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RESEARCH ON COMBATING SOIL EROSION THROUGH THE ARRANGEMENT OF HYDROGRAPHIC BASINS WITH ECOLOGICAL WORKS

Research Report no. 3
Research on the behavior over time of ecological works to combat erosion

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INTRODUCTION

The need to conserve biodiversity is objective and pressing because human communities cannot live and develop outside and independent of natural ecosystems.

Saving nature means saving the human species in the first place.

The natural environment and the environment created by man, are indispensable for the evolution of man and first of all for his survival. Mankind is at a crossroads of decision for the fate of the Earth and the life of every species on the planet to resolve the contradiction between the development of human societies and nature conservation. [1]

1. THE USE OF GABIONS TO ELIMINATE THE EROSION EFFECTS

1.1. Classic gabions

In the works of regularization of watercourses, various materials and construction elements are used, with local or easy to procure character, which can easily support the demands produced in high waters.

The gabions are made of boxes with concrete steel edges and side walls made of galvanized wire mesh (square or hexagonal mesh).

They allow the use of small river stone (they are filled with stone after being placed on the site and tied together with wire). The shape is a parallelepiped, and the ratio of the sides is 1: 1: 3.

Gabion defenses are indicated in areas without large rock and in intermittent watercourses, where fascines cannot be used because they are subject to drying.

The length of the boxes varies between 2 and 6 m, and the other measurements between 0.5 and 2 m.

After they are filled with stone large enough that they cannot come out through the mesh, the movable covers are secured with wire. [2]

Figure 1. Classic gabions (author's photo)

1.2. Alternative gabions

Box-type gabions are elements of rectangular prismatic shape, built of an armature and metal mesh, with hexagonal stitches, double twisted.

The ends of the box are reinforced with a wire with a larger diameter than the wire from which the actual net is made.

Ensuring total protection against corrosion, necessary if the works operate in marine or highly polluted environments, is done by protecting the wire through a winding from P.V.C. with a thickness of 0.4-0.6 mm.

Gabions without a diaphragm or gabions with multiple cells are also produced.

Gabion mattresses are made of an extensive and slightly high parallelepiped-shaped metal structure. After using a galvanized wire has a smaller diameter than the boxes.

To ensure an increased resistance diaphragms at a distance of 1 m are used, thus creating a cellular structure.

The contour of the mattress and the diaphragms are made of wire with a larger diameter.[3]

2.1.1. Description of the environment where they are used, anticorrosive coating requirements EN 10223-3: 2013

Level of environmental aggression	Synthetic protection	Metal protection	Class (EN 10244-2)	Lifetime (ani)
Mediu usor agresiv (C2) Condiţii uscate	-	ZN	A	25
	-	GALFAN	A	>50
	-	GALFAN PLUS	A	>120
Mediu agresiv (C3) Condiţii uscate	-	ZN	A	10
	-	GALFAN	A	25
	-	GALFAN PLUS	A	>50
	PVC	GALFAN	A	>120
	PA6		E	
	PVC	GALFAN PLUS	A	>120
	PA6		E	
High aggressiveness environment (C4) Humidity conditions	-	GALFAN	A	10
	-	GALFAN PLUS	A	25
	PVC	GALFAN	A	120
	PA6		E	
	PVC	GALFAN PLUS	A	>120
	PA6		E	
Very aggressive environment (C5) Humidity conditions	PVC	GALFAN	A	120
	PA6		E	
	PVC	GALFAN PLUS	A	>120
	PA6		E	
Extremely aggressive environment (CX) Increased humidity conditions	PVC	GALFAN PLUS	A	>120
	P/PA6		E	

Figure 2. Anticorrosive coating requirements [3]

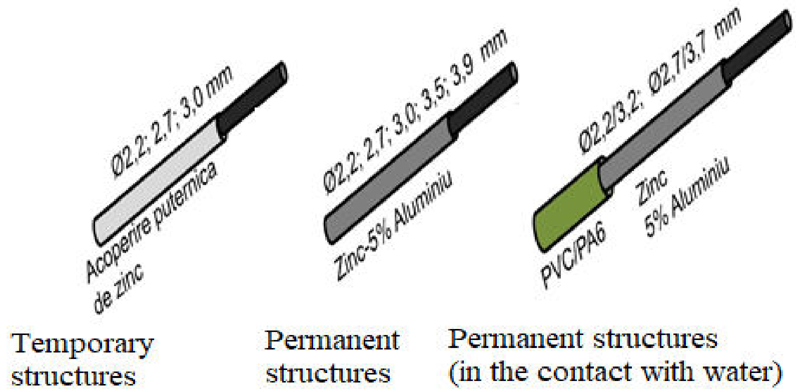
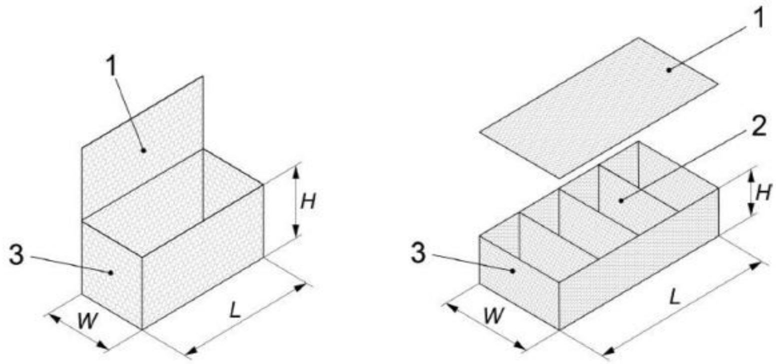


Figure 3. The degree of wire coverage used on gabions [3]



Composition:
1- cover;
2 - diaphragm;
3 - side panel;
H - height;
L - length;
W - width.

Figure 4. Alternative gabions [3]

2.1.2. Sizing according to EN 10223-3: 2013

Standard measurements:

- Length: 2-3-4-5 m;
- Width: 1-1,5-2 m;
- Height: 1-0,5 m-stitches 80x100 mm and 2.7 mm wire;
- Desired type of protection: Zn, Galfan (Zn+5%Al); Galfan plus (Zn+10%Al); PVC + Galfan;
- wire thickness can be between 2.7-3.9 mm;
- closing wire thickness 3.4 mm;
- 3.9 mm thick tie rods (4 pcs/m^3/ direction)
- staples ~ 40 pcs/m^3;

Different types of pliers can be used to hold the staples.

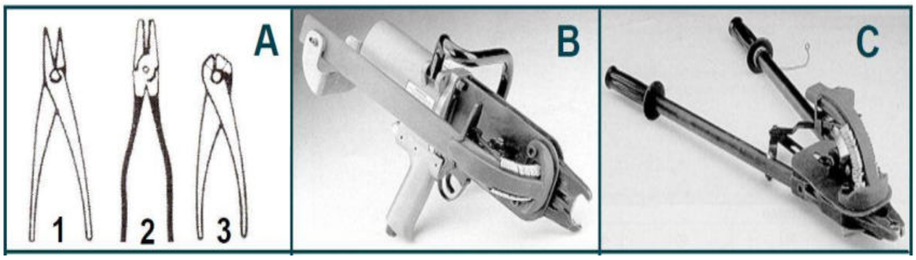


Figure 5. Types of pliers used to hold staples [3]

Figure 6. Attaching the staples using pliers manually (author's photo)

2.1.3. Mounting details

1. Unfold the package on a straight and rigid surface, lift the front, back and sides to form a box with an open cover, close the edges with a C-Ring or sewing net.
2. Place the gabion in the mounting position, temporarily stiffen the front panel with formwork panel and attach it to the side gabions at each mesh using C-Ring, thus making it easier to make the raw stone masonry and the gabion rectilinear, after which the panel will move to the next.
3. The gabion is filled with the appropriate stone. This can be done manually or with mechanized means.

At each 25-30 cm filling height, preformed ties with tie rods are applied inside.

4. Apply the cap that approaches the edges and grips with pliers. Close the gabion with staples or sewing wire, so now the gabions are stapled together.

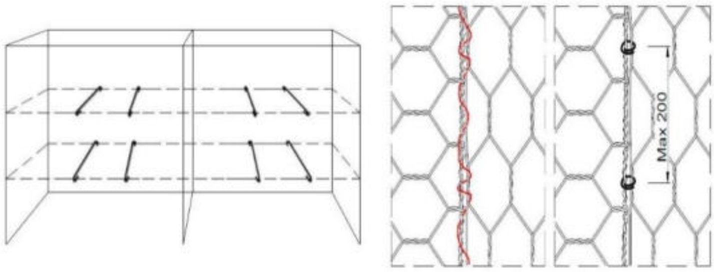


Figure 7. Applying tie rods and sewing the gabions [3]

Figure 8. Assembling of alternative gabions (author's photo)

The lifespan can be quite long depending on the type of coverage and the exposure environment, up to 120 years. Even the frames are protected against corrosion.

It is an extremely stable system, thanks to the diaphragms, tie rods, and covers that come together as a whole.

All consumables (electrodes, flex sheets, tool kits, welding gases, electricity) are eliminated.

There are no more material losses (mesh, wire, steel-concrete), and there is no more labor for manufacturing (welding, bending, binding, or handling of various materials).

The materials can be delivered directly to the construction site in quantities of up to 2000 m^3/truck, so there is no need for a complex construction site organization, and it does not take up much storage space.

All products are accompanied by quality documents: CE, CE declaration of performance, and BBA certificate compared to a gabion made on site that does not have these documents for the finished product.

It respects the design standards according to the norms - EN 10223-3/2013.

The disadvantage of these gabions is the use of quarry stone and that they can not be filled with river stone. [3]

1.3. Cylindrical gabions

Cylindrical gabions are constructed of a single sheet of mesh which forms an open cylinder at one end or both closed ends.

Gabions have imposed themselves in the field of construction due to a set of factors more favorable than other materials.

The tubular units are filled with river stone at the project site and hermetically sealed.

This modular unit is then used to provide protection against erosion on river banks, bridge piers, or in any situation that requires immediate protection from the effects of water erosion. The cylindrical gabions are lifted in position using appropriate equipment and are stacked on top of each other to form a mass of rocks.

The mesh is made of high-quality steel wire, which is strongly galvanized to provide long-term corrosion protection. An additional protective polymer layer is also applied for more aggressive environments or if a longer life is required for the project.

The gabions are supplied with steel reinforcement cables inserted during the manufacturing process to facilitate closure during installation. To strengthen the structure, all the edges of the nets are tiled with a larger diameter wire. [4]

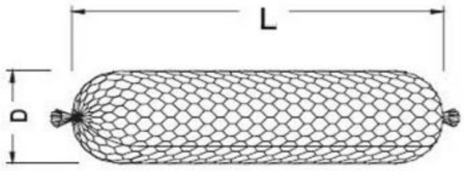


Figure 9. Cylindrical gabion [5]

Figure 10. Cylindrical gabion work [6]

1.4. Characteristics of gabion arrangements

- *Reinforcement resistance* to all stresses to traction. Gabions are not a set of overlapping boxes but a homogeneous and monolithic structure whose dimensions are established according to the forces to which it is subjected;
- *Flexibility,* respectively the capacity to absorb some unforeseen demands, even with extraordinary character. This characteristic is highlighted in all the elements of the structure that can follow the movements and settlements of the foundation without the danger of losing resistance;
- *Permeability* manifested by the possibility of water infiltration from the ground to the emissary, infiltration, which is one of the main factors of instability. This quality ensures proper drainage of the lands whose *physical and mechanical characteristics improve*;
- *Long service life*. Possible damage to the wire mesh is very slow.

In aggressive (polluted) environments, wire protected from P.V.C. clothing can be used. [7]

1.4.1. Safety factors

Safety checks are performed for user-defined task combinations under the directives imposed by the new regulations.

- Overturn safety factor;
- Sliding safety factor;
- Safety factor at limit load;
- Safety factor for global stability;
- Siphoning/infiltration safety factor

As for gabion walls, further safety checks are provided, in particular:

- Slip safety check at the gabion-gabion interface;
- Crush safety check at gabion-gabion interface

Hydraulic sizing:

- Compensation tilt. The compensation tilt is the slope of the riverbed at which the sedimentation of the material takes place behind the threshold, and for a fixed design flow, the inert bodies are in equilibrium.
- Overflow height.
- Maximum excavation downstream of the threshold, after the heights of the downstream and upstream current have been calculated.
- The siphoning/infiltration safety factor, calculated with the finite element method, is specific to the problem of infiltration in a porous medium.
- Maximum excavation depth calculated with Schoklitsch's formula.
- When a dissipation threshold is present, its minimum height is determined as well as the minimum length of the dissipation basin upstream of it, and the height of the corresponding current. [7]

1.4.2. Basis of calculation of gabion works

The following must be taken into account when designing retaining walls:

- *The action of water* is manifested only on tight and rigid surfaces and, therefore, in the case of gabions, the following particularities appear:
- Pushing water on the outer wall is zero because the gabion is permeable;
- For the same reason, the thrust of the water in the massif of the earth is zero;
- Underpressure does not manifest itself on the foundation sole because water enters the gabion;
- If the water level rises above the foundation base, the weight of the stone filling in the gabions below the water level decreases with the value of the water density ($\gamma a = 1$)
- *The gabion's weight* depends mainly on two factors:
- The volumetric weight of the material from which the filling stone comes;
- The way you can place the material in the gabion, which can ensure a greater or lesser occupation of space
- Ground thrust (active pressure) can be calculated in two ways:

$$P_a = K_a \times D_a x \frac{H^2}{2} \qquad \text{sau} \quad P_a = \frac{1}{2} D_a x H^2 x tg^2\left(45^0 - \frac{\varphi}{2}\right) \qquad (1)$$

Where: Ka - active pressure coefficient

D_a - apparent density of the earth

H - the height of the retaining wall

Φ - the interior friction angle of the earth

The design of the gabion walls with steps to the outside or the inside is done according to the same principles, starting from the choice of the verification measurements:

The next steps are as followed:

- Determining the forces acting on the wall;
- Checking that the resistance moment exceeds the overturning moment;
- Checking that the slip resistance exceeds the horizontal active force;
- Checking that the resultant of the vertical force is in the middle third of the wall and that the maximum pressure is within the allowed limits.

The stability of the wall defined by steps 2 and 4 must be checked both for the base and each row of gabions.

Forces acting on the wall are represented by the vertical force given by the weight of the gabions and the lateral pressure (pushing) of the earth (figure 12).

