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INUNDABILITY STUDY –PERIAM PORT AREA – MUREŞ RIVER

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Abstract – In this paper are presented the results obtained from a research contract, which had as its purpose the inundability study of Mureş river flood plain. This study was to highlight any measures imposed by what can be done to put the safety of structures already performed at this location, as long as possible.

Key words: numerical modeling, inundability study

1. INTRODUCTION

The study refers to a reach of Mureş River, associated with Periam city- Periam Port, a river reach of 1000 m.

The major objectives followed in this study case are:

- determination of flood extend in the buildings area,
- establishment of new embankment solutions in order to protect existing buildings,
- determination of potential flood extent in the protected area, in case of a new embankment solution on the left side of the floodplain.

The flooded area arise as a result from the comparison between the water levels of Mureş River from the floodplains and from the river banks. The class of importance of the hydrotechnical structure was set as IV (according to STAS 4273/83), so the computational discharges were determined.

In the first stage of the study was aimed to evaluate the design parameters necessary for maximum flow, in the context of recent years in the Timiş county there have been many great floods, which led to the determination of other values of the parameters imposed by current legislation, values differing from those provided in previous projects.

2. HYDROLOGICAL DATA

In order to determine the water level variation, the velocity of flow regime and the transit way of the flow on the Mureş River, nearby Periam city – Periam Port, the following elements were necessary: maximum discharges with different probabilities of occurrence $Q_{2\%}$ = 2054 m^3/s, $Q_{5\%}$ = 1404 m^3/s and $Q_{1\%}$, = 2600 m^3/s, the flood hydrograph, the roughness coefficients from the riverbed and floodplains, and the hydrodynamic river slope. The hydrological data were also necessary for the flood study, and they were provided by Romanian Waters National Administration, Water Basin Administration Mureş. From the flood histogram from July 1975, recorded at Nădlac gauging station (table 1), the maximum value was of 2190 m^3/s.

Table 1

Luna	Ziua	Ora	Debit (m^3/s)	Luna	Ziua	Ora	Debit (m^3/s)
VII	2	7	379	VII	12	5	1550
	3	11	674			13	1470
	4	15	794		13	13	1250
	5	15	850		14	7	879
	6	15	891			17	716
	7	15	946		15	17	550
	8	5	996		16	15	504
		21	1070		17	13	475
		23	1260		18	17	420
	9	2	1610		19	17	377
		4	1840		20	17	350
		8	2080		21	17	337
		13	2140		22	17	321
		15	2180		23	17	293
		16	2180		24	17	274
		17	2190		25	17	257
		18	2190		26	17	251
		19	2190		27	17	247
		23	2160		28	17	238
	10	11	2010		29	17	225
		20	1900		30	17	216
	11	10	1760		31	17	203
	11	18	1680				

Is observed from Table 1 that the highest discharge value recorded (2190 m^3/s) exceeds with almost 136 m^3/s the discharge $Q_{2\%}$.

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In the study area, Periam Port (fig.1 –red circle), topographic surveys were carried out, resulting 8 cross sections through the riverbed and floodplains, with reference points (reference) which include also the dikes. This cross sections are giving the geometry or the riverbed and floodplains, also are describing the morphological issues (like roughness coefficients) for the analyzed river reach.

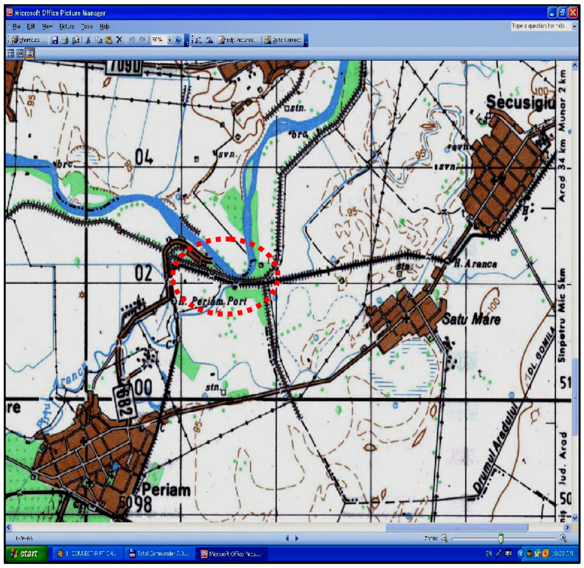

Figure 1 Plan View (scale 1:100.000) - Mureş River

In this profiles are represented the start (left side bank) and end (right side bank) landmarks points, and also the landmarks points between the existing dikes.

3. NUMERICAL MODELLING

For the building of a numerical model, it was chosen a reach of Mureş River, nearby Periam city, with a length around 1km, with a known shape from a plan view on a scale 1:2000. This river reach was divided in 9 parts, limited by 10 cross-sections. The cross –sections were made along the riverbed, riverbanks and floodplains.

The cross-sections from the edges of the entire river reach (PT0 and PT9) were obtained by multiplying the PT1 and PT8 profiles, and by adjusting (increasing or decreasing with around 0.20m) the intermediate level points.

For the numerical modeling of water flow in steady or unsteady flow regime, HEC-RAS 4.1 software was used.

In this modeling program for the identifying profiles it has been used a type count milestone /2/,/3/, marked by a real number.

This method is useful to generate by interpolation new cross sections between two cross sections known from the topography.

