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PRACTICAL SOLUTIONS FOR ECOLOGICAL RECONSTRUCTION OF GERAI POND

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Abstract

Gerai Pond is one of the last natural wetlands along the Danube, being connected to natural flooding regime of the Danube and is situated at the confluence of the Danube River, between Gârcov and Islaz localities, in Olt County. Aquatic vegetation characteristic is a favorable habitat for two species of conservation concern that nest along the Danube: red duck and pygmy cormorant. During 1961-1970, Gerai Pond has changed radically due to impoundment and draining under the program of drainage and flood meadow regulate of the Danube. These works of land reclamation for decreasing surface lakes and wetlands and water stagnation period, had reduced the breeding areas of the two species mentioned above. Ecological reconstruction of Gerai Pond project was conducted by Technical University of Civil Engineering of Bucharest in collaboration with E.P.A. Olt and W.W.F.-Romania. The project was based on a hydrological study (which included a component related to flooding) for the area analyzed, study in which were highlighted the areas which have water access to and from the Pond, surfaces and volumes of water corresponding to different rates, the optimal level of water for restoration of the nesting area. Based on this study were identified the areas of artificial feed-water discharge to and from the Danube. This paper presents the possible solutions for ecological reconstruction of Gerai Pond, identified in the project.

Keywords: Gerai Pond, ecological reconstruction, flood, water discharge.

1. INTRODUCTION

Gerai Pond is located at the la confluence of River Olt and the Danube river, in Olt county, between the villages Gârcov (west) and Islaz (east) (figure 1). Gerai Pond represents one of the last natural wetlands area along the river Danube, connected to the natural flood flow of the river. Being a flooded area where water pool in most time of the year, it attracts many water birds that find there a places for nesting and feeding, for which locals say, admiring the scenery, "Ce rai" , which later became Gerai (photo 1).

Figure 1.The terrain location of Gerai Pond.

The terrain topography is mostly flat, flood plain lookalike, but showing small bumps (type of sand dunes) that don't exceed a few meters, forming a characteristic micro relief, favoring water stagnation between the bumps, favor of a large and varied ecological complex. Flooded area is covered with water during the floods and when the water is low they become dry land, covered by alluvial soil and organic debris, representing the common grazing for the two villages. The existence of water for long period of time during a year, in comparison with the surrounding terrain makes it a good area for the growth of the sour dock, sea clubrush, bulrush, iris and arrowhead ,etc... The presence of this hydrophilic species depends on the duration and intensity of spring floods, which they depend in an inversely proportion. This complex of aquatic species represents a favorable habitat for the species that nest along the Danube, like the red duck (Aythya nyroca) and pygmy cormorant (Phalacrocorax pygmaeus).

2. THE CURRENT SITUATION OF THE GERAI POND ECOSYSTEM

During the 70 Pond Gera was the subject of embankment and drainage works carried out under the program for the regulation of the drainage and flooding waterside of the Danube. Thus such works were carried out for the magisterial draining channels, secondary drainage channels, works of art (bridges, culverts, roads, mining, etc.). For the surface water drainage that remained after the floods of the river Danube and its tributary rivulet Gircov with its tributary Ursa, works were carry out in a length of 1.2 km for water regulating and downstream of the confluence of rivulet Gircov with Ursa an accumulation in area of 9 ha was build.

These works of land improvement for decreasing lakes surface and wetlands and the water stagnation period has a direct effect on the birds species, which reduced their number and the size nesting areas for the area analyzed.

Thus the need to create and ensure the protection and conservation of bird species, by recreating the initial conditions favorable for nesting and food. This meant in fact need to find and apply solutions to extend the period of stagnation of water in Gerai Pond. In principal, water flow in Gerai Pond is accomplished thru the drainage channel that is now in a high clogged state (photo 2)

Foto 1. Gerai Pond.

Foto 2. Gerai Pond – drainage channel, partially clogged.

Besides water from the Danube, in periods of high waters, the area is fed by springs located at the terrace base, thus limiting the north region of the pond. In addition, in the north-west region was a creek, that originally (late 19th, early 20th century) download in the north-west area of the Gerai Pond.

3. MODELING THE PHENOMENON OF FLOODING/DRAINING IN GERAI POND

Following the modeling of flooding and draining phenomena that occur naturally in the analysis of the site (Gerai Pond), for the development of the solutions (technical and management) for expanding the period of water stagnation in Gerai Pond and to find the water levels that provides the best conditions for nesting and feeding for the wild waterfowl, especially the red ducks and the pygmy cormorant, the HEC-RAS software was use as a tool for mathematical modeling of the flow.

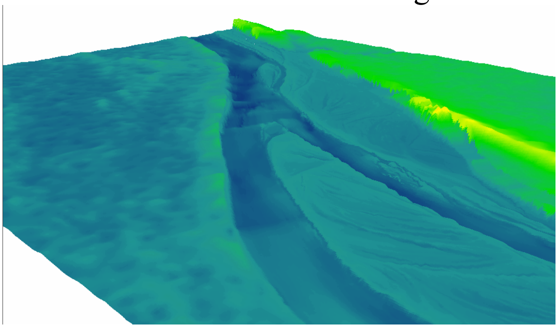


Figure 2. Digital terrain model – tridimensional view from downstream

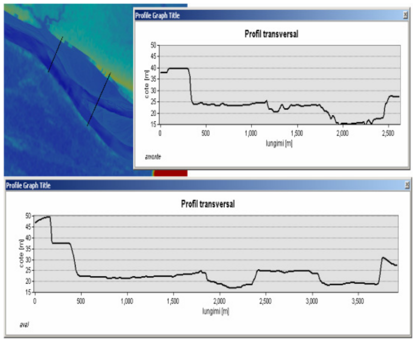


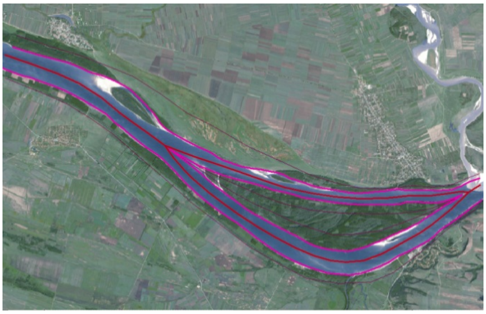
Figure 3. Cross section

A grid with with the pixel in horizontal dimension of 20 meters (Stereo 70 projection), was used in the model. The accuracy of the vertical grid is unknown, the range of the altitudes being between 12.4 and 194.6 m (figure 3).

Higher altitudes appear in the S-E corner of the grid, downstream of the interest area. The height in the area of Gerai Pond ranges between 22 and 24 meters, the location being almost horizontal. Only in the North area of the pond the heights increase somewhere around 40 to 45 m locally and in some cases reaches 50 m.

Due to the elevation resolution of the model, the draining channels of the emplacement can't be seen. They were added later to the model after the topographic survey and were interpolated with a greater resolution. Viewed tridimensional from downstream, with a vertical distortion factor of 10 results the quality model - figure 3. The existence of the dams on south shore of the Danube and the heights of the northern limit of the terrace can be distinguished.