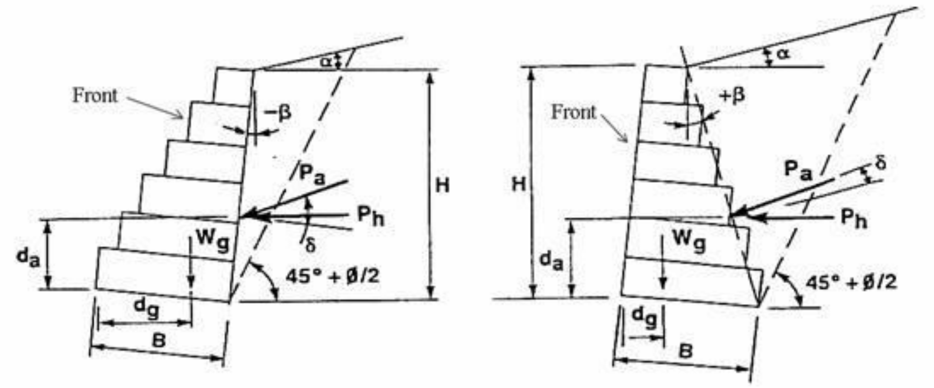


Figure 11. Gabion wall design

A. with steps on the outside B. with steps on the inside

Specific to gabion walls is the fact that the anti-slip stabilizing forces are the frictional forces, the cohesive forces at the sliding surface, the passive pressure at the base of the wall, and the anchoring forces at the top of the wall.

Mechanisms of yielding the structure to the retaining walls of the gabions.

In the case of massive structures for water retention (dams) or to take over the pushing of the earth (retaining walls), the failure mechanisms are taken into account, at which the construction is checked successively at overturning against the downstream foot, sliding on the foundation sole, pressure on the foundation. [7]

1.4.2.1. Checking the overturning

The active pressure force of the earth tends to overturn the wall, which must remain in balance with the resistance force mainly only with the weight of the wall.

Based on the principles of static, the moments are considered in the area of the foot downstream of the respective wall.

The verification has the expression:

$$M_r = SF_0 M_0 \ (2)$$

Where: M_r - the moment of resistance;

M_0 – the moment of overturning;

SF_0 - the overturning safety factor.

Neglecting the wall friction the active force acts normally on the inclined surface of the base H/3 remote filling.

If overpressures occur, the total active force will act at a distance:

$$d_a = \frac{H\left(H + 3x\frac{q}{D_a}\right)}{3\left(H + 2x\frac{q}{D_a}\right)} + B\sin\beta \qquad (4)$$

The moment of the overturn will be:

$$M_0 = d_a \text{ x } Ph \ (5)$$

The weight of the gabion wall acts vertically through the center of gravity of its cross-section, located at a distance dg.

The moment of resistance is the sum of the products of the vertical forces (W) per unit length and distance (d): $Mr = \Sigma dW$ (6)

For simple, heavy walls, the moment of resistance results entirely from the weight of the wall and the distance:

$$Mr = G_p \text{ x } d_p \ (6)$$

1.4.2.2. Checking the sliding

The active pressure of the earth tends to cause the wall to slide horizontally which must be opposed by the resistance of the base of the wall which is expressed by:

$$\mu G_t \geq SF_s \text{ x } Ph. \ (7)$$

where: μ - sliding friction coefficient (tangent of the earth's friction angle)

G_t - the sum of the vertical forces; in this case Gg.

SF_s - the sliding safety factor. [7]

1.4.2.3. Checking the pressure on the foundation

In this case you must first check whether the vertical force is manifested inside the middle third of the base..

If B represents the width of the base, the eccentricity of the vertical force at half the width is:

$$e = \frac{B}{2} - (M_r - M_o)xG_t \qquad (8)$$

At 1/3 of the half of the base the force is manifested:

$$-\frac{B}{6} \leq e \leq \frac{B}{6} \qquad (9)$$

The maximum pressure at the base will be:

$$p = \frac{G_t}{B}\left(1 + \frac{6e}{B}\right) \qquad (10)$$

This pressure must not exceed the permissible soil pressure Pb:

$$p \leq P_b \ (11)$$

The safety factor is included in Pb.

1.4.3. Experimental determinations on the functional characteristics of gabions

The verification of the reliability of the support walls in gabions is done during the operation of the works in which they support determined physical processes capable of modifying the resistance of the constructions.

Research has been carried out on the percentage of gaps formed by the filling material inside the gabion, the dynamics of the process of clogging with river deposits of these gaps, and the permeability of the gabions as a factor that contributes to the stability of the structure.

An element that intervenes in the design of gabion works is the percentage of gaps that remain between the particles of the material with which the gabions are filled. This percentage depends on the type of material used (quarry stone, river stone, sieve refuse), the placement (manual, mechanical), as well as the skill.

The experiments were performed under the following conditions:

- Material used: quarry stone and sieve refuse
- The way of placing in boxes: manual;
- It was made with gabions in 2x1x1 boxes and gabion mattresses. [7]

1.5. Clogging of gabions

The penetration of water into the gaps between the gabions reduces the kinetic energy, which causes the particles of solid material that make up the alluvium to deposit. This process of clogging the gaps depends on the turbidity of the water and the duration of the high water.

Or both elements are variable over time, and therefore clogging must be seen as a long process that ends when all the empty spaces are occupied by earthly material, and the work begins to be biologically consolidated by natural grassing.

The regression equations were obtained to allow the estimation of the gabion clogging dynamics for any values of natural factors between the experimental limits.

If the number of studied factors increases, the correlation analysis becomes more complex; the linear shape in the case of a three-dimensional distribution is expressed by the relation: $y = f(x1, x2)$.

The intensity of the links between the variables is determined by calculating the partial correlation coefficients, the multiple correlation coefficient, and the correlation ratios.

The existence of a multiple, significant correlation coefficient or a significant correlation ratio gives us a statistically significant assurance of the regression function.

In the case of partial correlations, there is a direct, positive, very significant connection between turbidity and the percentage of clogged gaps ($r = 0.82$) and between the volume of clogged gaps and the duration of clogging ($r = 0.89$).

There is a linear, negative correlation between turbidity and clogging duration ($r = 0.71$).

The obtained multiple regression function allows the calculation of the percentage of filled gaps according to the water turbidity (x1) and the clogged duration (x2): $y = 2.45\ x1 + 1.51x2 - 5.78$ for $2.0 \leq x1 \leq 3,5$ and $1 \leq x2 \leq 5$.

The determination of the permeability of the gabions was done in an experimental state by feeding the gabions with constant water flow and measuring the time required for the water to cross the mass of the gabion. The determinations were performed both for the gabion with "clean" filling material and in different degrees of clogging.

To determine the degree of clogging the gabions were kept below water level for a time equal to that resulting from the regression equations calculated in the previous step, and the clogging was verified by detaching from the work three gabions on which the clogging degree was determined.

It can be remarked that, immediately after the commissioning of the work, the permeability of the gabions is high (2.66 cm/s at the sieve refusal and 4.31 cm/s) at the quarry stone. Once the gaps are filled the speed decreases by 30 - 47% when 30% of the gaps are filled, and by 68-72% when 50% of the gaps are filled. [7]

1.6. Works design methodology

1.1.6. Works design methodology

Gabion retaining walls are resilient structures that behave differently from conventional concrete or masonry retaining walls that give the assembly a monolithic character.

They are analyzed as weight walls because they use their weight to withstand the lateral pressure of the earth.

The following must be taken into account when designing retaining walls:

- The action of water is manifested only on tight and rigid surfaces and, therefore, in the case of gabions, the following peculiarities appear:
- The water thrust on the outer parameter is zero because the gabion is permeable;
- For the same reason, the thrust of the water in the massif of the earth is zero;
- The underpressure does not manifest itself on the foundation sole, because the water enters the gabion;
- If the water level rises above the foundation base, the weight of the stone filling in the gabions below the water level decreases with the value of the water density (γa = 1);

The gabion's weight depends mainly on two factors:

- The volumetric weight of the material from which the filling stone comes;
- The way of placing the material in the gabion, which can ensure a greater or lesser occupation of space.

The ground thrust (active pressure) can be determined in two ways:

$$P_a = K_a \times D_a \times \frac{H^2}{2} \text{ sau } \quad Pa = \frac{1}{2} Da x H^2 x tg^2 (45^0 - \frac{\varphi}{2}) \quad (12)$$

Where: Ka - active pressure coefficient

Da - apparent density of the earth

H - the height of the retaining wall

Φ - the interior friction angle of the earth

The design of the gabion walls with steps to the outside or the inside is done according to the same principles, starting from the choice of the verification measurements.

The following steps are being considered:

- Determination of the forces acting on the wall;
- Checking that the moment of resistance exceeds the moment of overturning;
- Checking that the slip resistance exceeds the horizontal active force;
- Checking that the resultant of the vertical force is in the middle third of the wall and that the maximum pressure is within the allowed limits.

The stability of the wall defined by steps 2 and 4 must be checked for the base and each row of gabions. [7]

1.7. Synthesis on the verification calculations of the support walls in the gabions

The overturning of the face downstream can be determined by:

$$C \geq \frac{M_r}{M_0} \quad (13)$$

Where: M_r – the moment of stability (resistance)

M_0 – the moment of overturning

The coefficient "C" must have values of 1-2.

Sliding on the foundation sole is determined by:

$$C \geq \frac{\mu G_t}{P_h} \quad (14)$$

Where: μ - friction coefficient between the massif and the foundation ground (0.25 - 0.35);

Gt - the sum of the vertical forces; In this case, the weight of the gabion wall;

Ph - the horizontal component of the active pressure

The verification of the state of efforts in the critical sections is determined by:

$$\sigma_{am,}\sigma_{av} = \frac{G_t}{\Omega} \pm \frac{\Sigma M}{W} \quad (15)$$

Where: Ω - active section

ΣM - the sum of the moments concerning the axis of the section

W - resistance module

$$W = \frac{1}{6} bh^2 \quad (16)$$

Calculation checkings of gabion retaining walls:

Retaining wall with the stepped exterior.

Basic data:

- The height of the wall h = 3 m;
- Slope of adjacent land $\alpha = 0^0$;
- Inclination of the inner face of the wall $\beta = 0^0$;
- Internal friction angle $\Phi = 32^0$;
- The apparent density of the earthD_a = 1.900 kg/m^3;
- The apparent density of the filling D_u = 2.300 kg/m^3;
- Earth pressure P_a = 19.000 kg/m^2;
- Power surge q = 0.

1. The active pressure coefficient of a for $\alpha = 0^0$, $\beta = 0^0$, $\Phi = 32^0$, Ka = 0,31.(17)
2. Active earth pressure:

$$P_a = K_a \times D_a \times \frac{H^2}{2} = 2.650{,}5 kg/m \quad (18)$$

3. Horizontal component of active pressure:
$P_h = P_a \cos\beta$ = 2.650,5 x cos0 = 2.650,5 kg/m. (19)
4. Vertical distance to P_h:

$$d_a = \frac{H\left(H + 3x\frac{q}{D_a}\right)}{3\left(H + 2x\frac{q}{D_a}\right)} + \beta x \sin 0 = \frac{9}{9} = 1m \quad (20)$$

5. The moment of overturning:

$M_0 = d_a \times P_h$ = 1x2.650,5 = 25.650,5 kg/m. (21)

6. Th weight of gabions 1 m long:

$G_g = \Sigma S \times D_u = (S_1+S_2+S_3) \times D_u$. (22)

7. The horizontal distance to the center of gravity:

$Dg = (\Sigma S \times d_a)/\Sigma S$ (23)

8. The moment of resistance:

Mr = Dg x Gg = 1,72 x 17.250 = 29.670 mkg/m. (24)

9. Overturn safety factor:

$$SF_0 = \frac{M_r}{M_0} = \frac{29.680}{2.650,5} = 11,19 \geq 2 \quad (25)$$

10. Sliding safety factor:

$$SFa\frac{tg\phi x G_g}{P_h} = 4,06 \geq 1,5 \quad (26)$$

11. Eccentricity:

$$e = \frac{B}{2} - \frac{(M_r - M_0)}{G_g} = 0,06m \quad (27)$$

12. Eccentricity limit:

$$-\frac{B}{6} \leq e \leq \frac{B}{6} \quad (28)$$

13. Maximum pressure on the foundation:

$$p = \frac{G_g}{B} x \left(1 + \frac{6e}{B}\right) = 5.060 kg/m^2$$

$$p \leq P_b \quad (29)$$

5.060 ≤19.000 [7]

2. TECHNOLOGY ON THE EXECUTION OF EROSION CONTROL WORKS

2.1. The technology of works execution

The technology of construction executions from gabions supposes the completion of the following stages: the foundation of the construction, the placement of the gabions on-site, the filling of the gabions, the interconnection of the gabions between them.

2.1.1. Work foundation

The foundation conditions are established according to the geotechnical characteristics of the soil and the dimensions of the work (height, length, weight, etc.). Usually, the top layers of the soil must be removed up until the layer that ensures the stability of the construction, sometimes the foundation consisting of a filling of compacted resistant material.

Often, on the foundation soil, especially in the minor riverbeds, a layer of fascines is placed on which the whole work is resting.

Figure 12. Making a fascine mattress (author's photo)

2.1.2. Placement of gabions in the work

The gabions built in the form of boxes are transported to the implementation site and placed directly on site.

Welded wire gabions made in the form of panels are placed by lifting them vertically and securing them with clamps, after which they are set up on the site. When the whole row of gabions is planted, the gabions are bond to each other by mounting the spiral clamps vertically, on the entire height, reaching all the corners. Both edges of the diaphragms are also bond with spiral clamps. The stiffening corners are mounted, transversely, diagonally. [8]

2.1.3. Filling the gabions

The filling material must have the compressive strength and durability required by the designer so that it can withstand both loading and the effects of water and climatic conditions.

Quarry stone or river stone is being used. They are materials with high specific gravity, varying between 1700 kg/m^3 for tuff and 2900 kg/m^3 for basalt.

The most suitable size of the stone varies from 1-1.5 up to twice the diameter wire mesh holes from which the gabions are made of.

Smaller stones allow better and more economical filling of gabions, which ensures better adaptability to deformation.

The filling can be done manually, mechanized, or mixed.

It is also advisable to place the stones in the gabion manually so that the volume of the empty spaces is minimal, the shape of the gabions remains rectangular, and the visible faces appear as orderly as possible.

Filling of neighboring cells must be done with practically equal volumes of material in order not to favor the imbalance of the construction.

The degree of a gabion's stone filling is reflected in its porosity (which can vary between 0.3 and 0.4) and in the apparent density of the filling.