Were obtain in the numerical model the following consecutive cross sections: "42.272"the starting cross section- upstream, "42.199", "42.068", "41.740", "41.599", "41.456", "41.391", "41.311" and "41.216"- final cross section - downstream.

The whole part represents one associated km, and the decimal part represents multiples, in meters, is the corresponding distance between two consecutive sections (minimum possible value → 000 m, maximum possible value → 999 m, values within one km).

As a conclusion, the difference between two consecutive cross sections represents the measured distance at the middle of the river bed. The correspondent of Profile and "km" notation is: PT0→ "42.272"start section – upstream from the entrance , PT1→ "42.199", PT2→ "42.068", PT3→ "41.740", PT4→ "41.599", PT5→ "41.456", PT6→ "41.391", PT7→ "41.311", PT8→ "41.216" PT9→ "41.216" final section - downstream.

In Fig.2 is illustrated the study area represented in a graphical scheme (HEC - RAS vers. 4.1), the cross sections location, and in Fig. 3 is illustrated a current cross section of the riverbed and banks with landmarks, with known terrain level.

In the upper part, in the cross section, it can be observed the modality of choosing the roughness coefficients used in the numerical simulation. The coefficients distribution is variable in the cross section, as it follows:

- in floodplain on the left bank side: n = 0.100;
- in riverbed on the left side: n= 0.018, and on the right side: n = 0;
- in floodplain on the right bank side: n = 0.068.

On the study area were made 6 simulation cases, as it follows:

✓ **Case I.** Flow simulation in the case of permanent flow, existent dikes, without any structures in the floodplains on the left side of the Mureş River- model settings.

✓ **Case II.** Flow simulation in the case of permanent flow, existent dikes, without any structures in the floodplains on the left side of the Mureş River- for the discharge with the probability of overflow of 5%;

✓ **Case III.** Flow simulation in the case of permanent flow, existent dikes, without any structures in the floodplains on the left side of the Mureş River- for the discharge with the probability of overflow of 1%;

✓ **Case IV.** Flow simulation in the case of permanent flow, existent dikes, without any structures in the floodplains on the left side of the Mureş River- for the maximum recorded discharge in 1975, Q=2190 m^3/s;

✓ **Case V.** Flow simulation in the case of permanent flow, existent dikes, with structures in the floodplains on the left side of the Mureş River protected by the existing dike- for the discharge with the probability of overflow of 1%;

✓ **Case VI.** Flow simulation in case of existing dikes system, unsteady flow, flood wave generated, with structures in the floodplains on the left side of the Mureş River protected by the existing dike- for the discharge with the probability of overflow of 1%;

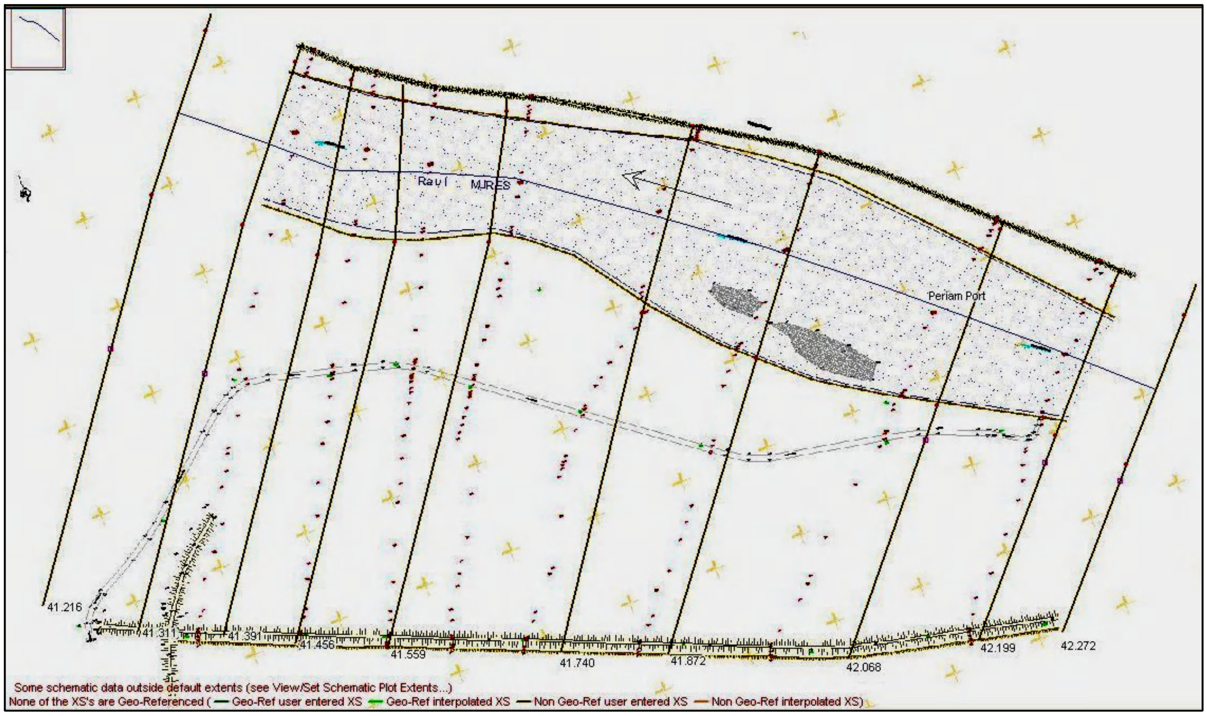

Figure 2 Schematic Location Plan, Profiles - from "*km 42.272*"–*PF0 Profile* to "*km 41.216*"– *PF9 Profile*

