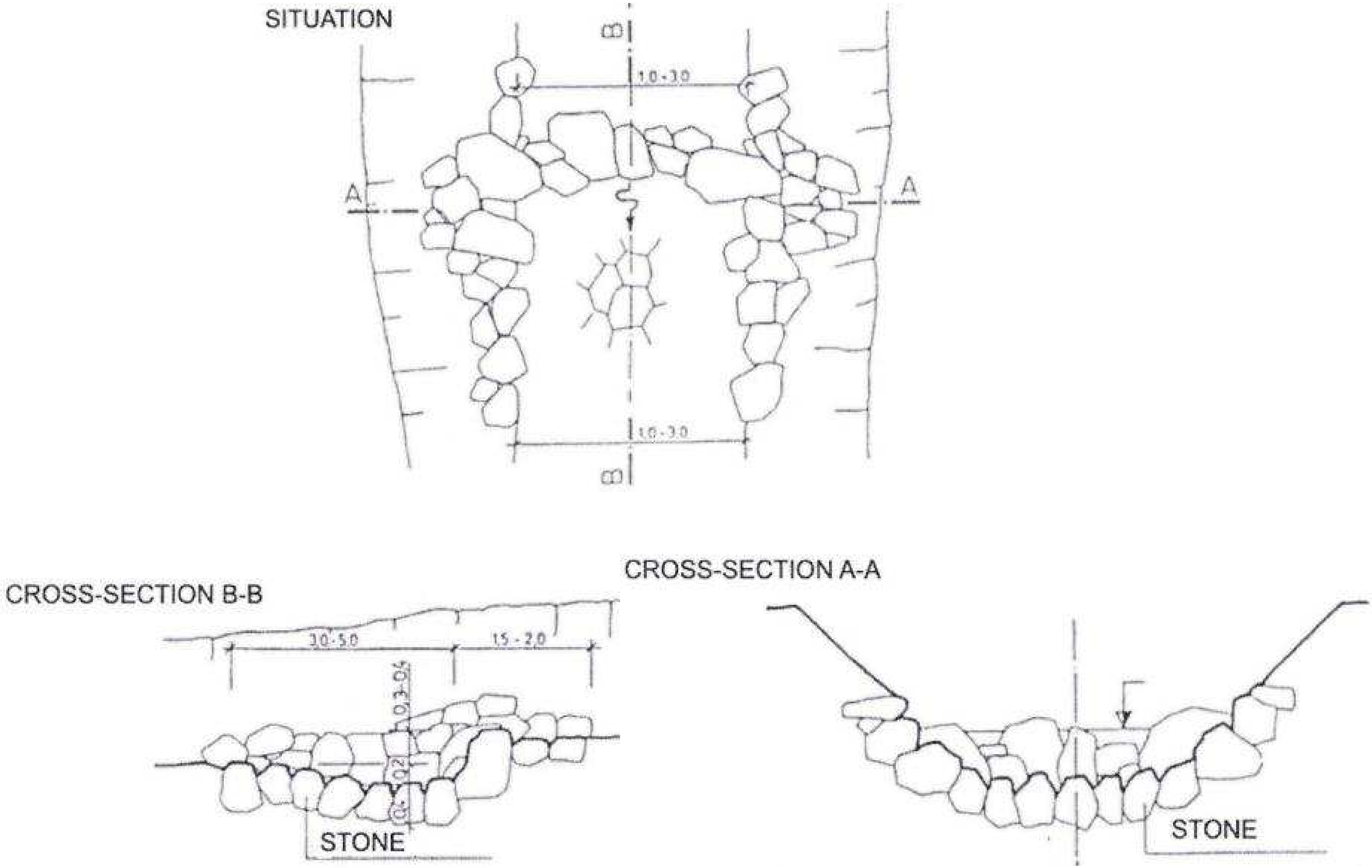
[2] NEW

WATER QUALITY IN THE JINDRICHOVICKY STREAM

Profile	NO_2^- (mg/L)	F^- (mg/L)	Cl^- (mg/L)	Br^- (mg/L)	NO_3^- (mg/L)	PO_4^{3-} (mg/L)	SO_4^{2-} (mg/L)	pH (-)
1	4.58	0.53	36.9	< 0.005	13.6	< 0.01	28.7	6.66
2	4.34	0.57	50.9	< 0.005	5.56	< 0.01	27.9	6.68

Profile	NH_4^+ (mg/L)	Mg^{2+} (mg/L)	K^+ (mg/L)	Ca^{2+} (mg/L)	Mn (mg/L)	Fe (mg/L)	Na^+ (mg/L)	O_2 (mg/L)
1	1.41	10.9	3.21	30.0	0.082	0.215	21.1	1.46
2	1.08	8.68	2.63	23.6	0.064	0.36	29.9	1.07

STONE STEP + POOL



BOULDER STEP or CHUTE with POOL, 2008

POOL, 2011

NEW RIPARIAN VEGETATION, 2011

CONCLUSIONS

– Land use change (conversion of arable land to permanent grassland) mitigated peak discharges on the catchment as it was confirmed by the KINFIL model analyses.

– Implementation of the hydraulic models has provided a good tool for the restoration criteria assessment: depth, velocity, shear stress values (SRH 2D better than HEC-RAS models).

– New nature close hydraulic structures: the step-pool system provided good conditions for water self-purification and for a biota migration.

– Improvement in riparian vegetation fits better to natural sites.

– Positive impact on biodiversity.

– Future assessments and evaluations are planned.

THE END

Thank you for your attention