After they have been filled, the covers will be fitted onto the boxes. [8]

Figure 13. Filling the gabions with rough stone (author’s photo)

2.1.4. Interconnection of gabions

In order to reach the projected height or width of the work, the individual gabions are placed on top of each other.

After placing the first row of gabions in place, the next one is placed in the first row in a zig-zag pattern so that the side walls (panels) are not in the same plane and the vertical edges of the boxes are not on the same line.

The gabions are connected with wire along the length of the edges.

The exploitation and maintenance of gabion works are essential for the longevity of the project.

Among the many aspects, we can note that:

- Gabions are checked periodically for the repair of broken nets and cables;
- Any dense woody vegetation is removed, and damage to the gabions is remedied;
- The gabion area is monitored for signs of erosion at the foot or behind the protection. There are as well stopping measures taken.

The aesthetics of gabions is not so pleasant, but it shows a sustainable solution where the damage and dangers associated with collapses are high or where there are serious erosion problems that cannot be controlled by other methods.

However, caution is advised when placing gabions where water carries large floats, boulders, which can degrade the net by impact and runoff or in areas where there is a risk of vandalism. [8]

2.2. The technology of executing geocontainer works

To achieve and determine the stability of works in geo-containers, the forces and factors acting in the riverbed must be taken into account.

The friction force (Ff) is the force that appears at the contact surface between two bodies and opposes the movement of one body towards the other.

The sliding friction force Ff is directly proportional to the normal pressing force exerted on the contact surface by one of the bodies on the other (N), and it depends on the nature of the surface of the bodies coming into contact.

$$F_f = \mu \cdot N \quad (30)$$

where:
μ - sliding friction coefficient;
N - normal pressing

$$[F_f]_{S.I.} = N \quad (32)$$

The mechanical work of gravity force is independent of the trajectory and law of motion, and it is given by the following relation:

$$L = m \cdot g \cdot h \quad (33)$$

where:
h - the level difference between the initial and the final position;
m - body mass;
g - local gravitational acceleration.
The mechanical work of the elastic force is given by the relation:

$$L_e = -\frac{k\Delta\ell^2}{2} \quad (34)$$

where:
k - elastic constant;
Δl - deformation. [9]

2.2.1. Making the mattress

Manufacturing the fascine mattresses will be done directly on the shore or the site following the embankment works. To make the fascines, use willow, poplar, or alder twigs, freshly cut so that the elastic mattresses can be done and possibly vegetated.

A geotextile will be placed at the base of the fascine mattress or directly on the ballast layer resulting from the establishment. The two rows of fascines will be connected, separately, with clamps to the geotextile at the base.

The same procedure will be followed in order to strengthen the entire length of it.

The fascine grid only serves as a support for the test material when diving on the site, below the water level.

The fascine grid is loaded with boulders. The weight is less than 25kg/piece, which is applied mechanically and manually depending on the mass.

Figure 14. Site preparation, fascine mattress ballasted with rock (author’s photo)

2.2.2. Filling the geotextile bags

The filling of the geocontainers is done by using a sheet metal funnel, with a capacity of 2 m 3, fixed on a frame, which has at the bottom two rails (soles).

The funnel has a circular "mouth" provided with a border, from which the geocontainer is bond, using a metal belt.

The funnel is loaded with the help of the excavator. It must be provided with a manually operated damper, which allows the controlled unloading of the filling material in the bag.

Once the geocontainer is filled, the funnel is pulled with the excavator and the same operations are repeated with the remaining geocontainers so that at the end the bags they are aligned in regular rows.

The filling is done with material available in riverbed, ballast, and gravel.

The degree of filling of the bags is 80%, which allows the geocontainers to adapt in accordance with the geometry of the resistance mass.

The filling of the geocontainers is done with material available in ballast and gravel riverbed. [10]

Figure 15. Bag filling operation (author’s photo)

2.2.3. Sewing the bags

After filling, the bags are sewn to the openings using a portable electric machine equipped with plastic cord spools.

The seam is also specially designed to guarantee that it will not give up when filling and handling the bag.

Figure 16. Geocontainer sewing operation (author's photo)

2.2.4. Implementation of geocontainers

The handling of the bags, after they are filled, will be done with: excavator, dragline with grapple equipment, with front loader or in more laborious conditions, with crane equipped with special equipment.

After filling and positioning, if a 50 cm thick ballast layer is spread over the last layer of geocontainers, it can be circulated with mechanized means, which makes it possible to approach a construction with hydro-technical specificity in the "advancing" technology.

Transport from the filling site to the installation site can be done with a front loader. It must be taken into consideration that a geocontainer can reach 0.80 - 1.0 t, a weight that can be safely handled by the machine.

When making the resistance mass from the geocontainers, the bags will be checked so that they do not have manufacturing defects, the filling material is prescribed, and the closure by sewing is correct.

The integration of the bags after installation will be checked, so that there are no broken bags during transport or when placing them in bulk. [10]

Figure 17. Preparation of geocontainers for placement (author's photo)

Figure 18. Placement of geocontainers (author's photo)

2.2.5. Integration in the natural framework of the work

In the area of works with geocontainers, there were tree seedlings planted, and the land related to the region was sown, for the development of protected flora and fauna and other species.

Figure 19. Framing in the natural environment of geocontainer works (author's photo)

3. ENVIRONMENTAL PROTECTION MEASURES FOR THE EXECUTION OF EROSION CONTROL WORKS

3.1. Overview

3.1.1. Methods used in construction

To comply with the principles of sustainable development and, implicitly, of environmental protection in the field of design and implementation of this investment, solutions have been taken to minimize the impact on the ecological balance.

The works are carried out according to ORD 1163/2007 on measures to improve technical solutions and implementation of hydro-technical duties for the development and redevelopment of watercourses in the field of environment and water, solutions that lead to a minimal negative influence on natural ecosystems and the balance of the course natural area.

Ecological balance has a fundamental dynamic character and it is achieved by maintaining the speed, depth, and magnitude of changes in watercourses within limits compatible with the balanced evolution of the natural environment, the ability to regenerate, and self-regulating the living world instead of maintaining an unchanged state of nature.

The general conception of the composition of these hydro-technical constructions has respected the criteria that minimize the effects on the ecological balance, among which can be enumerated:

- the priority objective should be the protection of the environment and the conservation of biodiversity, taking into account the conservation and protection of habitats and species of community interest;
- to be "elastic" type of works, able to withstand large, differentiated deformations;
- to allow free, natural drainage of water, especially during floods, as well as ice, floats, or solids in the body of water;
- to be properly grounded in the natural terrain, to avoid damage caused by the advancement of erosions under the body of the building, including at water withdrawal;
- to avoid increasing the degree of artificialization of the watercourse through sewers and changes in the geometry of the riverbeds;
- to allow, for water development sectors, the staged realization of the hydro-technical works, ensuring the follow-up in time of the morphological processes and the performance parameters of the project;
- the design of the hydro-technical arrangements will take into account the observance of the allowed limits for the hydro-morphological, physicochemical, and biological indicators of the aquatic ecosystems to fulfill the foremost goal of reaching the environmental objectives on all the arranged watercourses.;
- deviations from these criteria may be justified only by the purpose of defending the population and/or of some objectives with socio-economic value.
- the modification of the physical characteristics of the water bodies and the justification of these modifications will be presented in the management plan - an integral part of the guidelines.

3.1.2. Design alternatives

The design alternatives that can be assessed are limited by the technical norms that regulate the design activity in the field of hydro-technical constructions.

Differences in potential environmental impacts associated with different design options related to these landscaping works could be related to:

- reliability of works: preference for resistance to stress, error, or inadequate maintenance;
- quality of works: the ability to achieve a stable long-term quality of all projects, which complies with the requirements imposed by quality standards specific to each type of work;
- the complexity of works: preference for simple projects, easy to follow, exploit, and monitor.

3.2. Quality indices

3.2.1. Quality index for soil, subsoil, vegetation, and fauna

Environmental factors soil, subsoil, vegetation, and fauna will be initially affected by the execution projects, by temporarily occupying areas with construction sites, by using equipment and means of transport, by changing the ecosystem and by restricting breeding areas, restricting or even temporary disappearance of microfauna and flora.

After the completion of the works, the impact on these environmental factors will decrease so that the damage to the environment will be within the allowed limits, which will correspond to a quality index Ic s, s, v, f = 0.50 - 1.00.

3.2.2. Water quality index ($I_q$water)

The quality index for the environmental factor water is $I_q$water = 0.50 -1.00 because due to the work processes the physicochemical and bacteriological characteristics of the water change. This leads to the increase of the suspended materials and the modification of the pH, even if the incidents can be avoided by taking some organizational measures and storing the resulting waste in specially arranged spaces.

3.2.3. Air quality index ($I_q$air)

The air environment factor will be affected by the proposed execution works by the use of means of transport and construction equipment. The air environment factor will be affected within the permitted limits. The quality index is: $I_q$air 0,25 - 0,50.

3.2.4. Quality index for human settlements (I_q hum. stlm)

Since the objective has negative effects by affecting the environmental factors essential to life: water, air, soil, but more positive effects on the population by increasing confidence among the population and economic agents in the area, in connection with better protection of lives and their assets, by ensuring stability and avoiding disasters. The quality index for human settlements is I_q hum. stlm = 0,0 - 0,25.

3.3. Sources of pollutants and installations for the retention, disposal, and dispersion of pollutants in the environment

3.3.1. Water quality protection

- sources of water pollutants, place of discharge, or emissary;
- provided wastewater treatment or pre-treatment plants and installations.

During the execution of the works, the potential pollution sources for the environmental factor water can be represented by:
- accidental loss of carburetors from the equipment used in the execution of the works;
- unexpected loss of materials used in the effecting of projects;
- evacuation of sewage waters from the organization of the construction site.

The first two categories of pollutants can be entrained in surface water mixed with rainfall.

During the organization of the site, ecological toilets will be put up for the staff who will serve this work.

The sewage waters will be collected in decanters with fat separators and will be evacuated through a specialized unit in the area.

To avoid water pollution in the river, the supply of fuels and lubricants of the equipment, as well as their current repairs, will be carried out only in specially arranged places, with qualified personnel and other measures will be taken:

1. obliging the contractor to carry out the appropriate site organization in terms of facilities and protection of environmental factors by occupying as small areas of land as possible;
2. permanent attention will be paid to the way of rainwater drainage from the perimeter of the site organization.
3. carefully following the way of carrying out the activity, carrying out the management of the activity of execution of the works within the perimeter responsibly, and complying with all the objectives of the activity regarding environmental protection;
4. in case of accidental spillage, for various reasons, the specific procedure provided for waste disposal and adverse effects will be followed;
5. a permanent stock of absorbent petroleum products will be ensured within the site organization;
6. any fuel and fuel storage tank will be carefully sealed, monitored, and placed on the concrete platform, provided with drainage channels;
7. proper parking of machinery and vehicles (on the concrete platform, as much as possible);
8. selective collection of waste resulting from the execution of works and disposal according to their nature for storage or recovery to sanitation services, on a contract basis;
9. the equipment used will comply with European operating standards.

The locations where the construction site headquarters will be built must be established in such a way as not to harm its human-natural environment (by atmospheric emissions, by accidents caused by road traffic on-site, by material handling, by accidental unloading of machines transporting materials on surface watercourses, by producing noise).

3.3.2. Air protection

- sources of air pollutants, pollutants;
- installations for the retention and dispersion of pollutants in the atmosphere.

During the effecting of the designed projects, the activities on-site have an impact on the quality of the atmosphere (in the work areas and the areas adjacent to them).

The execution of the designed works is, on the one hand, a source of emissions of dust and dust in suspension, and on the other hand, the source of emissions of pollutants specific to burning fuels (distilled petroleum products) both in the engines of the equipment needed to perform these works and the means of transport used.

Suspended specks of dust that appear during the execution of the designed works are associated with the excavation works, the transport and commissioning of the construction materials, as well as other specific projects.

The temporary nature of the construction works, the specifics of the different execution phases, the continuous modification of the work fronts differentiate the specific emissions of these works from other undirected sources of dust, both in terms of estimation and control of emissions.

The main sources of air pollution specific to the execution of the works can be grouped as follows:

- the actual site activity from the execution period;
- operation of equipment, means of transport;
- transport of materials, prefabricated, personnel.

The main pollutants are:

- emissions of gases, suspended specks of dust and sediments resulting from the movement of means of transport;
- noxious emissions from the exhaust fumes of machinery and means of transport.
- emissions of volatile organic compounds resulting from the storage and handling of fuels.

These possible sources of air pollution will disappear completely after the period of setting the objective.

During dry periods and with high temperatures, the rolling of the means of transport on the technological roads determines the emissions of suspended and sedimentable specks of dust entrained from the running surface.

These emissions can be reduced by spraying the roads with water if necessary, which will also contribute to reducing fugitive dust emissions due to the action of atmospheric factors (wind).

Since the specificity of the activity determines the intermittent operation of vehicles and equipment, the estimated hourly consumption of diesel will be approx. 50 l/h.

Storage and handling of diesel in metal containers in the temporary fuel depot cause emissions of volatile organic compounds. Since diesel is a low-volatile fuel, emissions are low and do not contain lead tetraethyl.

3.3.3. The sources at ground level

They depend on:

- The average daily working time of the equipment and respectively the distance traveled by the means of transport;
- Type and capacity of the machinery/vehicle;
- Type of fuel used and its sulfur content;
- Fuel consumption for each machine;
- Working regime;
- Technical operating conditions.

The characteristic pollutants in the exhaust gases are particles, sulfur dioxide (SO2), carbon monoxide (CO), nitrogen oxides (NOx), and volatile organic compounds (VOCs).

The limits imposed by OM 592/2002 on air quality conditions in protected areas will be observed. Measures shall be taken to reduce dust pollution by transport and proper handling of construction materials, materials excavated during the works, and equipment used.

Dust can be significantly reduced and maintained at an acceptable level that does not cause inconvenience to employees and neighbors, possibly by wetting the surfaces on which excavation work is carried out and the roads on which the means of transport run.

Given that the volume of dust-free work is fairly high, it can be estimated that dust pollution in suspension will be significant, but this kind of deterioration will not cause discomfort to human communities because they are relatively long distances and emissions from such activities are specific, being characterized by the following:

- the mineral particles are not chemically aggressive, however, they can affect the people employed by the appearance of an upper respiratory tract irritation syndrome;
- they have low stability in time and atmospheric air due to the high specific gravity of the particles;
- settles quickly even in a strongly stable atmosphere;
- they do not produce pollution phenomena on the land on which they are deposited, having a similar composition if not identical to it;
- they can form nuclei favoring the production of fog.