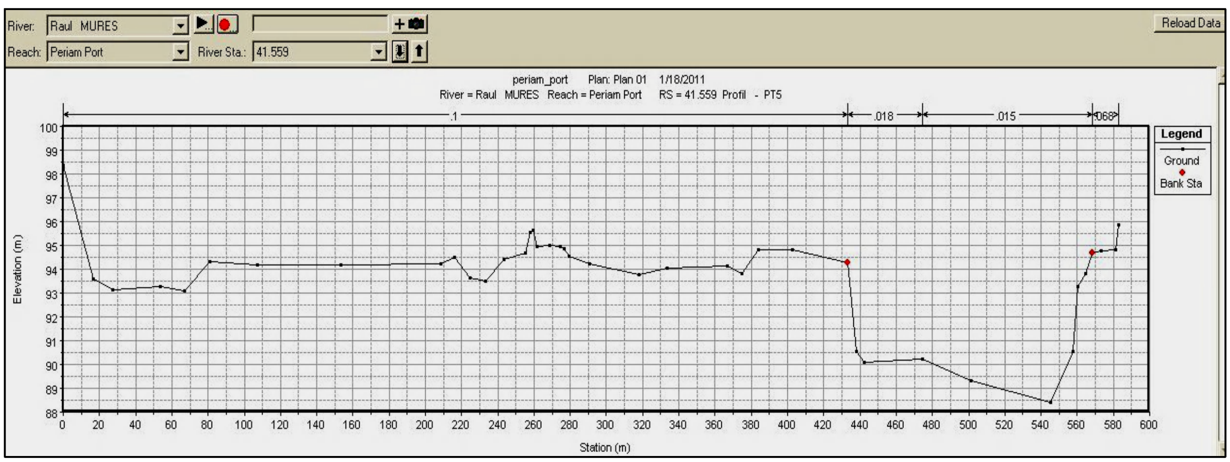

Figure 3 Cross Section "*km 41.599*" – *PT5 Profile* – With intermediate level

Initial and Boundary Conditions

Usually the boundary conditions are given by : a known transitory discharge or a flood hydrograph, values which were introduced upstream in section from "km 42.272", and the hydrodynamic slope, introduced in the downstream section from "km 41.216". As for the initial condition, the initial discharge is known and introduced in the section from "km 42.272".

The initial and boundary conditions for all the six cases are:

✓ **Case I.**

- Initial flow, introduced in the cross section from "km 42.272" at 22.10.2009, is Q = 177 m^3/s;
- Hydrodynamic slope J= 0.000215;
- Hydrostatic level topographically determined in section from "km 41.740" - Profile PT4 (at 532m from PT0 Profile, almost at the middle of the river reach) is 90.56 maBSL;

✓ **Case II.**

- Initial flow, introduced in the cross section from "km 42.272" is Q 5% = 1404 m^3/s;
- Hydrodynamic slope is J= 0.000215, and the hydrostatic level obtained from the numerical simulation is 93.40 maBSL;

✓ **Case III.**

- Initial flow, introduced in the cross section from "km 42.272" is Q 1% = 2600 m^3/s;
- Hydrodynamic slope is J= 0.000215, and the hydrostatic level obtained from the numerical simulation is 94.45 maBSL;

✓ **Case IV.**

• Initial flow, introduced in the cross section from "km 42.272" is Q2% = 2190 m^3/s;

• Hydrodynamic slope is J= 0.000215, and the hydrostatic level obtained from the numerical simulation is 94.34 maBSL;

✓ **Case V**.

• Initial flow, introduced in the cross section from "km 42.272" is Q 1% = 2600 m^3/s;

• Hydrodynamic slope is J= 0.000215, and the hydrostatic level obtained from the numerical simulation is 94.90 maBSL;

✓ **Case VI.**

• Flood wave generated in the upstream cross section at "km 42.272", with a maximum discharge of Q 1% = 2601 m^3/s;

• Hydrodynamic slope is J= 0.000215.

The numerical simulation for the Case VI was set for a period of time, starting from 2nd of July 1975, hour 07.00 till 31st of July 1975 hour 18.00.

The time step simulation was and for the output data the time step was 1 hour.

Numerical Simulation and Results Presentation

After the numerical simulations were obtained all the parameters related with the levels, discharges and velocities, in all the 6 case of flow. The meaning of the used parameters from this document is:

− ***PF1 and PF2*** – two profiles of the same cross section, with the difference that in the second one are included dikes, beside the geometry and water levels.

− ***WS Elev***. – Level of the piezometric line (maBSL) measured at the surface of the water;

− ***Prof. Delta WS*** - The water level difference between the two profiles (m);

− ***E.G. Elev.*** – Energetic line elevation (in maBSL, meaning WS Elev + α v2/2g);

− ***Top Wdth*** - Total width at the water surface (in m);

− ***Q Left*** - Left inflow (in m3/s);

− ***Q Channel*** - River discharge (in m3/s);

− ***Q Right*** - Right inflow (in m3/s);

− ***Enc Sta L*** – set dike position in the floodplain, on the left side, against the starting point of the profile;

− ***Ch Sta(tion) L*** – position on the rivers' left side bank (in m), against the profiles' starting point;

− ***Ch Sta(tion) R*** - position on the rivers' right side bank (in m), against the profiles' starting point

− ***Enc Sta R*** - set dike position in the floodplain, on the right side, against the starting point of the profile;.