The numerical model of the land was overlapped on the aerial photographs for so that the minor and major riverbed of the Danube can be identified (Figure 4).



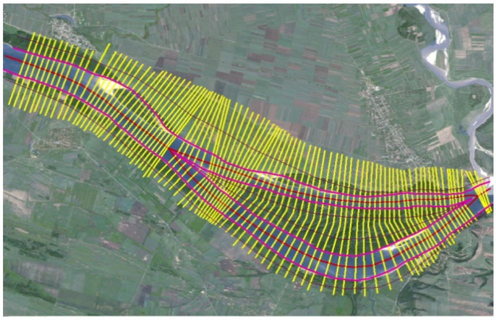


Figure 4. The major riverbed delimitation **Figure 5. Cross sections**

A number of 153 cross sections were taken, at 200 m one from each other. The roughness values assumed, ranges from 0.03 in the riverbed of the Danube up to 0.08 in the reeds (Figure 5). Finally the geometrical model was built in ArcGIS, which was exported to HEC-RAS, with extension HEC-GeoRAS. The hydrometric data available, were the hydrometric levels from 2006, from 3 stations: Bechet, Corabia and Turnu Magurele (Figure 6).

Figure 6. Hydrometrics stations: Bechet, Corabia and Turnu Măgurele

For identifying the flows hydrograph, the data from Bechet station was used, latter the flows were being imposed as boundary condition upstream for the model. Adjusting the limnimetrical key from the Bechet station, a polynomial expression of third grade was obtained resulting the hydrographs (figure 7).

The maximal flows at the Bechet station in the year 2006 had the value of 15950 m^3/s and was reached in 23.04.2006.

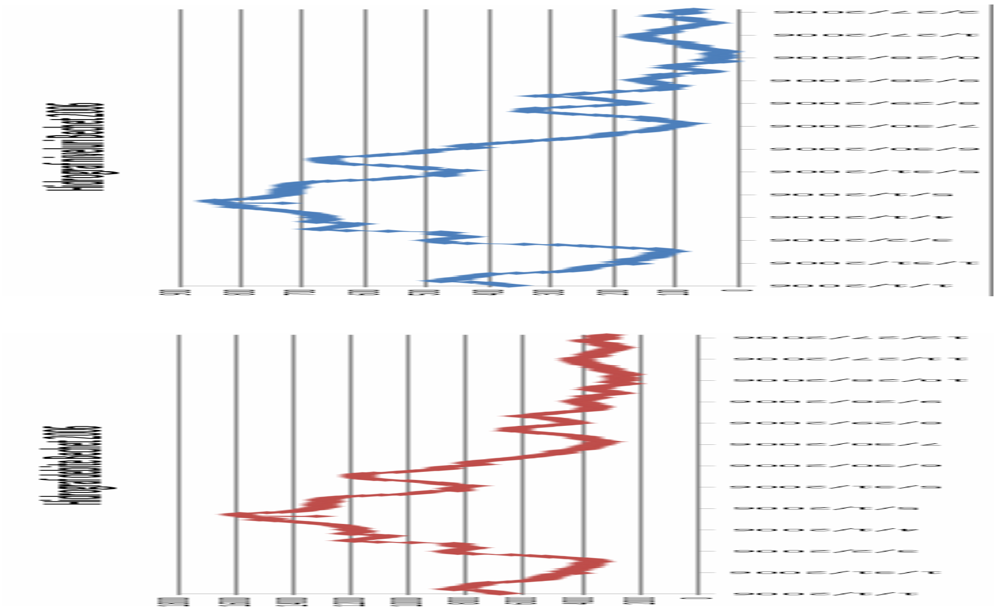


Figure 7. Hydrograph of levels and flows

As it was mentioned above, for the one-dimensional modeling of the flow, the HEC-RAS software was used, one-dimensional model under non-permanent flow that solves Saint-Venant equations, resulting the medium flow and level in the cross sections needed for the calculation.

The model, as it was defined in ArcGis, was imported in Hec-Ras were was checked from quality point of view.

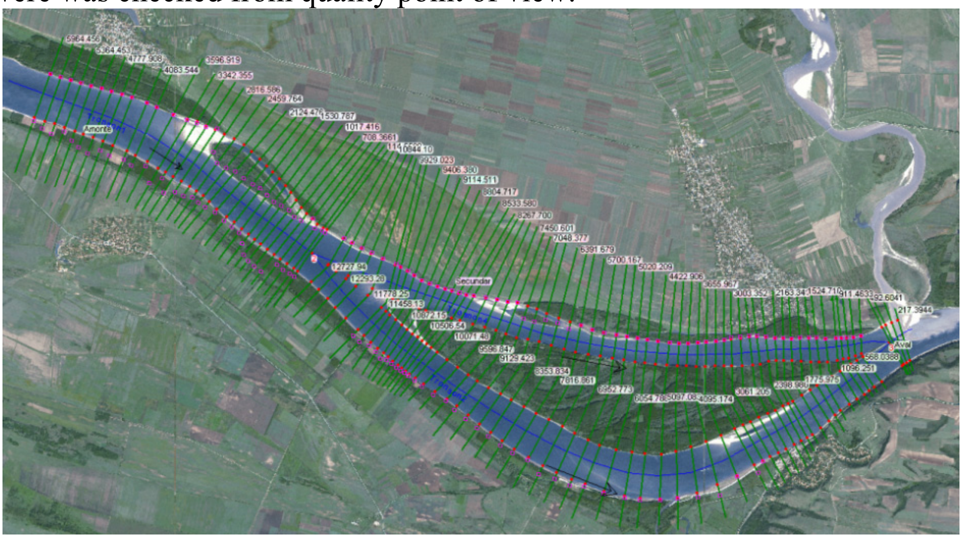


Figure 8. One-dimensional modeling of the flow – HEC-RAS

All the cross section were checked and every incoherent data was corected. (figure 8).

The boundry condition of the flow model were represented on the flows hydrograph (Bechet) and the limnimetrical key. It was necessary to input as limit the flow hydrograph upstream of Bechet for 2006, and downstream, for the last profile was built the limnimetrical key that was imposed in HEC-RAS. The simulation was carried out in transient phase by imposing a subcritical flow (Figures 9-10).

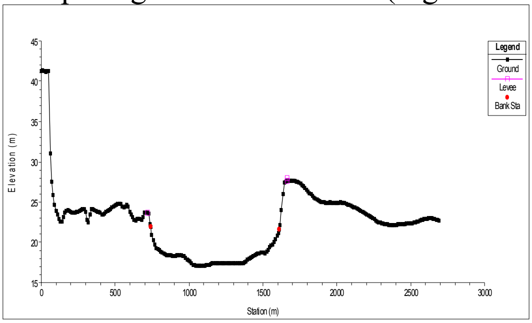


Figure 9. Cross section upstream on Danube, were the boundary condition were imposed

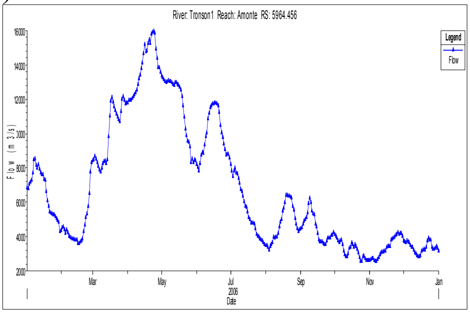


Figure 10. Flows hydrograph on Danube, Bechet 2006

Being a one-dimensional model, HEC-RAS offers the medium results in every section needed to be calculated, flows, levels and all the parameters derived from this.