The imposed air quality limits in protected areas shall be observed. Measures shall be taken to reduce dust pollution by transport and proper handling of construction materials, materials excavated during the works, and equipment used.

The equipment used will comply with European noise and operation criterion; the use of equipment with an exhaust system at least at the level of Euro 2, and for machines equipped with older diesel engines, the installation of catalysts in the exhaust systems, and their endowment with gas filtration systems.

Reduction of dust emissions when handling - transport of materials, by spraying during dry periods of materials and access roads, use of diesel with low sulfur content, corresponding to the provisions on limiting the sulfur content of diesel and limiting the speed of transport.

The sources of pollution of the atmosphere associated with the regularization activities of the Putna River are free, open sources, having completely different features than the sources related to industrial or similar activities. As a result, there is no question of installations for capturing - purifying-discharging into the atmosphere of polluted air/waste gases.

Concerning emissions from motor vehicles, they must comply with the technical conditions laid down in the technical inspections carried out periodically throughout the use of all motor vehicles registered in the country.

At the exit of the loan pits, portal-type structures will be inserted under which earth-laden dump trucks will pass and which will spray water to form a crust, thus preventing the wind from entraining the soil or due to traffic during transport.

Machinery and means of transport shall be regularly inspected for carbon monoxide levels and exhaust emission concentrations and shall be put into service only after any malfunctions have been remedied.

The refueling of the means of transport should be done only in the centralized station of the construction site organization.

Site roads will be permanently maintained by leveling and spraying with water to reduce dust. In the case of land transport, routes located on the body of the filling shall be provided as far as possible to obtain additional compaction on the one hand and to reduce the area of dust and exhaust emissions on the other.

The impact on the air during operation is insignificant, as there are no sources of emissions into the atmosphere. After the completion of the investment, all these noxious substances will be eliminated, and the operation of the objective will not involve air pollution.

During the operation period of the designed works, no measures are provided for the protection of the air environment factor, this being unaffected by the executed projects.

3.3.4. Protection against noise and vibration

The human ear perceives, without harmful effects, sounds up to 80 dB. Above this threshold, the intensity of the sound becomes harmful, creating malaise, embarrassment, and prolonged exposure can cause permanent hearing loss.

All measures shall be taken to attenuate the noise produced by the machinery and to comply with the limit.

High levels of noise and vibration, as well as disturbing the natural habitat, will have the temporary effect of withdrawing animals to less man-made areas. The high level of noise and vibration will be perceived with greater amplitude at the level of these receptors, determining the migration to other regions more "favorable" for survival.e

In the case of the Putna River development works, during the peak periods, at a distance of 100 m from the works site, the noise level decreases, falling below 75 dB.

The following measures shall be taken to reduce noise and vibration:

- a maximum permissible limit of the continuous noise level of 87dB will be kept under control at workplaces, and the level of noise propagated outside will not exceed the level of 65dB.
- during transport, the traffic speed will be limited to max. 12 km / h;
- the work schedule will be limited to max. 10 hours/day, 5 days/week;
- monitoring the influence of noise and vibration on the ground or buildings with appropriate equipment.

3.3.5. Soil and subsoil protection

Soil as an environmental factor could be affected:

1. During the objective arrangement works;
2. Road traffic generates NOx, SO, SO 2, CO, heavy metals that through the atmosphere can be deposited on the soil surface leading to its contamination;
3. By temporary storage of construction materials;
4. By storing waste in other areas than in specially arranged ones;
5. Technical equipment failures, refueling, machine repairs, accidents can lead to leaks of fuel and oil that can be deposited in the soil, also leading to structural changes in the soil;
6. Rainwater that washes the construction site platform and access roads, wastewater if not collected and treated properly can seep into the soil, leading to its loading with pollutants.

The transport activity is a source of soil pollution adjacent to the perimeter of the activity by using access roads, by affecting the vegetal soil layer, microfauna, and microflora, due to the circulation of means of transport.

The transport activity carried out in the area produces the entrainment of activated sedimentable specks of dust from the exploitation road.

Also, the maintenance and feeding operations of the machinery are a possible source of soil pollution with mineral oils and diesel, in case of negligent handling.

It is possible to accumulate pollutants at the surface of the soil, coming from the atmosphere, as a result of the exhaust gases emitted by the means of transport.

The impact of the activity in the perimeter is superimposed over that produced by road traffic, including heavy traffic, which takes place on roads in the area of the site, and it is reduced and manifests itself only for the period of operation.

During the execution of construction works, the activity carried out in the analyzed perimeter may affect and/or pollute the soil and subsoil through the following:

- soil damage by carrying out deforestation works of arboreal vegetation, where applicable;
- accidental soil pollution by handling petroleum products;

Soil pollution through the use of defective equipment and means of transport that can cause oil leaks;

1. uncontrolled storage of waste or various construction materials from construction activities carried out on-site;
2. improper storage on the land of household waste from construction workers;
3. other emissions to air, which under certain conditions may be deposited on the ground surface.

The arrangement of the objectives implies the accomplishment of some works that will affect the natural state of the soil, this consisting of the following:

1. Realization of technological roads;
2. Building of the construction site organization;
3. Damage to the soil by occupation with metal barracks, for administrative purposes.

The possibility of soil pollution with petroleum products can be determined by the following:

1. negligent handling of petroleum products by personnel serving the equipment and means of transport used;
2. storage of waste oils in unsuitable containers or their storage in places other than the temporary storage of fuels and lubricants, thus there is a danger of leakage or overturning;
3. improper storage on the ground of used batteries and accumulators resulting from maintenance and repair activities of the equipment;
4. non-compliance with the maintenance and repair schedules of the equipment and means of transport.

During operation, the planned works do not represent sources of soil or subsoil pollution.

To prevent accidental pollution of the soil and subsoil only means of transport and machinery corresponding to the technical norms in the field shall be used in order to avert spills of diesel or oils from their engines.

And in terms of household waste management, it will be dumped in European bins and then taken to the landfill.

The execution and internal headquarter plan of action will be observed.

First of all, the minimization of the possibility of affecting new lands is considered. This involves:

1. saving reserves by sizing the works strictly at the level of ensuring the project execution plan;
2. directing and concentrating the activity in the targeted perimeter;
3. avoiding the blocking of some resources, which are to be put into operation later, under the piles of uncovered soil;
4. minimal construction of new roads.

To reduce the impact on the environment during the project the following measures will be taken:

1. obliging the contractor to carry out the appropriate site organization in terms of facilities and protection of environmental factors by occupying as small areas of land as possible;
2. avoiding the occupation of high-quality lands for construction site organizations, machinery bases, temporary or permanent warehouses of embankments and construction materials;
3. prohibition of the location of construction organizations, equipment bases, in protected areas or landslide areas;
4. the pollution of the soil with fuels, oils resulting from the operations of parking, supply, storage or refueling of the machinery and means of transport or due to their improper operation shall be avoided;
5. any fuel and fuel storage tank will be carefully sealed, monitored, and placed on the concrete platform, provided with drainage channels;
6. proper parking of machinery and vehicles (on the concrete platform, as much as possible);
7. selective collection of waste resulting from the execution of works and disposal according to their nature for storage or recovery to sanitation services, on a contract basis;
8. rational storage of the excavated material, so that as few land areas as possible are occupied;
9. soil restoration (ecological reconstruction) in the areas where it was affected by excavation works, storage of materials, stationary equipment to restore the circuit to the category of use originally held.
10. in the case of tree felling, they will be replanted according to the provisions of the legislation.
11. controlled discharge of wastewater during the execution of investment works to avoid their infiltration into the groundwater.
12. all staff will be trained to comply with environmental protection regulations;
13. performing on time the maintenance and repair operations of the machinery of the means of transport;
14. it is recommended that the production base platform has a concrete or crushed stone surface to prevent or reduce the infiltration of pollutants;
15. inside the site organizations, there must be ensured that the drainage of meteor waters, which wash a large area, on which there may be various substances from possible losses, so as not to form puddles, which over time can infiltrate underground, polluting the soil groundwater.

During the exploitation period, the designed works do not present sources of soil or subsoil pollution, so they do not harm the soil and subsoil but, on the contrary, a positive impact by stopping erosion.

The impact of the activity is a short-term one, during the execution period of the rehabilitation works. After this period, due to the natural dynamics of the watercourse, the area tends to recover.

3.3.6. Measures to reduce the impact on species, habitats and human settlements

The work area will be delimited to prevent/minimize the destruction of vegetal surfaces.

1. Affecting other surfaces (than those for which this study was prepared) by the temporary groundwork created during the project;
2. within the plan for the prevention and control of accidental pollution (obligation of the executor), protection measures will be established against pollution of aquatic ecosystems.

Special attention must be paid to pollution with sedimentable solids during construction work;

3. the areas occupied by the site headquarters will be reduced to what is strictly necessary; the construction site, the temporary access roads, and all surfaces whose vegetation cover has been affected will be adequately renaturalized and returned to their initial use, under the careful guidance of a biologist to avoid the possibility of introducing new species in the project area.;
4. for a period of at least 3 years, the restoration stage of the affected habitats will be verified at the beginning and end of the vegetation period, with the obligation of the beneficiary to intervene with the necessary correction works;
5. to avoid the destruction of benthic macroinvertebrate communities by sediment deposits generated by construction works, their retention measures will be established and applied within the perimeter of the projects;
6. it is forbidden to store construction materials and waste outside the perimeter of construction site organizations;
7. the direct placement on the ground of construction materials and waste will be avoided. Their temporary storage will be done only after the intended surfaces have been waterproofed with polyethylene foil;
8. the circulation of motor vehicles outside the roads drawn by the project of organization of the site (access roads, technological roads) is forbidden, to minimize the impact of any kind on the habitats/species;
9. the builder is obliged to use only silent equipment to avoid disturbing the species of birds and mammals present in the area;
10. the disturbance of the mammals in the area is avoided by the punctual execution of the works
11. project modifications during the execution of construction works will comply with the recommendations of this study.

3.4. Waste management

The waste resulting from the activity carried out at the objective is household waste, such as waste of an organic nature from the staff's food, packaging especially paper, cardboard, metal foils, or plastics.

The composition of these types of waste is specifically household, not being considered waste with toxic configuration or that would present any danger, so they do not require a specially designed management program.

The amount of waste resulting from the objective is dependent on the number of employees, occasional staff in transit, and the operating schedule of the office.

These wastes will be collected and stored temporarily, in the perimeter of the objective, in specially designed metal or European garbage cans, which are periodically emptied and transported to the household waste landfill established in the territorial-administrative unit.

Given the ones presented, we do not consider that there are problems related to the production and disposal of household waste produced as a result of the activities described in the previous chapters.

The principles of proper waste management aim in particular at maximizing energy efficiency, regardless of its form, and minimizing the amount of waste that results.

Proper waste management aims to neutralize, recycle, and minimize landfilling as much as possible. These methods consider the use of processes and methods that do not endanger the health of the population and the environment, as a result of the production and disposal of specific waste from industry.

Construction staff generates all sorts of wood waste, glass, and plastics that fall into the category of household waste.

Excavated earth and materials, plant debris, stone and stone fragments, concrete, bricks, ceramic materials are wastes from the excavations necessary to carry out the designed works.

Mixed construction materials waste and metal mixtures are wastes from construction materials excess. The constructions will be made according to the quality norms so that the quantities of the resulting waste will be limited to a minimum.

Some of these wastes, respectively those from excavations, will be recycled in fillings, leveling, and inert material.

It is difficult to make a quantitative assessment of this waste, the technologies adopted by the entrepreneur being a priority in assessing the nature and quantity of waste.

The activities on site will be monitored from the point of view of environmental protection, monitoring which will also include waste management.

3.4.1. Methods of waste management

Household waste - collection will be done on a contract basis in metal bins located in specially designed areas. They will be transported to authorized landfills or the transfer stations of the neighboring localities.

Evidence will be kept for the quantities delivered by the provisions of GD no. 349/2005 on waste storage, with subsequent amendments and completions.

Metal waste - the collection will be made on specially arranged and capitalized surfaces on a contract basis.

Evidence will be kept for the quantities capitalized by the provisions of GEO no. 16/2001 on the management of industrially recycled waste, approved by Law no. 456/2001, with subsequent amendments and completions.

Construction material waste - collection on specially designed areas and recovery by use in landfills.

Toxic and hazardous waste - in addition to the waste provided in the project, waste specific to their activity will accumulate on site. Quantities of engine oils from machine maintenance, sulfuric acid for batteries, metal parts (spare parts from machine repairs), used tires will accumulate.

3.5. Stipulations for environmental monitoring

3.5.1. Equipment and measures for the control of pollutant emissions into the environment

To prevent, reduce and eliminate the accidental harmful effects resulting from the Putna River development projects the unit will have a plan for the prevention of accidental pollution in which the service and maintenance personnel have well-established responsibilities.

The working personnel is obliged to participate in the labor protection training that is carried out by the leaders of the work processes and to acquire the labor protection norms corresponding to the activity they carry out.

3.5.2. Monitoring in the execution phase

To monitor the quality of environmental factors and to monitor site activities, it is preferred to conduct direct inspections, measurements, and laboratory analysis of the quality of environmental factors.

It is also mentioned that, by the current legislation, the establishment of the lands for the location of the site organizations of the material and waste depots is done by the builders when elaborating on the offers.

The behavior of the objective site in time will be visually monitored, through periodic inspections performed by the technical staff of the unit executing the works.

Monitoring of site activities will include the following:

1. monitoring the quality of the air in the emission at the site limit - periodically;
2. keeping records of waste management;
3. records of drinking water and electricity consumption as well as natural gas;
4. keeping records of water and air analysis bulletins;
5. report to the competent authorities for environmental protection.

As the impact on the environment during the operation of the planned works is minimal, the monitoring will consist of:

1. regular and scheduled direct observations to assess the state of the works and to make the necessary interventions in case of erosion;
2. collecting and removing captive floats;
3. prohibition of works in rehabilitated sectors, in order not to change the stability and integrity of the works as well as the flow conditions.

3.6. Works necessary for the organization of the site

3.6.1. Description of the works necessary for the organization of the site

The locations where these headquarters will be built must be designed in such a way as not to harm its natural human environment, by atmospheric emissions, by accidents caused by road traffic on-site, by material handling, by accidental unloading of machines transporting materials in surface watercourses, by producing noise.

They must be avoided: near sensitive areas, near watercourses that constitute water supply sources, near groundwater catchments or their compliance with protection conditions must be ensured. It is also recommended that they occupy as few areas as possible, so as not to remove too large areas of land from the current circuit.