The results are presented, after the simulation, in graphs (fig. 4 – fig. 14) or in tables(table 2), depending on the scenarios.

• Piezometric line (water level– in maBSL) and velocity variation in the cross section (in m/s) – graphic representation in a current cross section (ex. PT4 Profile);

• Piezometric line variation (water levels – in maBSL) in longitudinal profile, for Q discharge on each case;

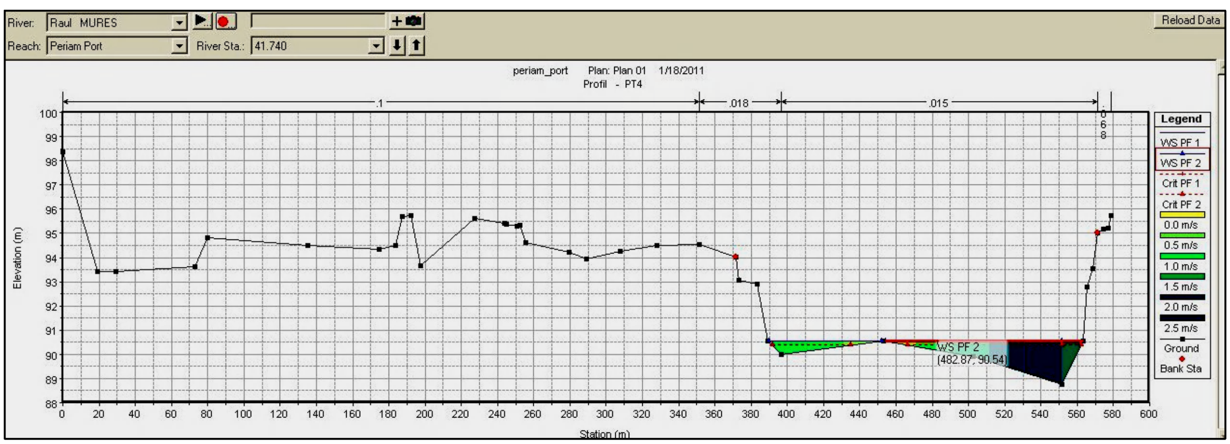

Figure 4 Piezometric Line (water level – **90.54 maBSL**) and Velocity Variation Profile - Case I, in"*km 41.740*" – *PT4 Profile*

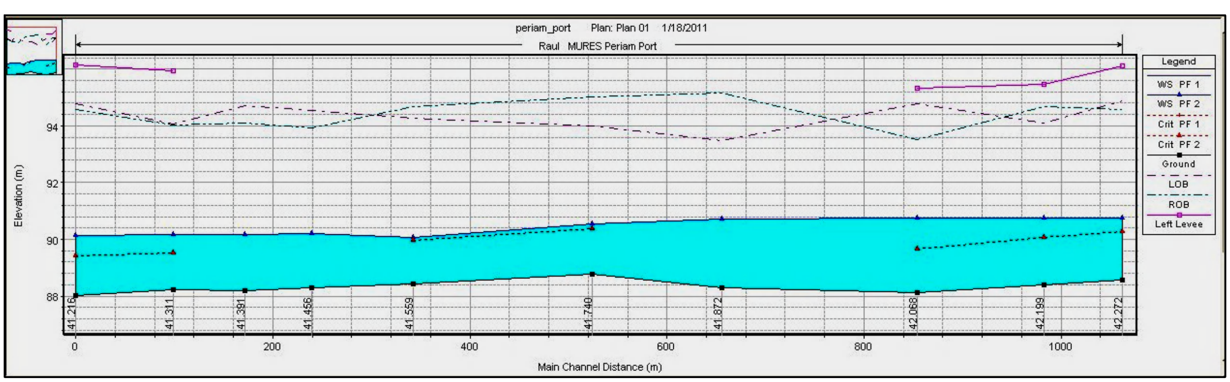

Figure 5 Piezometric Line Variation in the Longitudinal Profile (water levels in maBSL) - Case I, from "*km 42.272* " – *PT0 Profile* to "*km 41.216*" – *PT9 Profile*