Represented in the longitudinal section, the thalweg with the shores, it's possible to see the time evolution of the levels. It can be obtain lower levels of the Danube, corresponding with the hydrograph imposed upstream, but also maximum levels, where the major riverbed is flooded, the situation of Gerai Pond (figure 11 and 12).

The flows coresponding with the maximum level in the minor river bed are in the order of 15,000 m^3/s, upstream, reaching on the channel of Gerai Pond a value of around 6,000 m^3/s, and on the left major riverbed corresponding to the Pond a value of about 3,500 m^3/s.

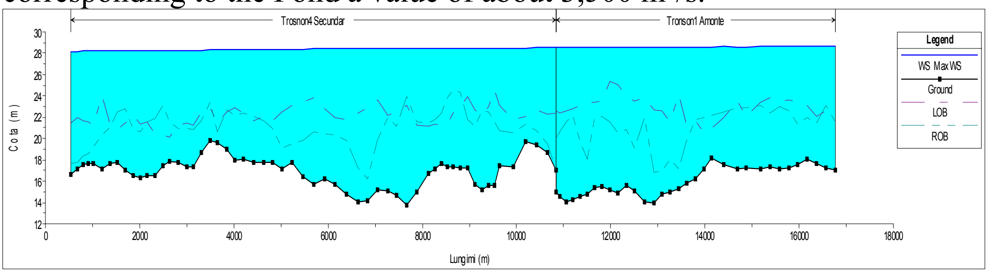


Figure 11. The high levels of water on the Danube

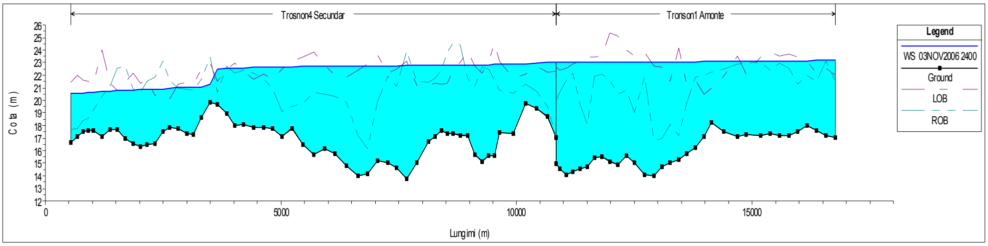


Figure 12. The lower levels of water on the Danube

Following the highlighting of flooding and draining phenomena of Gerai Pond, in the following cross sections are presented the water level on Danube and Gerai Pond, at different time steps.