It is recommended that the site of the site organization should not be near-surface waters, forests, and be outside the localities.

Incidents can be avoided by observing some organizational measures. Refueling the equipment while they are stationary will be done with the help of metal containers. The necessary repairs of the equipment will be made only in the workshops arranged within the site organizations.

It is forbidden to store earth, rubble, and raw stone in the lake bed or near the accumulation.

3.6.2. Site organization location

The site headquarter will be located on the land provided by the territorial administrative authority, having ensured the necessary utilities, respectively possibility of connection to the water source, electricity, telephone.

Inside the enclosure, with a permanent security guard, there will be placed/stored the barracks, the sleeping wagons, the equipment, the fuels, as well as the materials that will be used for the execution.

After the completion of the project the land on which the site organization is located will be returned to the mayor's office, under the conditions imposed by the owner.

3.6.3. Description of the environmental impact of the works of the site organization

Given the modalities chosen in the organization of the site, it is considered that the impact produced by this objective on the environment will be insignificant. In the case of a regular operation, no situations are foreseen in which events with a significant impact on the environment at the area level could occur.

Sources of pollutants and installations for the retention, disposal, and dispersion of pollutants in the environment during the organization of the site.

1. Site development works;
2. Road traffic generates NOx, SO, SO2, CO, heavy metals that through the atmosphere can be deposited on the soil surface leading to its contamination;
3. By temporarily storing construction materials;
4. By accidental spillage of petroleum products and motor oils from means of transport;
5. By storing waste in other areas than in specially arranged ones;
6. Technical equipment failures, refueling, machine repairs, accidents can lead to spills of fuel and oil that can be deposited in the soil, also leading to structural changes in the soil, rainwater that washes the site organization platform, and access roads. Wastewater if not collected and properly treated can seep into the soil, leading to its loading with pollutants.

It is appreciated that the mitigation and impact elimination measures, proposed together with the beneficiary's obligations comply with environmental legislation.

3.7. Site restoration works at the end of the activity

1. Proposed works for the restoration of the site at the end of the investment, in case of accidents and/or at the cessation of the activity;

2. Aspects related to the prevention and response to cases of accidental pollution;
3. Aspects related to the closure/decommissioning/demolition of the installation;
4. Ways to restore the initial condition/rehabilitation for later use of the land.

At the end of the works, closing works will be performed, which will consist of the following:

1. Technological road rehabilitation works;
2. Dismantling and evacuation of all industrial constructions and greening of the afferent surfaces necessary for the organization of the construction site;
3. Disposal of all machinery and means of transport;
4. Restoration of green areas if they were affected during the execution of the objective.

The construction period is a stage with a limited duration. It is appraised that the natural balance and the landscape will be restored after the completion of the works.

For the landscaping of the designed works, vegetation elements are recommended.

The vegetation elements proposed in the landscaping are trees and shrubs from resinous species that keep their green foliage throughout the year and deciduous species with deciduous leaves but with the advantage of chromatic variation depending on the season.

The primary background of landscape planning is grassland. The grassy strips on either side of the road on the route in the safety zone constitute exclusively the vegetal decoration, covering the embankments. The grassed surfaces, besides the role of soil stabilizer, compose the background on which the shrub vegetation stands out. [11]

4. PROTECTED PLANT AND ANIMAL SPECIES IN THE LOWER SIRET MEADOW (NATURALLY PROTECTED AREA)

4.1. Hydrographic characterization and the influence of hydrography on species and habitats

From a hydrological and hydrogeological point of view, ROSPA0071 falls into the Siret Hydrographic Basin.

The groundwater aquifer located in the sands and gravels of the alluvial meadow and terrace deposits is generally located at shallow depths of 1-5 m, except for the areas covered with diluvial proluvial deposits in the Şiretului plain, with a piezometric level of over 8-10 m, depth.

The coarse alluvial deposits have the highest thickness in the Mărăşeşti-Doaga-Cosmeşti region where they reach over 100 m. To the south, the alluvium thickness decreases to about 40 m in the Jorăşti-Boţârlău-Vulturu area and 15-20 m, in the Milcov-Risipiţi-Gologanu-Bordeasca, on the border with the Piedmont plain. With the decrease of the thickness and granulometry of the deposits to the south, there is thickening up to over 20 m, of the clay silt formations from the roof of the aquifer.

The waterproof bed develops continuously only in the Siretului meadow and terraces in the Adjud-Ciorani sector, as well as in the rambling plain and south meadow of Putna.

According to the Siret River Basin Management Plan, the hydrogeological parameters have the following values:

- The hydraulic conductivity varies in wide limits between 10 and 300 m/day, with average values between 30 and 100 m/day.
- The transmissivity is, on average, between 100-500 m^3/day, with much higher values between 1000-3000 m^3/day between the localities: Focşani, Jorăşti, Milcov-Risipiţi, Vlăduleasca, Vulturu, and Suraia, but also with values below 100 m^3/day.

The predominant type of groundwater is calcium bicarbonate or magnesium calcium bicarbonate. Starting from the Slobozia Ciorăşti area to the east, in the whole area that develops to the South of Milcov and Putna, both the mineralizations and the hardnesses increase. The intense process of groundwater mineralization is closely related to the decrease of the permeability of aquifer deposits and the decrease of the circulation speed of the groundwater aquifer towards the discharge areas from the confluence.

The groundwater aquifer is fed mostly by the underground inflow from the piedmont plain or from springs that appear in contact with this area. The supply from precipitation is very low where the aquifer is covered by clayey loess and more intense in the areas where the deposits of the aquifer appear on the surface, common situations in this area.

The mineralization of the waters from this hydrogeological unit is generally high, presenting values of 6000-12,000 mg/l, in the plain of Lower Siret where the chlorine content is the highest.

The main watercourse that crosses ROSPA0071 is the Siret river, which receives in this sector as tributaries the Trotuș rivers with 37 m^3/s, Sușița with flow under 1 m^3/s, Putna with 15.3 m^3/s, Râmnicu Sărat with 2.53 m^3/s and Buzău with 28.3 m^3/s on the right and Bârlad with

11.1 m^3/s, Călmățui with values below 1 m^3/s, Geru with values below 1 m^3/s, Suha with values below 1 m^3/s and Lozova with values below 1 m^3/s on the left. The supply of these watercourses is predominantly rain-level, the underground sources contributing to 10-35%.

Rivers in this sector have low runoff slopes, with values higher at Adjud 1.5 m/km and lower at Lungoci 0.4 m / km.

For this reason, the specific average runoff registers values between 2 and less than 0.5 l/s square km. The low drainage slope, doubled by a small specific average drainage, favors the clogging processes, as well as the meandering.

The average multiannual flow of the Siret at discharge is 250 m^3/s, with a minimum of 35 m^2/s and a maximum of 4650 m^3/s. The highest flow values appear in April-May, amid melting snow and high rainfall.

In fact, in springtime, 39.7% and summer 31.5% are the highest values of water leakage. At very high flows, floods occur, significant in this respect being the years 1969, 1991, 2005, and 2008.

The minimum flows occur in the cold period of the year, 12.1% of the total leakage, due to the accumulation of precipitation in solid form and negative temperatures.

The solid flow registers average values of 95 kg/s at the discharge into the Danube, with an annual transported volume of 5.98 million tons per year. To these are added 10% dragged alluvium. The values of this indicator have been considerably modified due to the construction of the Călimănești and Movileni accumulations.

The average water temperature is 11-12ºC, with minimum values in January 0.5-1ºC and maximum in July 22-23ºC. Freezing phenomena such as floods, ice on the shore, ice bridge are recorded annually, from the second decade of November until the first decade of March. In the last 50-100 days, it is more common in areas with low water speed.

In meandering areas, ice bridges are installed in very cold winter, which has a persistence of 20-30 days.

On an annual basis, according to Romanian Waters data, there are no exceedances of the second quality class, the general ecological status is well.

An important component of the hydrology of this area is represented by lakes.

Representative by size are:

- Călimănești accumulation lake, with an area of 749.9 ha and a volume of 44.3 million cubic meters, was put into use in 1993 to regularize water runoff, electricity production - 40 MW, and provide the necessary water for the Siret-Bărăgan Canal;
- Movileni storage lake, put into use in 2009, with an area of 900 ha, with a functional volume of 10 million m3. Its purpose is to regulate water flow on the river Siret and electricity production - 33.9 MW;
- The fish ponds Baltă Verde, Lacul de Argint, Baltă Doagă, Baltă Draglina, Lacul Negru, Lacul Măxineni, Lozova - 130 ha and Tălăbasca 192 ha;
- The meadow lakes - Nămoloasa Lake, Sacu Lake, Horseshoe - 48.8 ha.

4.1.1. Climate

The climate in ROSPA0071 is temperate continental with excessive shades. In the transition seasons, the influences of temperate-ocean air masses can be sensed, and in the warm season the tropical-dry ones. During winter, temperate-continental air advection from the northeast and east are frequent.

A key factor that accentuates the excessive character of the climate in the cold season is the substrate, dominant smooth and with a high share of aquatic surfaces. These favor wind intensifications and sharp temperature drops.

Solar radiation, the most important source of energy for biogeochemical processes, has average annual values between 125 and 127 kilocalories/square centimeter. The duration of sunlight is 2100-2200 hours per year, given that the nebulosity is 5.8-6 units.

Air temperature is one of the most important climatic parameters, as it influences physical, biological, and chemical processes, but also human activities, including tourism.

The average annual temperature in the studied area is between 9.3 ºC in the cloud and 11.1 ºC in the south. At Focsani weather station, the average air temperature is 9.6 ºC.

During the year, the air temperature registers a continuous increase from January to July, from 3-4 ºC to 20-22 ºC. The period with the thermal optimum for carrying out tourist activities begins in April and ends in November. The number of winter days, with a maximum daily temperature of ≤0 ºC, is 25-30 days a year, and the number of frosty days is over 100.

Atmospheric precipitation is another important climatic parameter for species and habitats. The annual amount of precipitation varies between 465-533 millimeters, the lowest values being registered in February, 20-30 millimeters, and maximum in June, 60-70 millimeters.

In Lower Siret Meadow the average annual number of days with snow cover is between 36 and 42. The average thickness of the snow layer reaches the highest values in January, 5 - 7 centimeters.

Hail precipitation, less specific in this area, has an incidence of 0.5-1 days per year. The average duration of hail episodes is 1-15 minutes, and the hail size is less than 3 cm. The period of occurrence of these phenomena is April-September, these being associated with stormy phenomena.

Drought episodes also affect the attractiveness of ROSPA0071 by favoring lower water levels, increasing the risk of collapse of steep banks, increasing substrate temperature, especially that uncovered or protected by vegetation, excessive drying of the substrate, with crust formation in areas predominant with clay fractions or with the entrainment in the atmosphere of the powders in suspension using the wind.

Representatives due to the high duration of the drought are the years 1961, 1963, 1964, 1967-1969, 1971, 1975, 1977, 1978, 2000. The periods with a high risk of drought are those related to the transition seasons.

The predominant winds are those from the northern and northeastern sectors, followed by those from the south, northwest, and southeast. Atmospheric calm has a frequency of 20-25% in the north and 15-20% in the south, near the confluence with the Danube. The average wind speed is 3.6-4 m/s, with higher values during the winter, when the gust reaching speeds of 30 m/s is sensed.

4.2. Describing soil and its influence on species and habitats

The distribution of soil types in ROSPA0071 is influenced by the lithological substrate, relief microforms, climatic characteristics, vegetation, aquatic surface characteristics, and anthropogenic activities.

In the Lower Siret Meadow, protisols have been developed on alluvial deposits, with carbonate loading, and in some places with deep glazing and salinization. Hydrosols can be identified near watercourses, where the solidification processes are in an incipient state.

On smaller surfaces, in the Lower Siret Meadow, in the confluence areas with the main tributaries, there are areas with intense salinization, on which salsodisols have formed.

Along ROSPA0071, on the slopes of Tutovei Hills and the terraces of Siret, luvisols appear.

Cernisols develop on the left bank of the Siret, near the Covorului Plateau.

In the Lower Siret Meadow, the dominant capitalization of the soils is the forest one, followed by the agricultural one - pastures. The areas occupied by arable land or other permanent plantations are very small and are limited to the spaces located near the localities.

4.3. The biotic environment

4.3.1. Habitats on the basis of which the protected natural area has been declared

The types of habitats for which the protected natural area has been declared have been described in terms of their existence in the protected natural area and the characteristics they have in general and in particular within it.