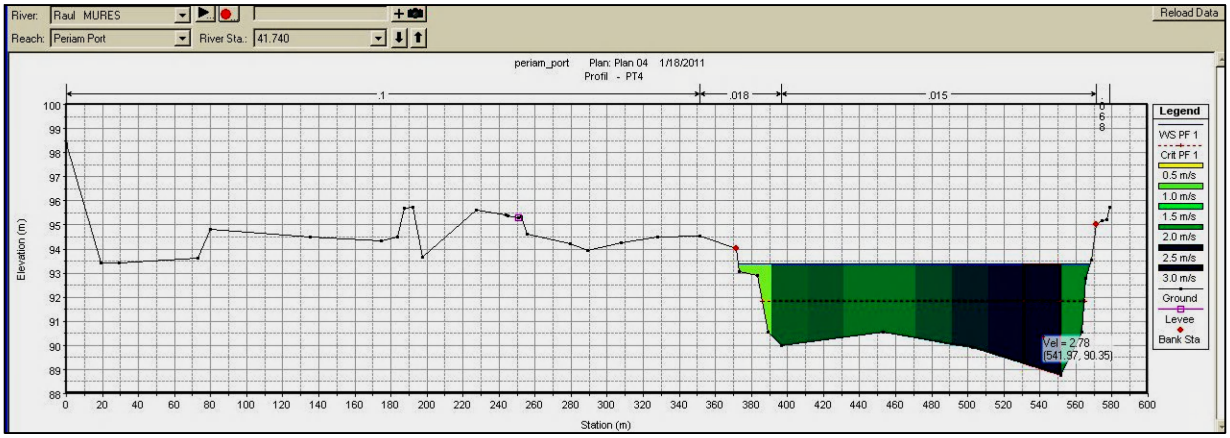

Figure 6 Piezometric line (water level- **93. 37maBSL**) and Velocity Variation Along the Cross Section - Case II, at "*km 41.740*" – *PT4 Profile*

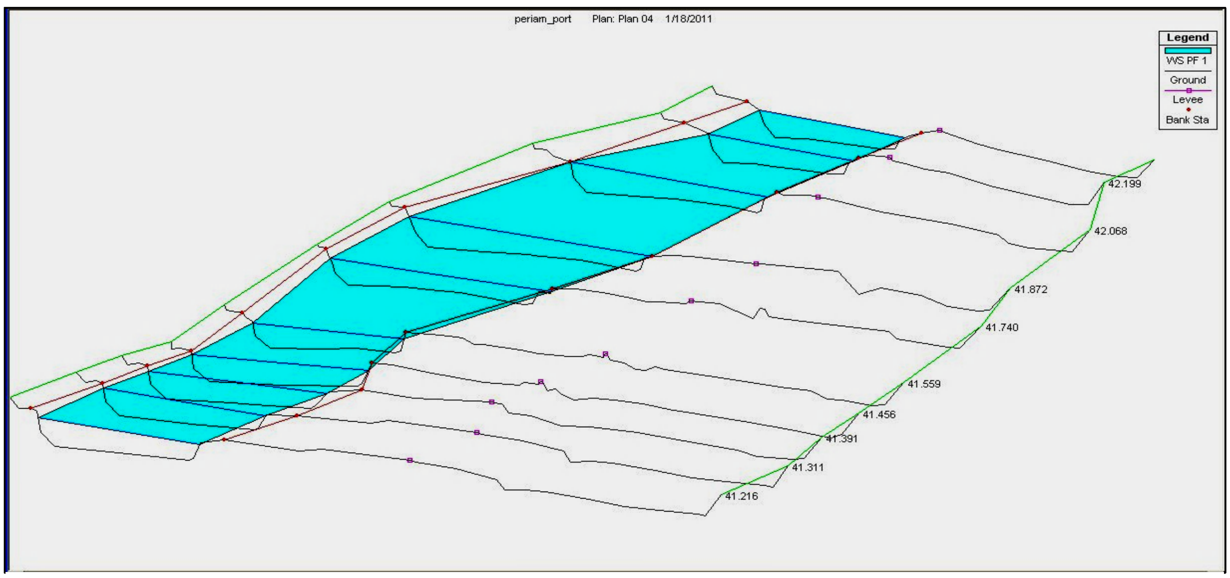

Figure 7 Spatial Variation of Surface Water - Case II, from "*km 42.272*"– *PT0 Profile* to "*km 41.216*"– *PT9 Profile*

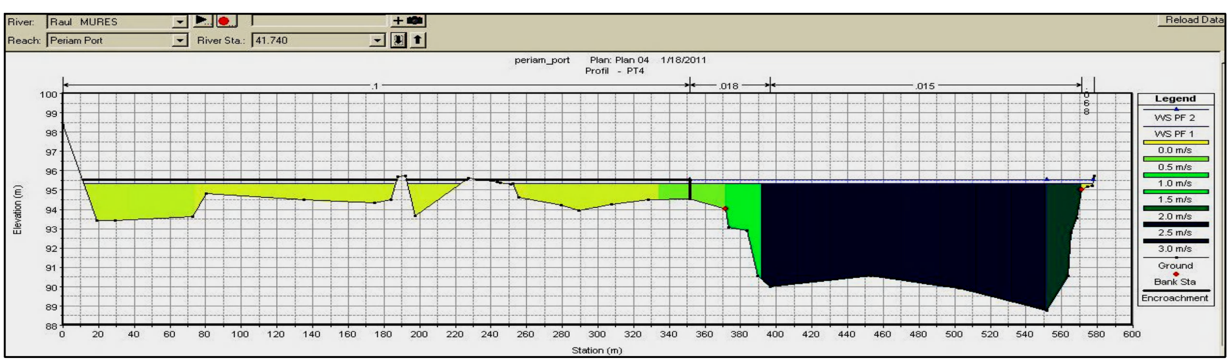

Figure 8 Piezometric line (water levels PF1 and PF2 → 95.32 maBSL, 95.55 maBSL) and Velocity Variation Profile - Case III, at "*km 41.740* " – *PT4 Profile*