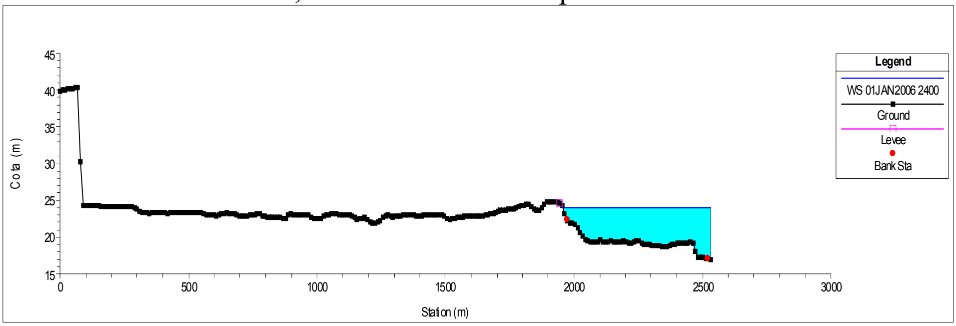


Figure 13. Water level in Gerai Pond - 01 January 2006

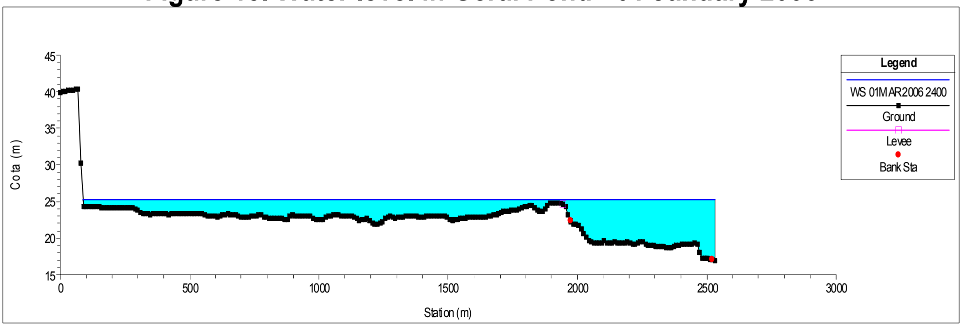


Figure 14. Water level in Gerai Pond - 01 march 2006

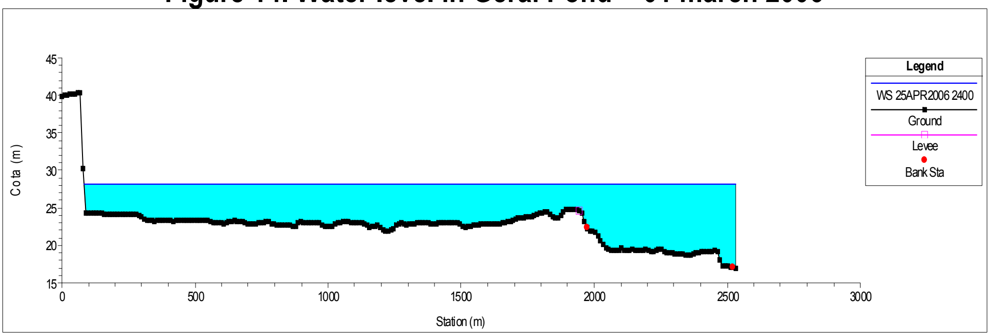


Figure 15. Water level in Gerai Pond - 25 April 2006

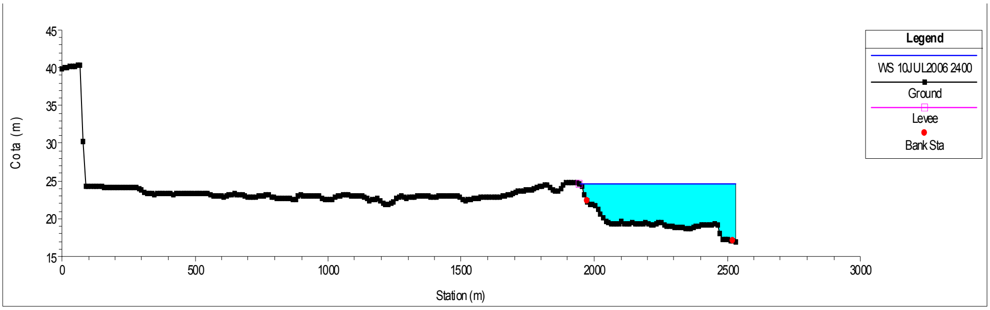


Figure 16. Water level in Gerai Pond - 10 July 2006

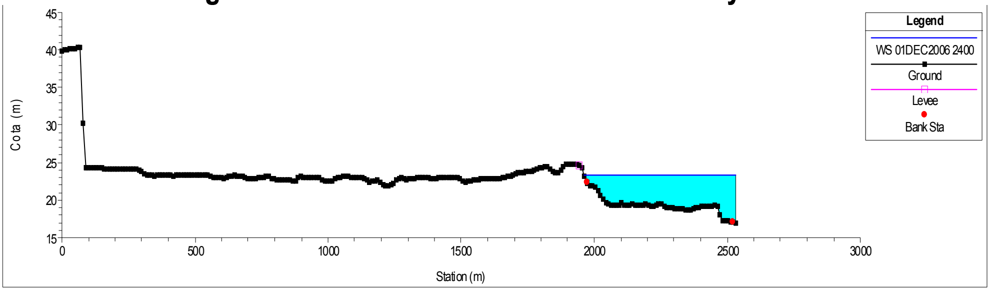


Figure 17. Water level in Gerai Pond - 01 December 2006

The period when the water is in Gerai Pond is between 26 february and 08 july (figure 18 and figure 19).

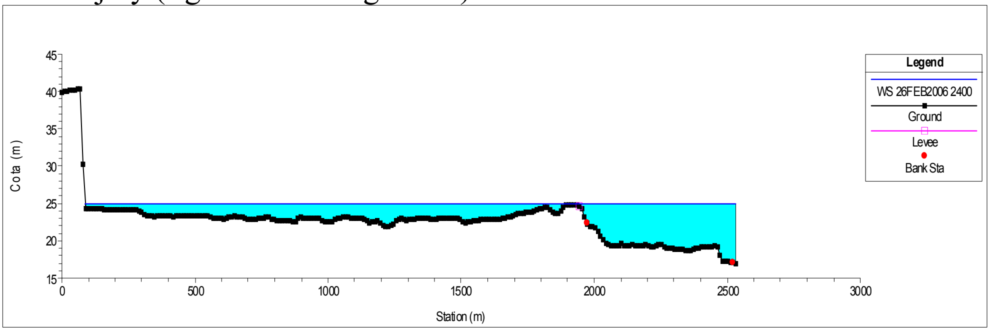


Figure 18. Water level in Gerai Pond - 26 February 2006

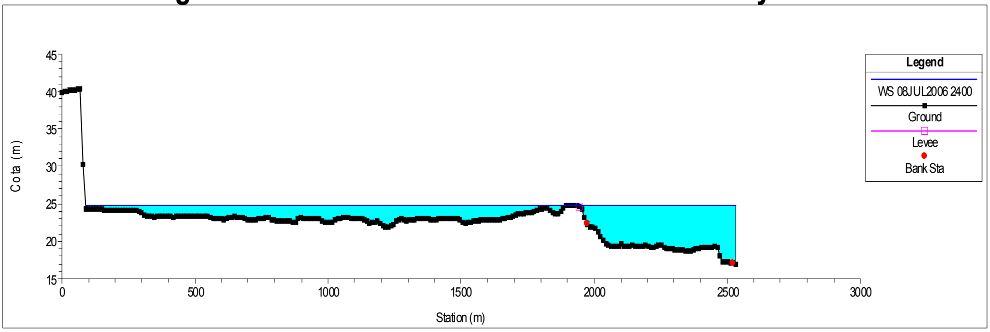


Figure 19. Water level in Gerai Pond - 8 July 2006

The lateral extension of the water, correspondig with the maximun level, is presented in figure 20, and the complete retreat of the water from the pond is presented in figure 21.

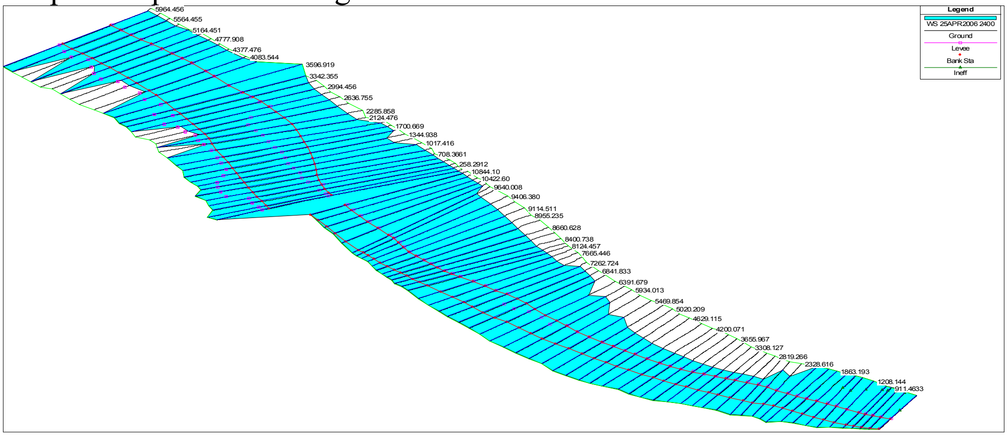


Figure 20. Lateral extension of the water for the maximum level of the Danube.

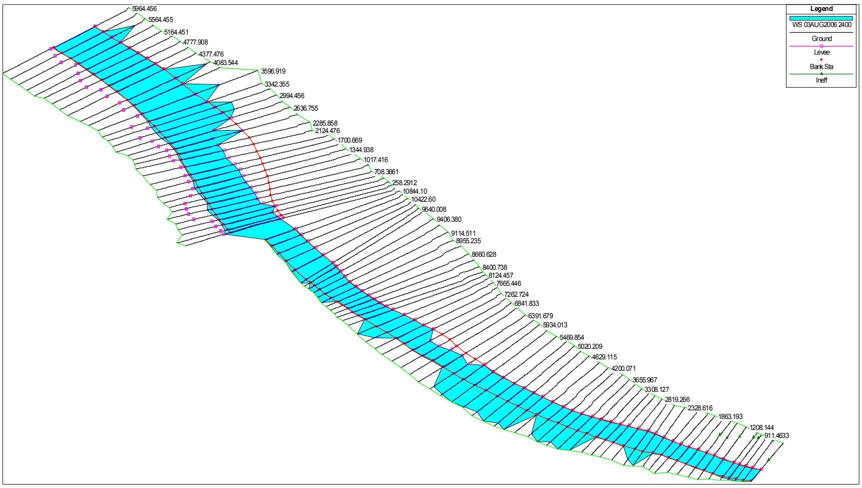


Figure 21. Lateral extension of the water in the case of the complete retreat of water from the Gerai Pond

4. MODELING A WATER DISCHARGE CHANNEL FROM GERAI POND

In the north-west area of Gerai Pond, a discharge channel in the Danube is located. The mathematical model of free surface flow in this channel from the north-west of Gerai Pond, aims to find out how the water drainage works in the area of Gerai Pond.