At the level of the study area that overlaps with ROSCI0162 Lunca Siretului inferior, respectively ROSCI0072, the sand dunes from Hanul Conachi, the following categories of habitats were reported:

Habitat category ROSCI0072/ROSCI0162

Habitat category	**ROSCI0072**	**ROSCI0162**
6120 * Xeric grasslands on calcareous substrate	X	
91AA Ponto-Sarmatic forest vegetation with fluffy oak	X	
3260 Streams from the plains to the mountains, with vegetation from *Ranunculion fluitantis* and *Callitricho-Batrachion*		X
6440 Alluvial meadows from *Cnidion dubii*		X
91F0 Mixed riparian forests with *Quercus robur, Ulmus laevis, Fraxinus excelsior or Fraxinus angustifolia, along the great rivers Ulmenion minoris*		X
3270 Rivers with muddy banks with vegetation of *Chenopodion rubri and Bidention*		X
92A0 Tales with white *Salix and white Populus*		X
91I0 * Euro-Siberian forest-steppe vegetation with *Quercus spp*		X
91E0 * Alluvial forests with *Alnus glutinosa and Fraxinus excelsior Alno- Padion, Alnion incanae, Salicion albae*		X

Table no.1.Types of habitats bin protected area

4.4. Avifauna species based on which the protected natural area was declared ROSPA0071 The Lower Siret Meadow

4.4.1. List of avifauna species protected by ROSPA0071 The Lower Siret Meadow

Species	Population size	Species	Population size
Alcedo atthis	S=50-100 individuals	Anas crecca	P=200-300 individuals

			I=100-150 individuals
Ardea purpurea	C=5-12 couple P=50-100 individuals	Anas penelope	C=10-20 couple P=5000-10000 individuals I-5000-10000 individuals
Ardeola ralloides	C=5-10 couple P=10-50 individuals	Anas platyrhynchos	C=3-5 couple P=50-100 individuals
Aythya nyroca	C=20-30 couple P=50-100 individuals	Anas querquedula	C=3-5 couple P=50-100 individuals
Chlidonias hybridus	C=50-80 couple P=100-500 individuals	Anas strepera	C=3-5 couple P=400-500 individuals
Chlidonias niger	C=5-10 couple P=10-50 individuals	Anser anser	C=3-5 couple P=400-500 individuals
Ciconia ciconia	C=25-30 couple P=500-1000 individuals	Aythya ferina	C=3-5 couple P=400-500 individuals
Circus aeruginosus	C=8-12 couple P=50-100 individuals	Aythya fuligula	I=10-20 individuals
Cygnus cygnus	I=50-100 individuals	Buteo buteo	C=4-6 couple P=100-500 individuals I=50-100 individuals
Egretta albă	C=10-15 couple P=50-100 individuals I=10-15 individuals	Chlidonias leucopterus	C=2-3 couple P=10-50 individuals
Egretta garzetta	C=30-40 couple P=200-300 individuals	Cygnus olor	C=20-30 couple P=300-500 individuals I=100-200 individuals
Glareola pratincol	P=5-10 individuals	Falco tinnunculus	C=10-20 couple P=50-100 individuals I=50-100 individuals
Ixobrychus minutus	P=10-14 individuals	Fulica atra	C=30-50 couple P=2500-3000 individuals I=300-500 individuals
Lanius collurio	C=100-500 couple P=1000-5000 individuals	Larus cachinnans	C=20-25 couple P=300-500 individuals I=50-100 individuals
Lanius minor	C=20-35 couple P=100-500 individuals	Limosa limosa	P=500-1000 individuals
Larus minutus	P=20-50 individuals	Merops apiaster	C=300-500 couple P=1000-5000 individuals
Nycticorax nycticorax	C=20-30 couple P=100-200 individuals	Phalacrocorax carbo	P=500-1000 individuals I=100-500 individuals
Pelecanus onocrotalus	P=100-200 individuals	Podiceps cristatus	C=30-50 couple P=300-500 individuals
Platalea leucorodia	P=10-50 individuals	Tadorna tadorna	P=5-20 individuals
Recurvirostra avosetta	P=25-50 individuals	Tringa erythropus	P=100-150 individuals
Sterna hirundo	C=100-200 couple P=500-1000 individuals	Tringa totanus	P=10-50 individuals
Anas acută	P=20-35 individuals	Vanellus vanellus	C=30-40 couple P=500-700 individuals
Anas clypeata	P=30-60 individuals	Larus ridibundus	C=30-50 couple P=1000-5000individuals I=200-300 individuals

Table no.2. Bird species from the protected area

Inscription:
S - Permanent, sedentary/resident population;
P - Passing population using protected natural area for rest and/or feeding;
C - Non-resident nesting population - which uses the protected natural area for reproduction;
I - Population that only winters in the protected natural area.

Figure 20. Winter swan (Cygnus cygnus) (author's photo)

4.4.2. List of invertebrate species subject to the protection of protected natural areas ROSCI0162 and ROSCI0072

Species	Population size
Cerambix cerdo	30-70 individuals
Lucanus cervus	100-500 individuals

Table no.3. List of invertebrate species

4.4.3. List of reptilian and amphibian species protected by protected natural areas ROSCI0162 and ROSCI0072

Species	Population size
Emys orbicularis	100-150 individuals
Triturus cristatus	1000 individuals
Bombina bombina	100000 individuals

Table no.4. List of reptile species

Figure 21. Turtle (Testudines) [12]

4.4.4. List of mammal species protected by ROSCI0162

Species	Population size
Lutra lutra	30-50 individuals
Spermophilus citellus	100-300 individuals

Table no.5. List of mammal species

Figure 22. Otter (Lutra lutra) [12]

4.4.5. List of fish species subject to the protection of protected natural areas

Species	Population size
Aspius aspius	500-1000 individuals
Cobitis taenia	1000-5000 individuals
Gobio kessleri	1000-5000 individuals
Gobio albipinnatus	1000-5000 individuals
Gymnocephalus schraetzer	100-300 individuals
Misgurnus fossilis	100-500 individuals
Pelecus cultratus	500-1000 individuals
Rhodeus sericeus amarus	300-600 individuals
Zingel streber	3000-7000 individuals
Zingel zingel	5000-1000 individuals

Table no.6. List of fish species [12]

Figure 23. The eel or the lamprey (Misgurnus fossilis) [13]

Figure 24. Danube streber (Zingel streber) [14]

5. FORMS OF DEGRADATION OF EROSION CONTROL WORKS - CASE STUDY

5.1. Degradation of gabion works

Degradation of gabion works is a process due to the destructive action exerted by external geomorphological and chemical agents, by decreasing the elevation of the trough, the movement of the land behind the work, and the destructive action exerted by corrosion.

5.1.1. Overturning of the works with gabions

Overturning is the phenomenon of moving a body from its normal position, causing it to fall to one side or reach upside down.

Figure 25. Gabion work covered with overturned concrete (author's photo)

Figure 26. Overturned gabion work (author's photo)

5.1.2. Sliding degradation

Sliding is a smooth movement, without encountering any resistance, when two bodies in contact move relative to each other tangentially, without rolling.

Figure 27. Gabion work degraded by sliding (author's photo)

5.1.3. Degradation by lowering the elevation of the trough

A trough means the line that follows the lowest part of the bed of a watercourse or a valley and which joins between them the deepest points of the bed of a running water or of a dry valley.

The trough is also called the water concentration line.

Figure 28. Degradation by lowering the level of the trough of simple gabion works (author's photo)

Figure 29. Degradation by lowering the level of the trough of the works of gabions covered with concrete with concrete (author's photo)

5.1.4. Degradation caused by execution method

Improper execution of works can cause degradation of gabion works.

Figure 30. Degradation resulting from incorrect execution (author's photo)

5.1.5. Degradation caused by the transport of alluvium and floats

During floods the transport of coarse alluvium or floats is much higher than in the period when the river flows are low.

In areas with spontaneous forest vegetation located in the minor riverbed or in the area of the banks during floods, the banks are eroded and the trees are displaced and then transported.

Trees can cause dams that block the free flow of water or destroy the net from gabion work.

Figure 31. Degradation caused by the transport of alluvium and floats (author's photo)

5.2. Degradation of works in geocontainers

5.2.1. Degradation of the geocontainer itself

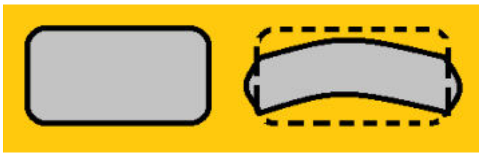


Figure 32. Degradation by bending

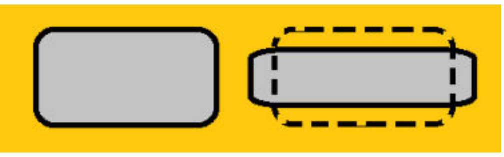


Figure 33. Degradation by flattening

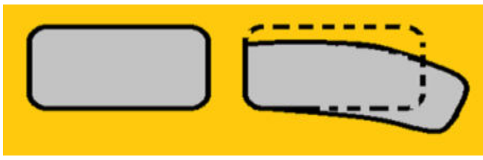


Figure 34. Degradation by leaning

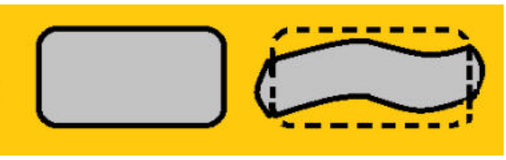


Figure 35. Degradation by the "caterpillar" effect

Figure 36. Degradation by flattening and bending

5.2.2. Degradation of works in geocontainers

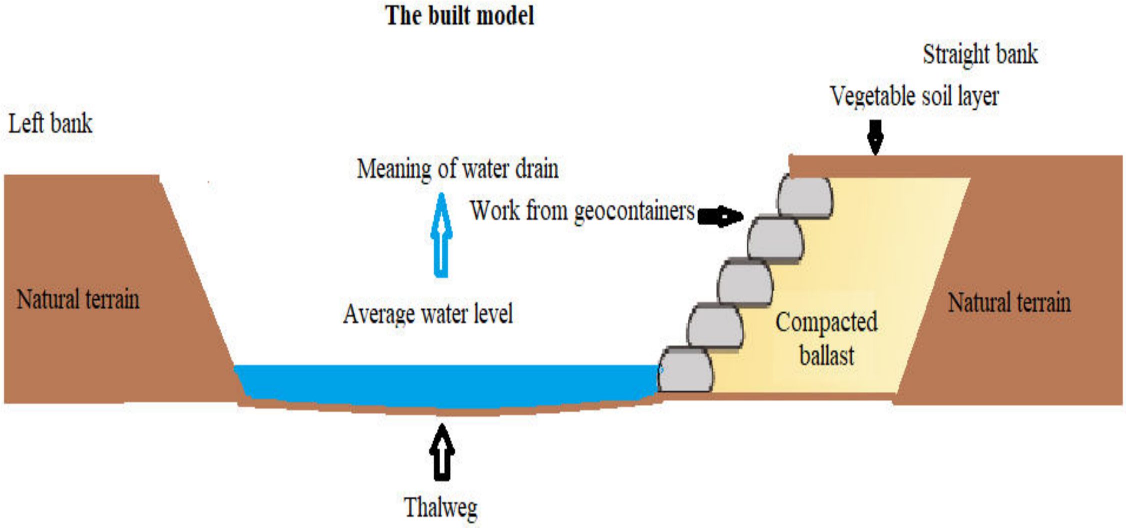


Figure 37. Model of location of the work in geocontainers

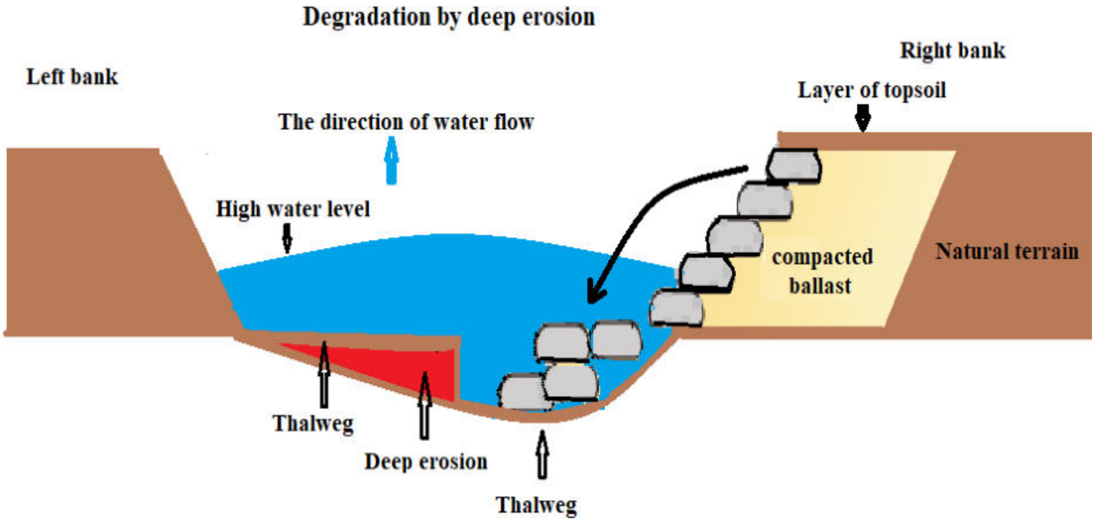


Figure 38. Degradation of geocontainer work by decreasing the elevation of the basin

Figure 39. Degradation of the geocontainer work by decreasing the elevation of the basin - situation on site (author's photo)

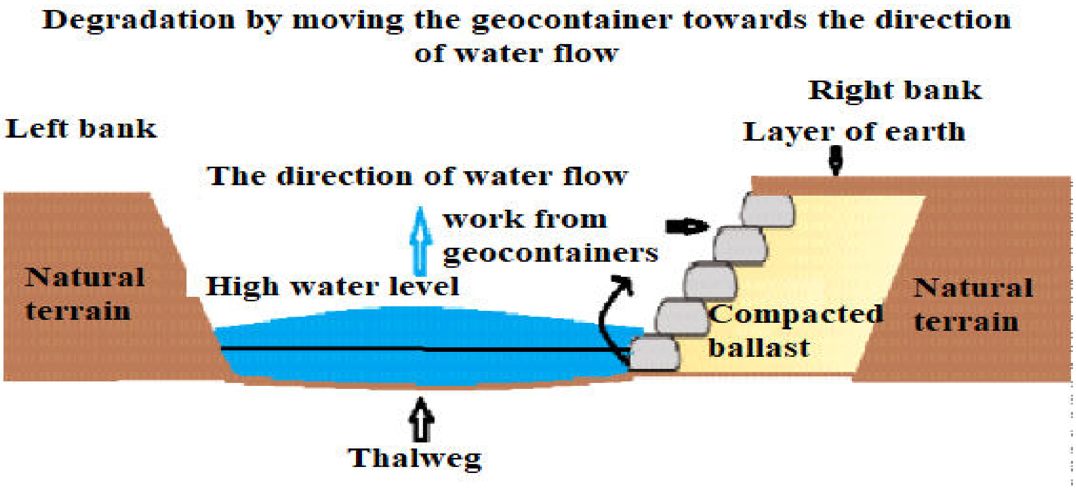


Figure 40. Degradation of geocontainer work by moving the geocontainer

Figure 41. Degradation of the geocontainer work by moving the geocontainer - transversal work (author's photo)

5.2.3. Degradation by exceeding the level of the work

During floods, the water level exceeds the crown of the transverse works (groynes) and can degrade the work by twisting the geocontainers.

Following the observations made in the studied area with transversal works from geocontainers, only one case of degradation was identified.

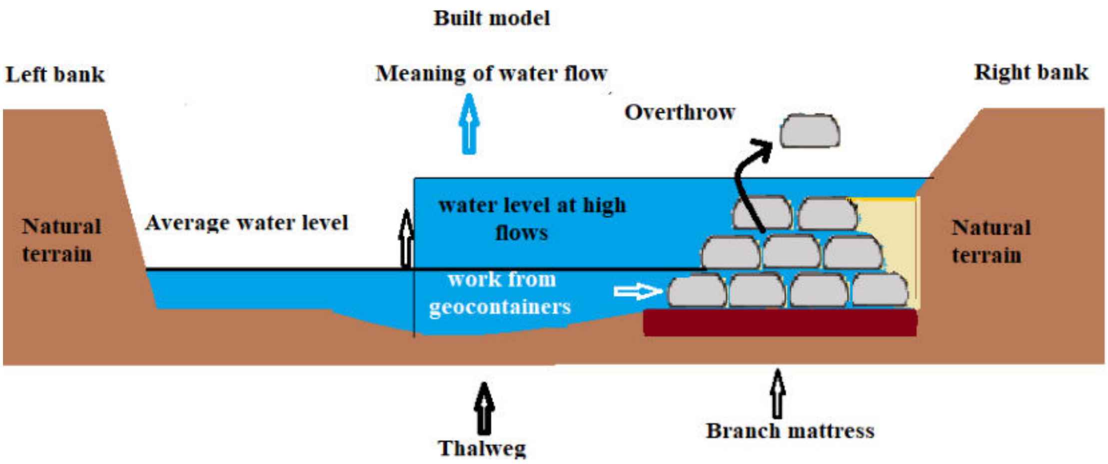


Figure 42. Degradation by exceeding the level of the work

Figure 43. Degradation by exceeding the level of the work (author’s photo)

5.2.4. Degradation through vandalism

Vandalism is an act that involves the intentional destruction or damage to property.