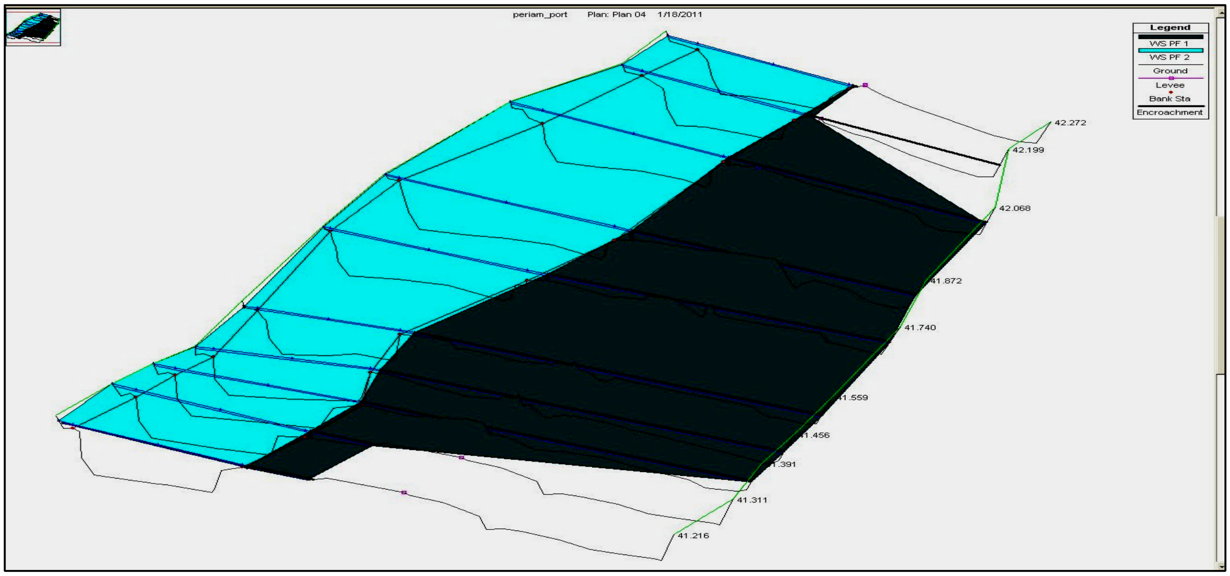

Figure 9 Spatial Representation of Water Surface and Floodplains
- Case III, from “*km 42.272* ”– *PT0 Profile* to “*km 41.216* ”– *PT9 Profile*

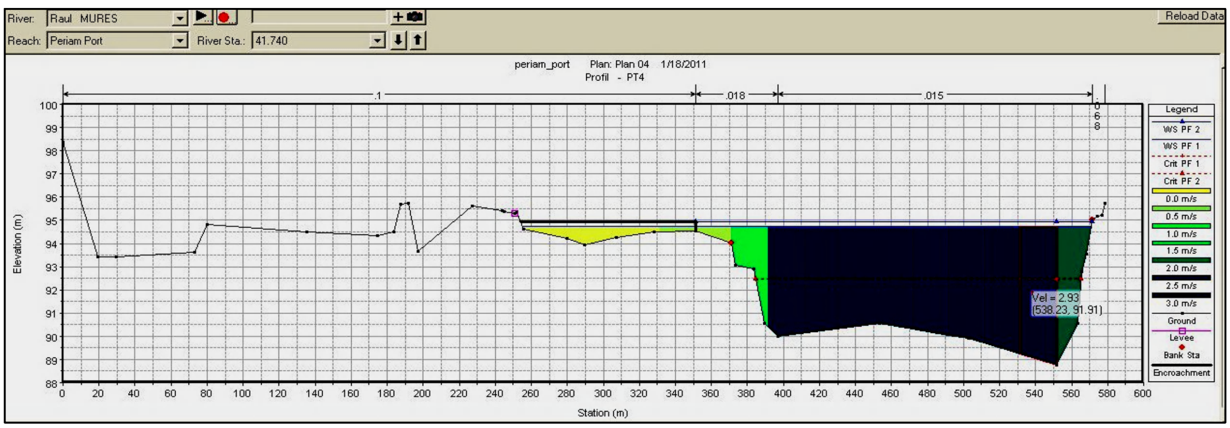

Figure 10 Piezometric Line (water levels PF1 and PF2 → 94.72 maBSL, 94.96 maBSL) and velocity variation along the cross section - Case IV in cross section “***km 41.740***” – ***Profile PT4***