After the terrain survey, the roughness coefficient for the channel river bed was chosen to have the value of 0.035, and roughness coefficient for the major riverbed a value of 0.45. The hydraulic slope in the analyzed section of the channel was obtained from the digital terrain model (DTM), created with the topographical measurements and the altitudes of the river bed. For avoiding the local asperities in the calculation of the slope, a linear regression was used for identifying the medium hydraulic slope. The medium hydraulic slope of the channel in the analyzed section resulted at 0.1% (figure 22).

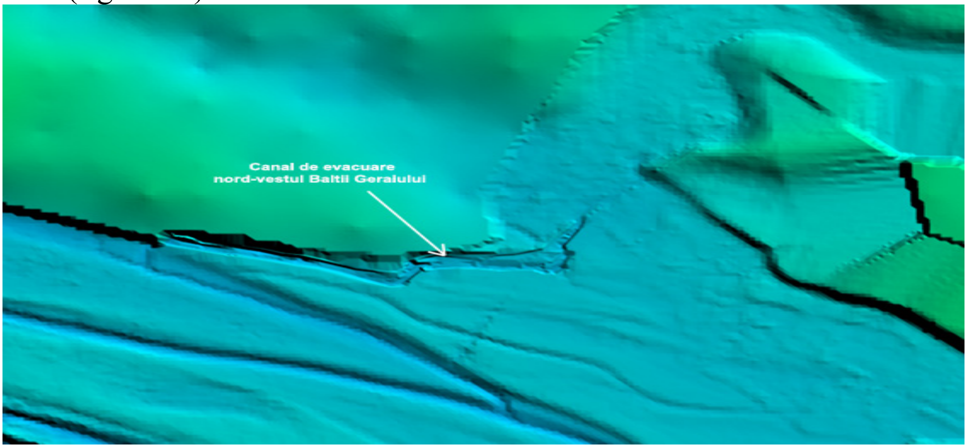


Figure 22. Discharge channel in the north-west of Gerai Pond – digital terrain model

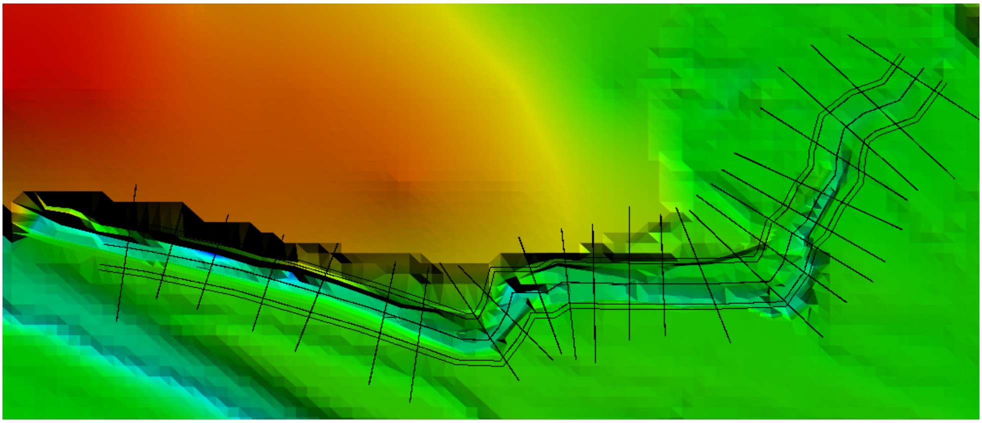


Figure 23. Digital terrain model, with the cross sections through the channel

Hydraulic calculations were performed on a permanent basis, varying flow value between 0.5 m^3/s and 30 m^3/s.

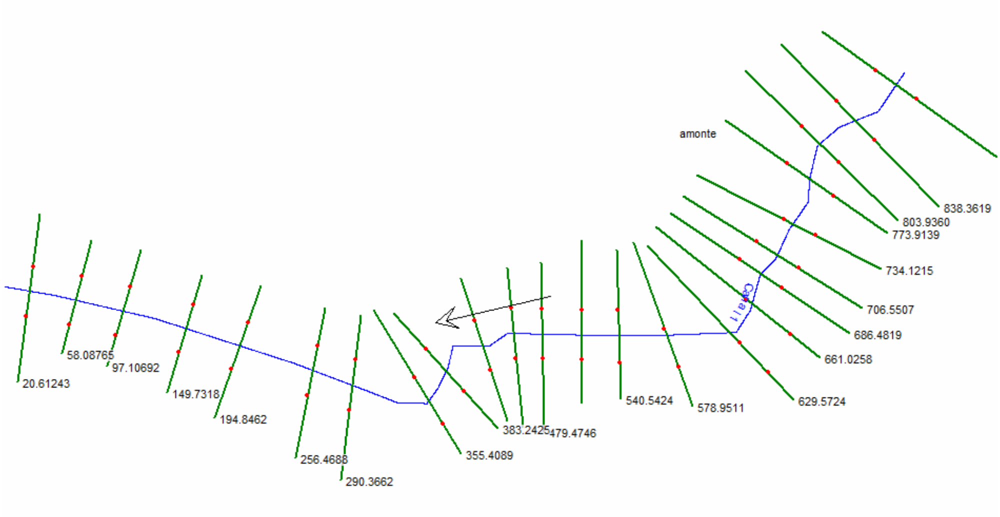


Figure 24. Hydraulic model of the channel, with the indication of the cross sections

In the following figures, are presented the cross sections through the riverbed with the corresponding levels calculated for a flow of Q = 10,00 m^3/s, considered to be a flow that could be transported in a optimal way thru the channel (without exiting the major river bed and avoiding the flooding of the nearby area).