Works in geocontainers can be vandalized through:

- cutting the bags;
- arson.

Figure 44. Degradation through vandalism (author’s photo)

5.2.5. Degradation by breaking the seams

The thread used to sew the geocontainers, if it is of low quality when in contact with the water, it rots and the seam is destroyed.

By destroying the seam, the material in the bag is transported by water or comes out of it depending on the position of the deocontainer located.

Figure 45. Degradation by breaking the seam**s** [15]

5.2.6. Degradation caused by sharp or angular objects

Sharp or angular objects during loading into the geocontainer or handling it in carrying out the work, pierce the geotextile, and over time the material inside it is washed with water and the phenomenon of "caterpillar" can occur.

Figure 46. Degradation caused by sharp or angular objects (author’s photo)

5.2.7. Degradation caused by float transport

Following the field verifications in the areas with studied geocontainer works, the degradation phenomenon caused by floats is identified in the case of transversal works (groynes).

Figure 47. Degradation caused by float transport (author’s photo)

6. EVOLUTION OF WORKS IN GEOCONTAINERS - CASE STUDY

6.1. Methods approached in the analysis and modeling of the work behavior

The methods approached in the analysis of the evolution of works in geocontainers is a combination of traditional methods based on measurements made in the field and modern ones based on spatial analysis.

Spatial analysis was performed based on morphometric maps from Google Earth, and the classical one was performed by field measurements using GPS Hi-Target and Leica Total Station, and the interpretation of data from field measurements was performed by the method of analytical calculation with the AutoCAD and ProgeCAD programs on georeferenced maps in the ArcGIS and Orthophotoplan program.

The method of analytical calculation is applied to surfaces when rectangular coordinates of the top of the polygon are known. Compared to the other methods, it ensures the highest accuracy and does not require the existence of the topographic plan.

The general calculation of the area of a polygon with n sides is:

$$2 \cdot S = \sum_{i=1}^{n} X_i (Y_{i+1} - Y_{i-1}) \quad (35)$$

The rectangular coordinates individualize the horizontal position of the topographic points by the abscissa (Y) and the ordinate (X) of the projection of the points in the reference plane.

By topographic points is meant a series of topographic points, which reported on the plans faithfully reproduce the topographic details on the ground.

By choosing the characteristic points, a geometrization of the irregular figures in the field is achieved, which facilitates both their representation on the plane and the calculation of the surfaces.

These contours reproduce with great fidelity the sinuous line and represent the advantage that they can be determined horizontally or vertically, compared to a reference system.

Following the projection of the topographic points, a topographic profile results and is the graphic representation in the plan of the intersection line between the land surface and a vertical surface that passes through two or more given points.

Following the overlapping of the topographic profiles, the level difference results which is the vertical distance between the level surfaces of two points A and B:

$$\Delta HAB = B B' , \text{ sau } \Delta H_{AB} = H_B - H_A. \quad (36)$$

The level difference can be positive or negative, depending on the altitude of the point and the direction considered, if HB > HA, then ΔHAB = HB - HA is positive, but ΔHBA = HA-HB is negative. [73]

The total station also called *electronic tachometer* is an optical instrument used in topographic measurements. Total stations are a new generation of devices that include state-of-the-art fine mechanics, electronics and optics.

The design of such a tachometer brings together in a single portable unit, the size, and appearance of an ordinary theodolite, the components needed to measure the following elements using electromagnetic waves.:

- Horizontal and vertical angles;
- Inclined distances and/or short distances on the horizon;
- Relative rectangular coordinates DX and DY;
- DH level differences.

The coordinates of an unknown point can be determined using the total station and using a point with known coordinates as a reference. The two points and the station must form lines of direct visibility between them. However, it is possible that the station does not have direct visibility but a GNSS (Global Navigation Satellite System) receiver.

Angles and distances are measured by the total station from the point of interest using trigonometry and triangulation.

The measurement of angles at modern stations is done by scanning with extreme precision the digital barcode engraved on the rotating glass cylinders or discs in that instrument. The measurement of distances uses the principle of triangulation, by emitting a beam of light to the point of interest. The reflected beam is captured and interpreted by the computer in the total station. The measurement error is of the order of millimeters.

From a practical point of view, the angular and linear elements mentioned above are measured between the station point and the target point and based on the calculation program the short distances to the horizon, the relative coordinates DX, DY, and DH, and the absolute X, Y, H coordinates of the waypoints are determined as well as of the radiated points.

The total measuring stations have their own memory center and external memory, as well as a series of calculation programs specific to topo-geodetic measurements that are used in topographic surveys.

The measured and calculated data are stored and then transferred to the memory of a computer, wherewith the help of processing programs the graphic components are determined, which are drawn in an automated system with plotters attached to the computer. [16]

G.P.S - Global Positioning System

GPS is an important application based on the principle of triangulation. It is a global radio navigation system consisting of a constellation of 24 satellites and their ground stations.

GPS uses satellites as reference points to calculate positions with an accuracy in the range of meters, but with advanced variants of G.P.S. measurements there can be made with an accuracy of less than one centimeter. [17]

The spatial analysis used aerial photography and Google Earth software that includes a virtual globe, a map and geographic information. The Earth map is generated from the overlap of satellite images, aerial photographs and geographic data on a 3D globe. [18]

Orthophotoplan, orthophotography or orthoimage is an aerial photograph or a geometrically corrected image ("orthorectified") so that the scale is uniform: the photograph has the same lack of distortion as a map.

Unlike uncorrected aerial photographs, an orthophoto can be used to measure true distances because it is an accurate representation of the Earth's surface, being adjusted for topographic relief, lens distortion, and camera tilt.

Orthophotographs are commonly used in geographic information systems (GIS) as a precise background image on the map. [19]

The calculation of the volumes of sand and gravel was performed by the method of transversal profiles (sections perpendicular to the flow direction) that delimit the calculation units.

The calculation was based on topographic surveys by making transverse profiles.

The evaluation of the volumes of sand and gravel was done with the help of the following calculations:

Area (m^2) the designed flow section that delimits the calculation units;

Distance (m) between two successive sections or from the section to the edge of the study area. The volume is determined by:

$$V_B = (S_1+S_2)/2xd \quad (37)$$

where:

V_B - unit of calculation volume (m3)

S_1+S_2 - area of delimitation sections (m2)

d - distance between sections (m)

The total volume of resources is determined by the relationship:

$$V = \sum_{1}^{n} V_B \quad (38)$$

where:

n - number of blocks

6.2. Evolution and analysis of works in geocontainers

6.2.1. Râmnicu Sărat river bank consolidation, Râmnicu Sărat locality, Buzău county

Analysis and evolution of erosion by the spatial method

Figure 48 shows the evolution of bank erosion and the profile of the Râmnicu Sărat riverbed in the period 2018-2019, in the area of Râmnicu Sărat locality.

Following the execution of the work in geocontainers and the floods registered on the Râmnicu Sărat river, the right bank was eroded, the river basin is at the base of the bank, and alluvium in the riverbed accumulated in the right bank area. The total eroded surface is approximately 4,336 m2, with a total length of 214 m.

Figures 51, 52 and 53 show the configuration of the right bank, generated by the satellite following the evolution of the work in geocontainers in the period 2018-2019, where in 2018 erosion was pronounced in the right bank area.

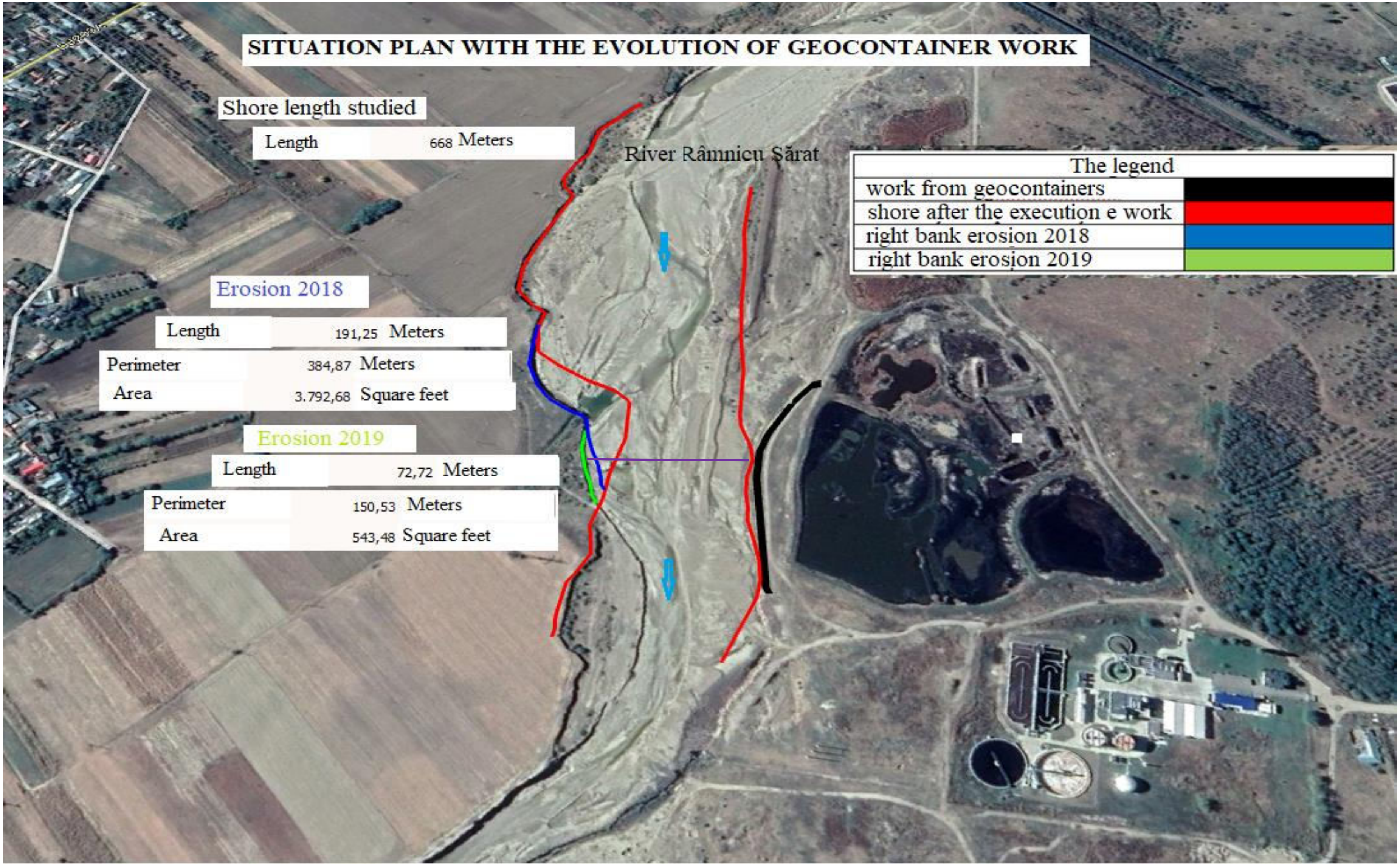


Figure 48. The evolution of the work in geocontainers in the period 2018-2019

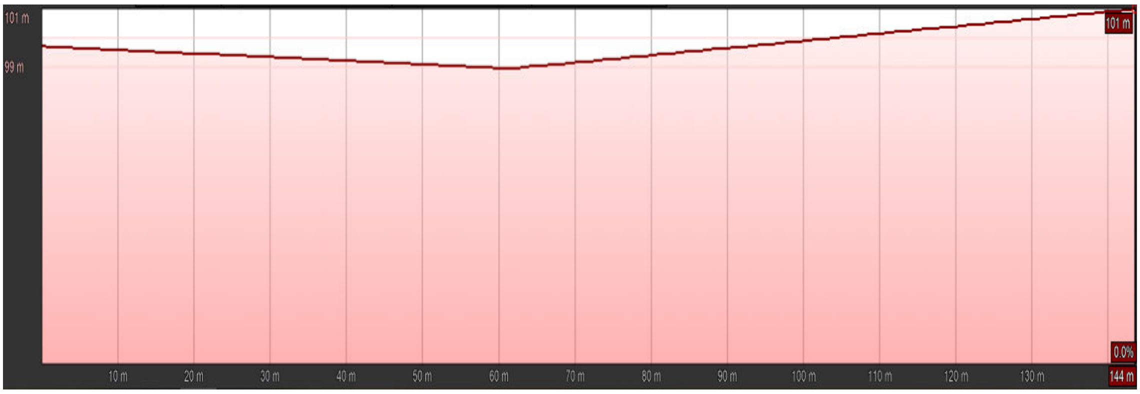


Figure 49. The transversal profile of the erosion of the bank of the Râmnicu Sărat river in the area studied in 2017

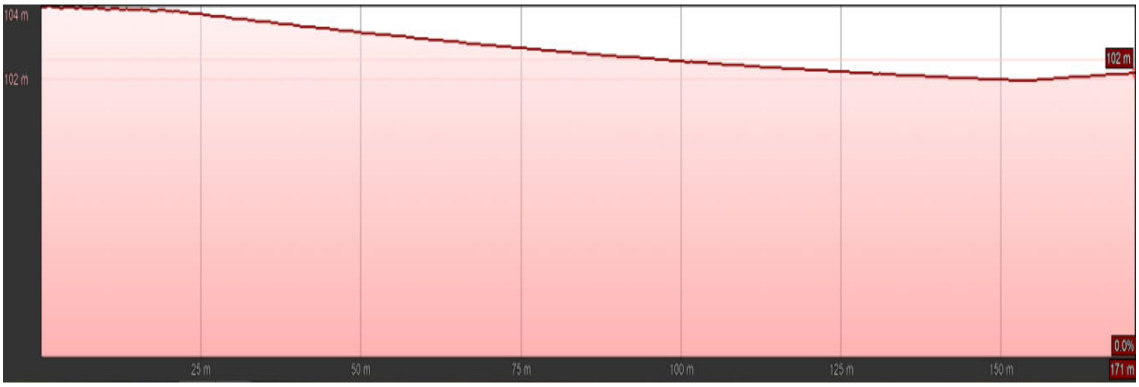


Figure 50. Transversal profile through the Râmnicu Sărat riverbed in 2018 after the execution of the work