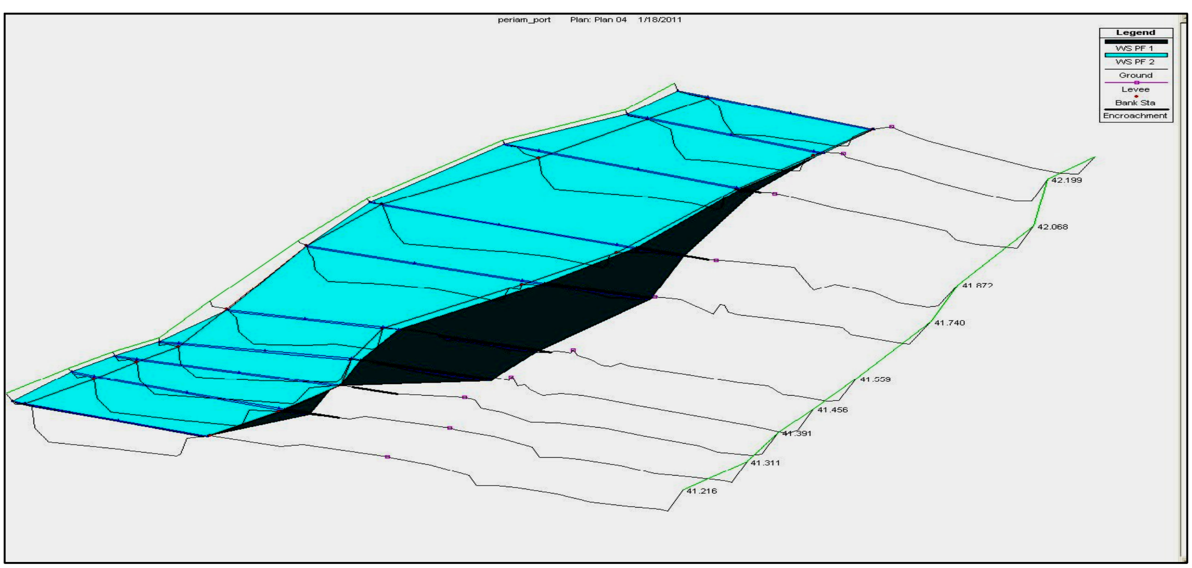

Figure 11 Spatial Water Surface and Floodplains Representation - Case IV,
from “*km 42.272*” – *PT0 Profile* to “*km 41.216*”–*PT9 Profile*

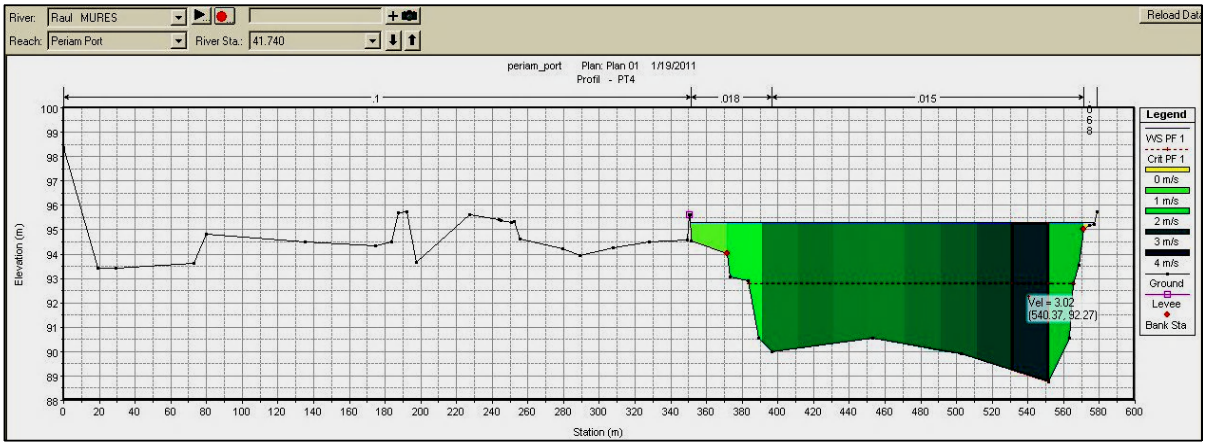

Figure 12 Piezometric Line (Water level – 95.32 maBSL) and Velocity Variation Profile - Case V, at "*km 41.740* " *– Profile PT4*

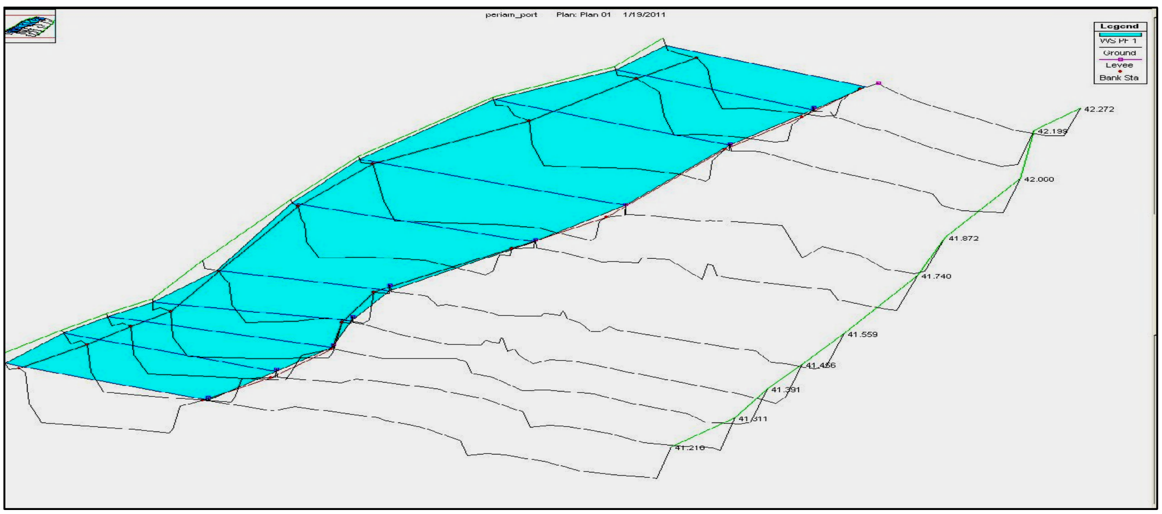

Figure 13 Spatial Water Surface - Case V, cross sections from "*km 42.272*" *– PT0Profile to* "*km 41.216*" *– PT9 Profile*