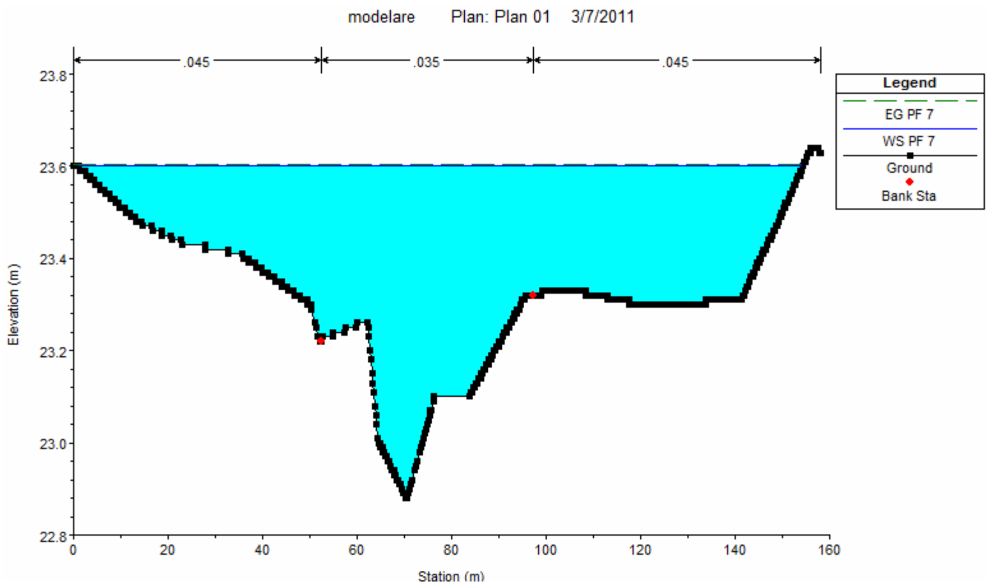


Figure 25. Cross section through the channel - nr. 773,9139

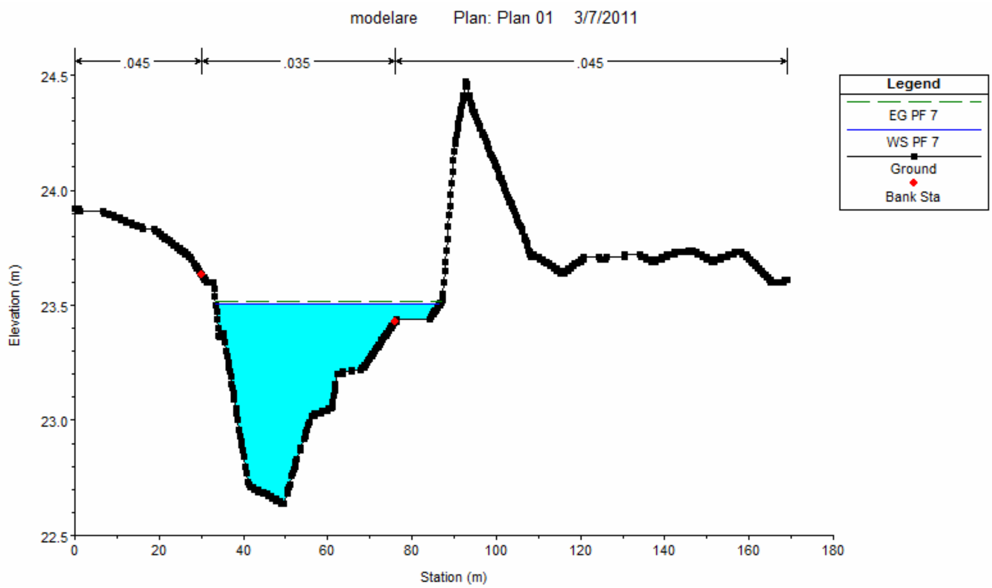


Figure 26. Cross section through the channel – nr. 661,0258

Figures 27 and 28 presents the limnimetrical keys in the cross sections presented above.

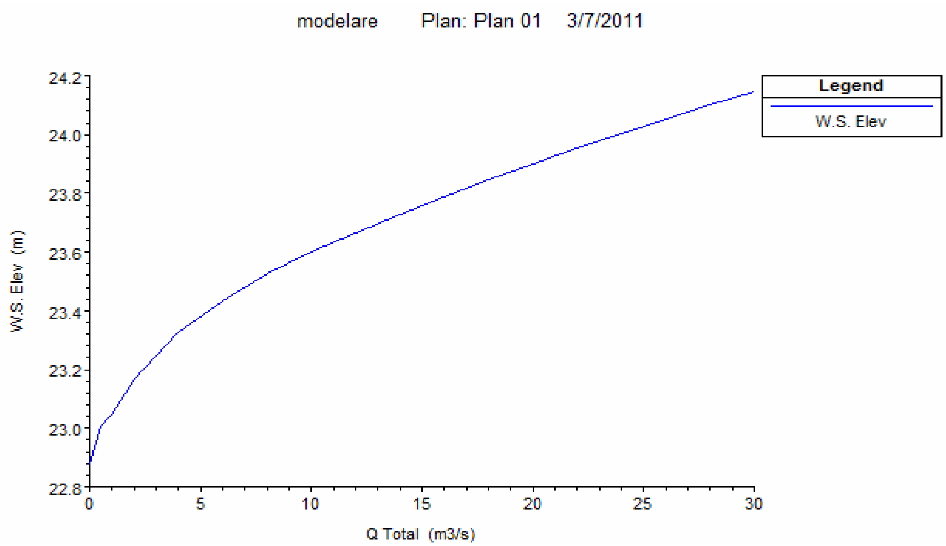


Figure 27. Limnimetrical key in the cross section nr. 773,9139

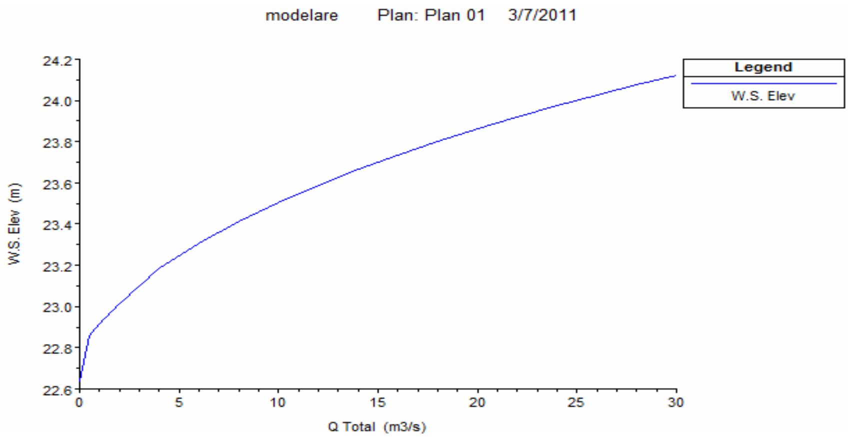


Figure 28. Limnimetrical key in the cross section nr. 661,0258

In the table 1 are presented the results of the hydraulic computations in the cross sections of the channel, for a flow of 10,00 m^3/s.