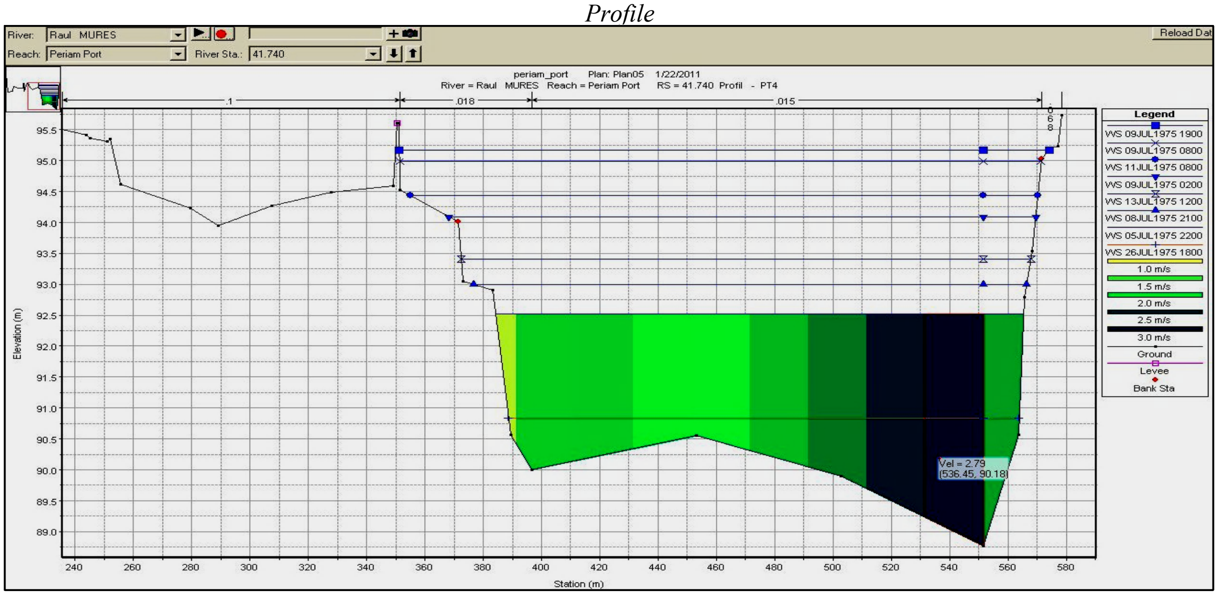

Figure 14 Piezometric Lines (Maximum Water Level – 95.17 maBSL) and Velocity Variation Profile - Case VI, at "*km 41.740* "*– PT4 Profile*

Table 2.

Profile	Assumed Ground level [maBSL]	Model water level [maBSL]	Right side level of the existent dike [maBSL]	Dike height col.1−col.2 [m]	Estimated hight [m]	Dike level [maBSL]
0	**1**	**2**	**3**	**4**	**5**	**6**
PT1	95.09	95.29	95.75	0.20	0.70	95.59
PT2	94.73	95.44	95.72	0.71	1.21	95.23
PT3	94.14	95.45	95.77	1.31	1.81	94.64
PT4	94.53	95.32	95.74	0.79	1.29	95.03
PT5	94.45	95.74	95.87	1.29	1.79	94.95
PT6	94.70	94.92	95.41	0.22	0.79	95.20
PT7	94.70	94.95	95.31	0.25	0.75	95.20
PT8	94.24	94.93	95.23	0.69	1.19	94.74

4. CONCLUSIONS

In **Case I** the model was set and the numerical simulation was made. In **Case II** according with the results, the water was moving only along the river bed, and so no flood could occur into the flood plains. In Case III, from the graphs (Q1% = 2600 m^3/s), it could be observed that the water movement occurs along the river banks and floodplains. From this case are obtained the flooding lines and surfaces from the floodplains on the right and left side of the riverbanks. In the same time are determined the final landmarks for the dikes location in all the cross sections. In **Case IV**, for the peak flow in 1975, Q = 2190 m^3/s, the values of the real measured discharge are verified, and the landmarks of the dike of fix points in all the cross sections. In **Case V**, the situation with the existing dikes, permanent flow regime, the transit way of a discharge with $Q_{1\%}$ = 2600 m^3/s is verified, in order to determine the velocities and water levels. After the simulation, the right dike is unobstructed and on the left dike was located the configuration of the local dike (which was set in Case III). In case VI, after the simulation, the right dike is unobstructed and on the left dike was located the configuration of the local dike (which was set in Case III) in all the cross sections.

Analyzing the maximum water level values nearby the local dike in scenarios Case V and Case VI, in each cross section, is determined the water height above the terrain level. If is added a safety height δ = 0.50 m, then are obtained the estimated design heights of the local dike in each cross section.

As a conclusion, it can be observed from all this simulations scenarios, that by positioning a local dike on the left side bank of the Mureş River, is created a protected area, where the water is not allowed to enter when the transitory flow reaches maximum values, such $Q_{1\%}$ = 2600 m^3/s.

5. BIBLIOGRAPHY

[1] Gheorghe I. Lazăr, Modelarea numerică asistată de calculator a curenților cu nivel liber în regim amenajat, Ed. Politehnica, Timişoara, 2007

[2] HEC-RAS River Analysis System, vers. 4.0 Beta, Developed by the U.S. Army Corps of Engineers, Hydrologic Engineering Center, USA

[3] Gary W. Brunner, HEC-RAS 4.1, River Analysis System Hydraulic Reference Manual, US Army Corps of Engineers, 2010