Table 1. The hydraulic parameters for the discharge channel

Section	Q Total	Talweg level	Free surface water level	Depth	Hydraulic slope	Velocity	Discharge area	Free surface width	Froude nr.
	(m^3/s)	(m)	(m)	(m)	(m/m)	(m/s)	(m^2)	(m)	(-)
883,7348	10	23,19	23,64	0,45	0,001	0,42	34,64	163,42	0,23
838,3619	10	23,03	23,62	0,59	0,001	0,29	49,28	181,14	0,14
803,936	10	23,01	23,61	0,6	0,001	0,28	50,07	171,41	0,14
773,9139	10	22,88	23,6	0,72	0,001	0,31	44,21	153,05	0,15
734,1215	10	22,34	23,57	1,23	0,001	0,52	30,46	149,71	0,23
706,5507	10	22,56	23,53	0,97	0,001	0,7	14,49	57,78	0,34
686,4819	10	22,32	23,52	1,2	0,001	0,41	32,59	88,65	0,16
661,0258	10	22,64	23,5	0,86	0,001	0,5	20,69	53,29	0,23
629,5724	10	22,33	23,5	1,17	0,001	0,34	36,13	88,06	0,12
578,9511	10	22,39	23,48	1,09	0,001	0,46	23,75	45,08	0,18
540,5424	10	22,41	23,46	1,05	0,001	0,41	24,67	38	0,16
510,9123	10	22,48	23,45	0,97	0,001	0,46	21,97	33,51	0,18
479,4746	10	22,73	23,43	0,7	0,001	0,49	20,48	33,78	0,2
456,0981	10	22,63	23,42	0,79	0,001	0,41	24,57	38,86	0,16
428,0607	10	22,13	23,39	1,26	0,001	0,72	13,94	24,15	0,3
338,2425	10	22,14	23,37	1,23	0,001	0,45	22,4	25,56	0,15
355,4089	10	22,44	23,35	0,91	0,001	0,68	14,8	24,17	0,28
290,3662	10	22,44	23,27	0,83	0,001	0,66	15,05	27,58	0,29
256,4688	10	22,45	23,23	0,78	0,001	0,73	13,79	21,91	0,29
194,8462	10	22,15	23,15	1	0,001	0,74	13,44	19,37	0,29
149,7318	10	22,19	23,07	0,88	0,001	0,92	10,84	18,96	0,39
97,10692	10	20,9	23,06	2,16	0,001	0,42	23,81	23,04	0,13
58,08765	10	22,2	23,01	0,81	0,001	0,9	11,14	21,09	0,39
20,61243	10	22,13	22,97	0,84	0,001	0,67	18,15	36,33	0,27

5. THE ANALYSIS OF THE NUMERICAL SIMULATION RESULTS

The one-dimension mathematical model of Gerai Pond led to the reproduction of the flooding and draining phenomena that occur naturally in this area. Due to the quality of basic data, an unrefined model resulted, but it allowed to draw some clear preliminary conclusions and to propose structural or non-structural solutions that accomplish in a certain measure the objective of this study, the ecological restoration of the Pond.

For finding the possible solutions for the ecological reconstruction of Gerai Pond, is recommended to be done, after new topographical and geotechnical studies, the incorporating of new levels in the numerical model of the terrain and the remaking of the simulation of water flooding, the level of the pixel resolution of 20 m cannot faithfully reproducing the geometry of the area.

Calculation were made for the Danube sector, corresponding with Gerai Pond, of the flows in the riverbed and major beds, the average speeds in consecutive cross sections and the average levels of water in the profiles. Results were obtained with time step of one day, but can be refined in smaller time steps.

It was also analyzed the flow through the channels in the south-east and north-west of Gerai Pond, in natural state, for a vary range of flow rates covering different water levels in Pond, under its greening. After modeling, there can be made qualitative and quantitative assessments of controlled release of water from the Pond, on these 2 channels.

Defining the model geometry in Stereo70 projection, the results can be exported to GIS where new maps can be overlaid on the existing one.

As initial conditions in determining the solutions necessary to control water levels in the pond, it's proposed:

- The water level height in Gerai Pond must be maintained around 22.50 m; this rate is considered optimal for re-ecological area;
- For the channel in the south-east of Gerai Pond, the location of the hydrotechnic works (control dams) will be made in the right section 106.12, section where the length of control dams will be minimal;
- For an additional flow of water in the pond, is recommended a stream diversion in the northwest area of the Pont, to the inside.

6. SOLUTION FOR THE ECOLOGICAL RECONSTRUCTION OF GERAI POND

The ecological reconstruction of Gerai Pond is based on a hydrological study (that included a component linked to flooding) related to the analyzed area, study made by TUCB. In this study we have highlighted the water access area to and from the Pond, the water surfaces and volume, for different elevation, the best water level of the Pond for assuring the ecological reconstruction of the nest areas.

In the study a hydrological study was carried out, making a one-dimensional mathematical modeling of the water flow for the Danube sector, corresponding with Gerai Pond, the debit flows of the minor and major river bad, the medium velocity in the consecutive considerate section and the medium profile level. The calculation was made with the help of the HecRAS program and the review was based on a numerical model of the terrain.

During the field visits, the review of the digital terrain model and the conclusion of the hydrological study, we determined that the water flow in and out of the Pond is made through 2 channels:

- The drainage channel of the rivulet, on the north-west of the Pond (photo 3)
- The drainage channel, located in the central of the Pond (photo 4)

Photo 3. Gerai Pond – drainage channels of rivulet Gircov.

Photo 4. Gerai Pond – drainage channel in the central area of the Pond.

In conclusion, in the same hydrological study, the flow through the drainage channels of the south-east and north-west region of the Pond was made, in natural state, for a multitude of debits that covers different levels of water in the Pond, in the ecological reconstruction. After the model, we could do a qualitative and quantitative estimation concerning the controlled evacuation of the Pond water, through the 2 channels.

The delimitation of the ecological area was agreed upon with the environmental authorities and its presented in fig.2 In the same area that the hydrological model was made, needed for establishing the optimum water level for the ecological reconstruction of the area.

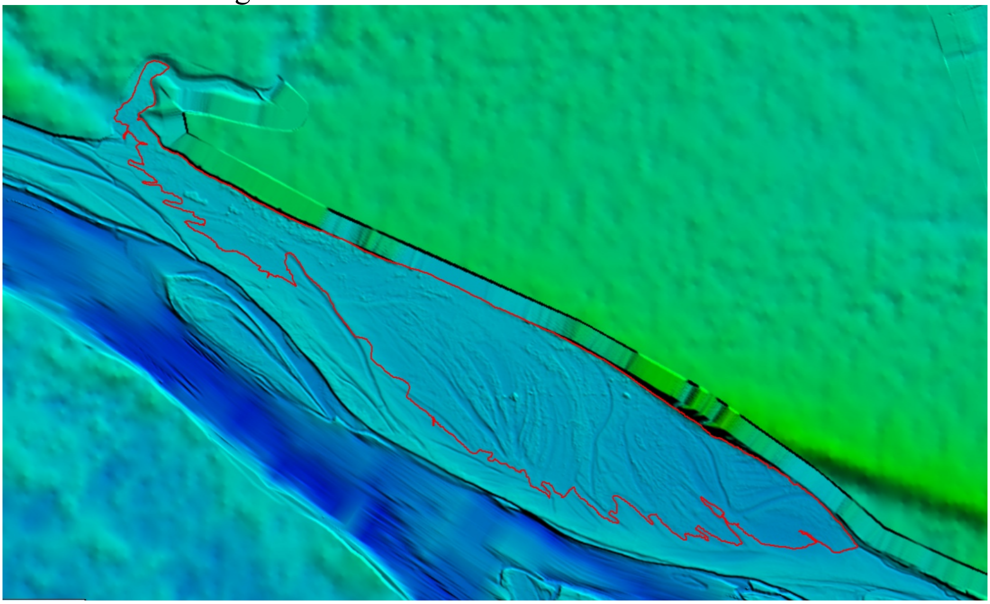


Figure 29. The digital model of the terrain where for the proposed area for ecological reconstruction.

The propose solution for the ecological reconstruction of Gerai Pond consist in:

- The river deviation of the channel in the north-west region of the Gerai Pond, from the limit of the village Gârcov, by building a new channel that will unload the water in the central region of the Gerai Pond and an obstruction dam of the existing channel(figure 2). This deviation channel will ensure the water surplus needed for the central area of the Pond.
- The obstruction channel in the central area of the Pond(figure 3), by using the resulted material from the building of the deviation channel in the north-west region.

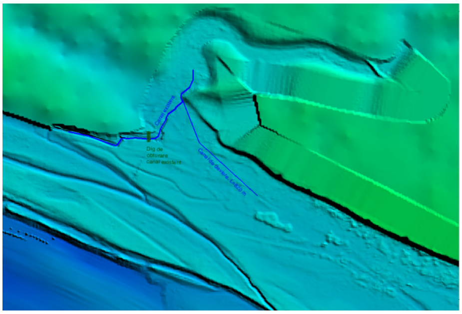


Figura 30. The digital model of the terrain with the proposed works- deviation channel of rivulet Garcov.

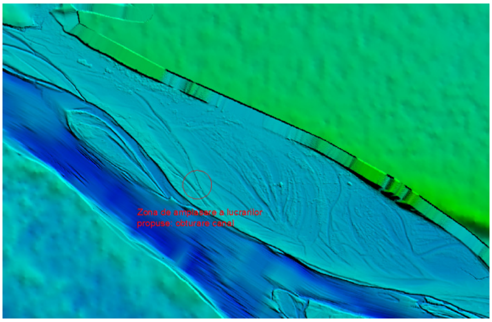


Figure 31. The digital model of the terrain with the proposed works – the obstruction of the drainage channel in the central area of the Pond.

From the point of view of the working area condition and the execution technology adopted by the contractor, depending on the site facilities, the deviation works for the obstruction for both channels, will be carried out manually and/or mechanize, with small capacity equipment.

The deviation channel will have a longitudinal slope bigger then the existing channel slope, thus creating a new direction flow. The longitudinal slope of the new channel will have a minimum 1‰. The section of the channel will be trapezoidal and the slop of the will be 1:1, the channel capacity will vary depending on the local condition. For example, for a medium depth of 1.1 meters, the channel will transport, at a depth of 1 meter, a flow of 2,3mc/s, and at a width of the bed channel of 2 meters.

The existing channel that drains the water from rivulet Gircov, will be obstructed by the building of the dam made from the local materials resulted from the deviation channel, with slopes of 1:3 upstream and downstream, with a width of 3 m at the canopy

For the protection against erosion of the slope, in the time of high water, an anti-erosion net made from polyethylene will be placed.

After the works are complete a the dam will be covered with grass upstream of the slope (toward Gerai Pond and the plantation of trees on the downstream slope (toward Danube)

The obstruction channel in the central region of the Pond will begin after the deviation channel in the north-west and will be made by building the execution dam similar with the one propose for the obstruction channel in the north-west. It will be made from the resulting material of the earthworks needed for the construction of the deviation channel

In the following figure it is presented the transversal section and longitudinal section through a earth made dam propose for building.

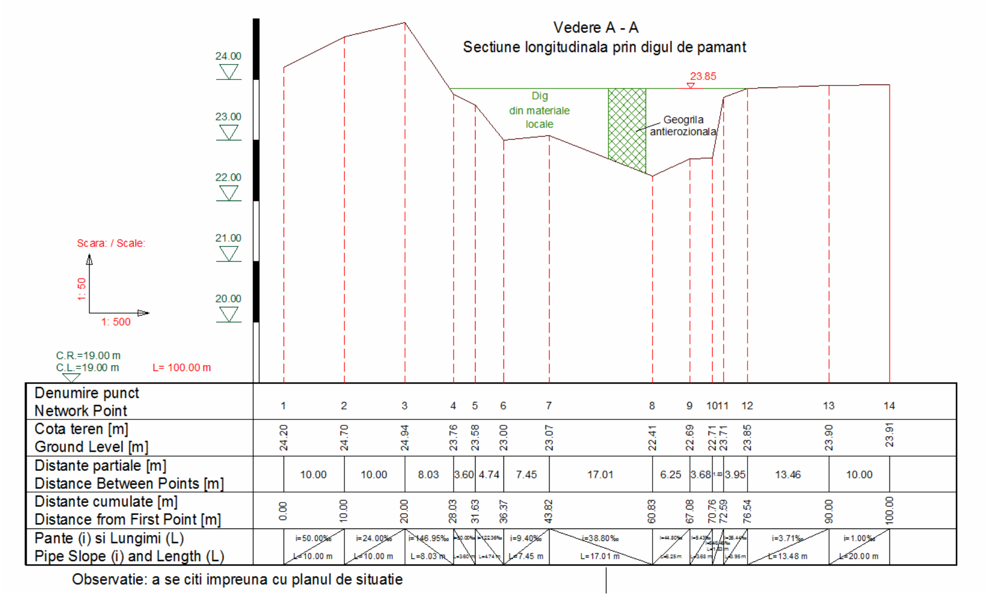


Figure 32.Longitudinal section through the closing dam for the drainage channel

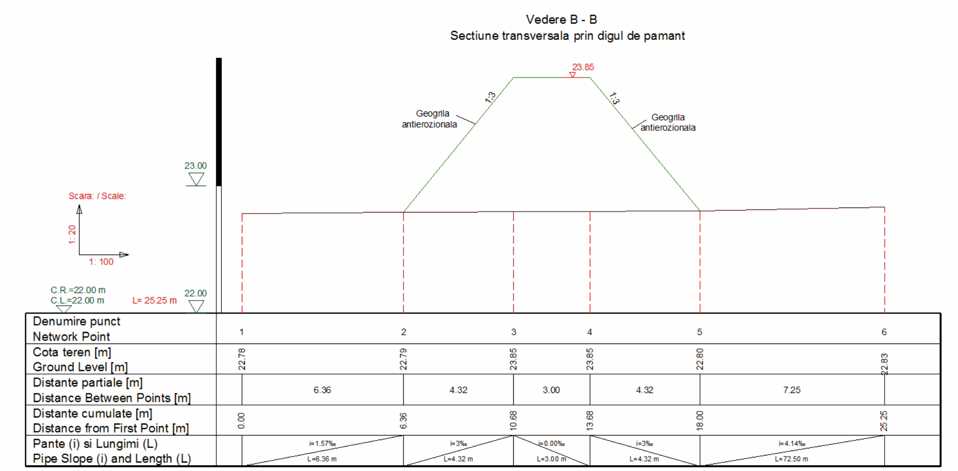


Figure 33. Cross section through the closing dam of the drainage channel

7. CONCLUSION

After completing the propose work, the next stage will be the monitoring of the effects made by the hydromechanics work-out.

The monitoring will be made for a calendaristic year and will contain: the visual inspection of the water evacuation areas from starting

point when the Pond is flooded and emptied, the measurements of the surface water level of the Pond, measurement of the debits and the levels of the new deviation channel.
If the time for evacuating the water from Gerai Pond remains insufficient for making the proper condition for nesting, then the necessity for a new hidrotechnic construction for the control of the water debit and the levels will be made in the south-west of the Gerai Pond.

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