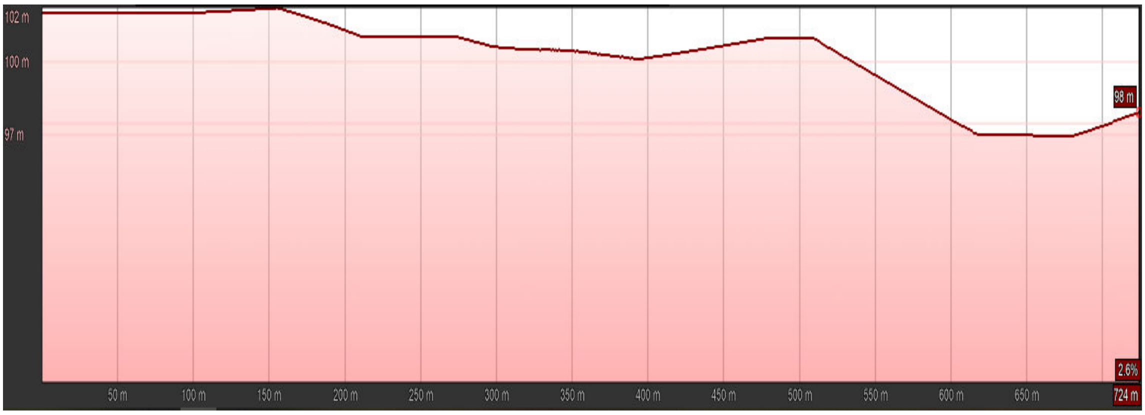


Figure 51. Transversal profile through the Râmnicu Sărat riverbed in 2019 after the execution of the work

Evolution by the method of analytical calculation

Following the overlapping of the topographic profiles, the level difference results and is the vertical distance between the level surfaces of two points A and B.

The interpretation of the data obtained from the field measurements is presented below.

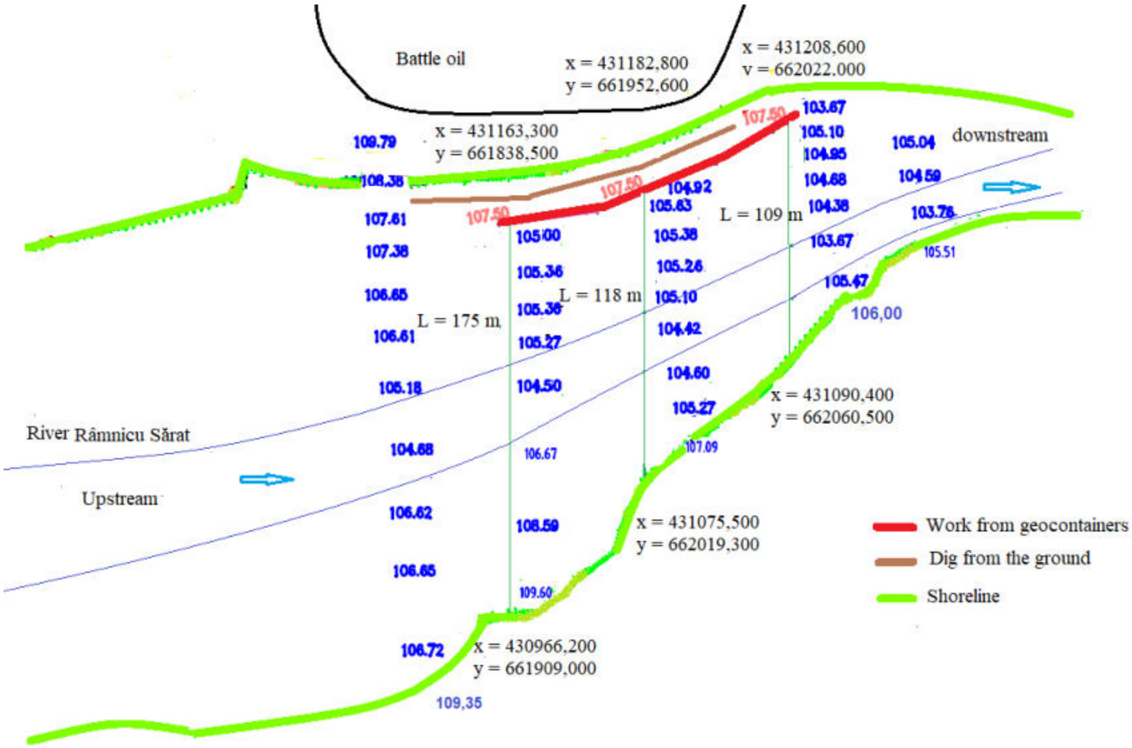


Figure 52. Situation plan with topographic measurements

Elevations of the riverbed profile, upstream

Nr.crt	Land elevation
1	107,50
2	105,36
3	105,27
4	104,50
5	106,67
6	108,59
7	109,60

Table no.7. Land elevations in the studied area, upstream

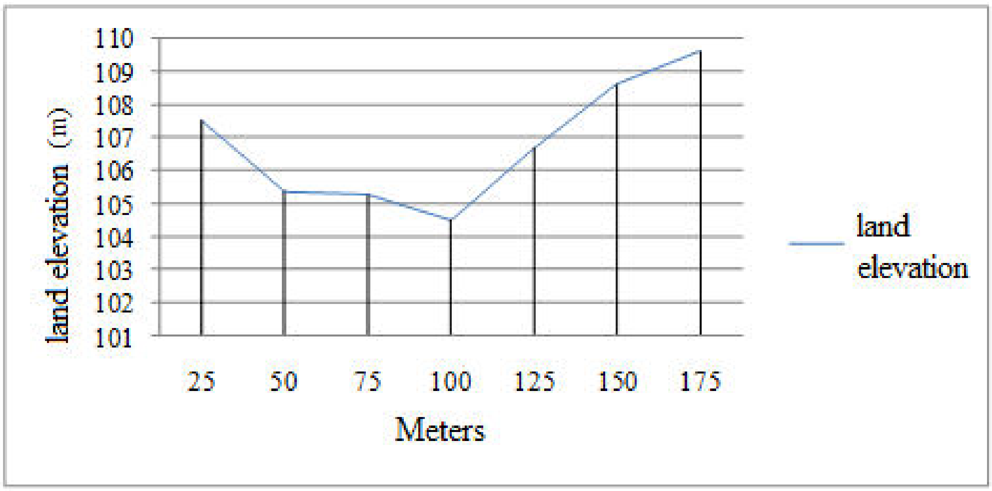


Figure 53. Riverbed profile of the studied area, upstream

Nr. crt	Land elevation	Level Q 65,7m³/s	Level Q 70,7m³/s
1	107,50	106	107
2	105,36	106	107
3	105,27	106	107
4	104,50	106	107
5	106,67	106	107
6	108,59	106	107
7	109,60	106	107

Table no.8. Land elevations and water flow levels in the profile section, upstream

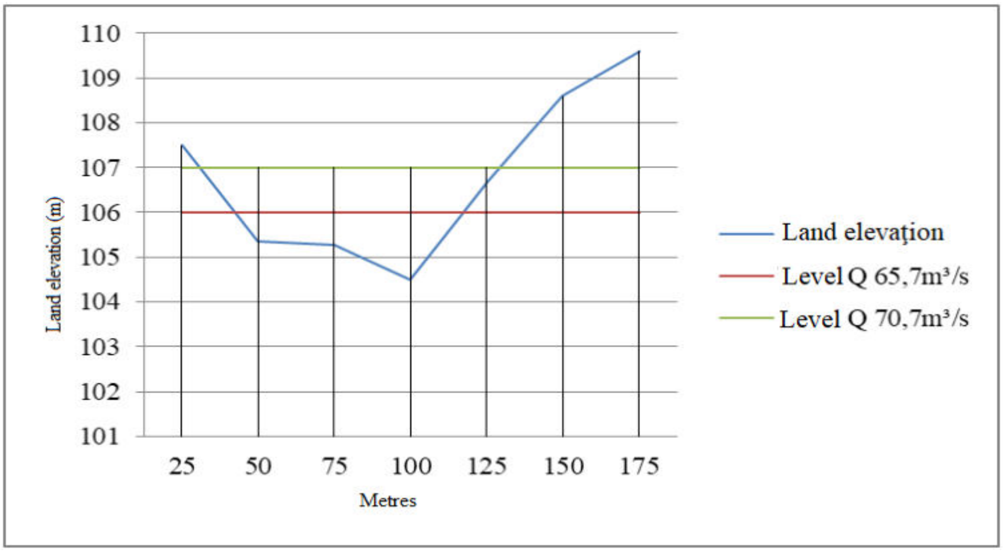


Figure 54. Land elevations and water flow levels in the profile section, upstream

The elevations variation of the riverbed profile with the clogged area upstream

Nr. crt	LEVEL	INITIAL PROFILE LEVEL	TRIM. 3-2018	TRIM. 4-2018	TRIM. 1-2019	TRIM. 2-2019
1	WORKING LEVEL	107,50	107,50	107,50	107,50	107,50
2	FOUNDATION LEVEL	104,50	104,50	104,50	104,50	104,50
3	GEOCONTAINER WORK LEVEL	105,00	105,00	105,00	105,00	105,00
4	THE INITIAL LEVEL MONITORED	105,36	105,36	105,44	105,56	105,56
5	POINT LEVEL 1	105,36	105,36	105,46	105,43	105,49
6	POINT LEVEL 2	105,38	105,39	105,37	105,46	105,51
7	POINT LEVEL 3	105,27	105,30	105,35	105,40	105,45
8	LEVEL THALWEG	104,50	104,50	104,51	104,53	104,60

Table no.9. The elevations variation of the riverbed profile with the clogged area upstream

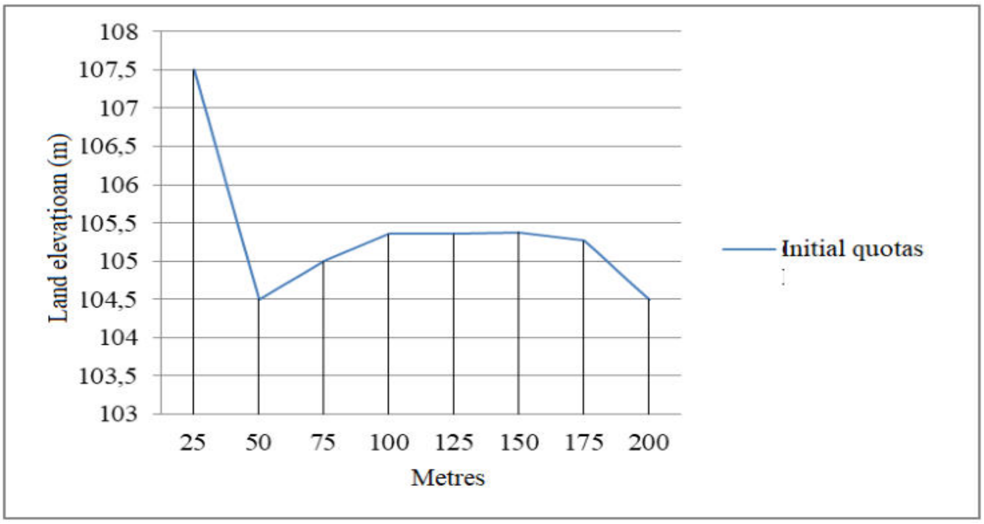


Figure 55. Profile ratings tracked upstream

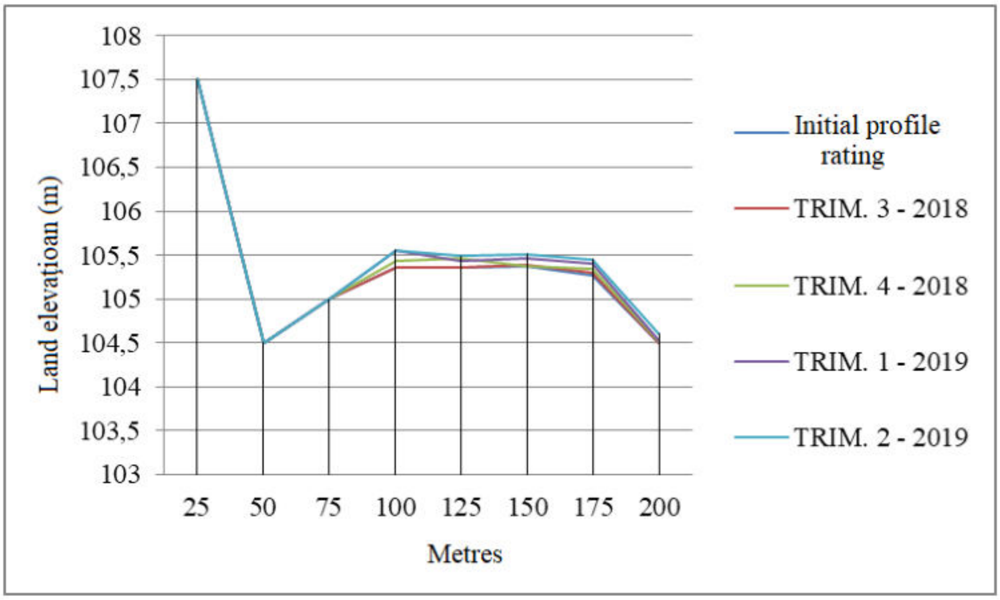


Figure 56. The variation of the upstream riverbed profile, with the area clogged after the execution of the work in the period 2018-2019

The level of variation of the riverbed profile after the execution of the work, upstream

Nr. crt	Initial profile level	TRIM. 3 - 2018	TRIM. 4 - 2018	TRIM. 1 - 2019	TRIM. 2 - 2019
1	107,50	107,50	107,50	107,50	107,50
2	105,36	105,39	105,37	105,46	105,51
3	105,27	105,30	105,35	105,40	105,45
4	104,50	104,50	104,51	104,53	104,60
5	106,67	106,67	106,67	106,67	106,67
6	108,59	108,59	108,59	108,59	108,59
7	109,60	109,60	109,60	109,60	109,60

Table no.10. Level variation of the riverbed profile after the execution of the work, upstream

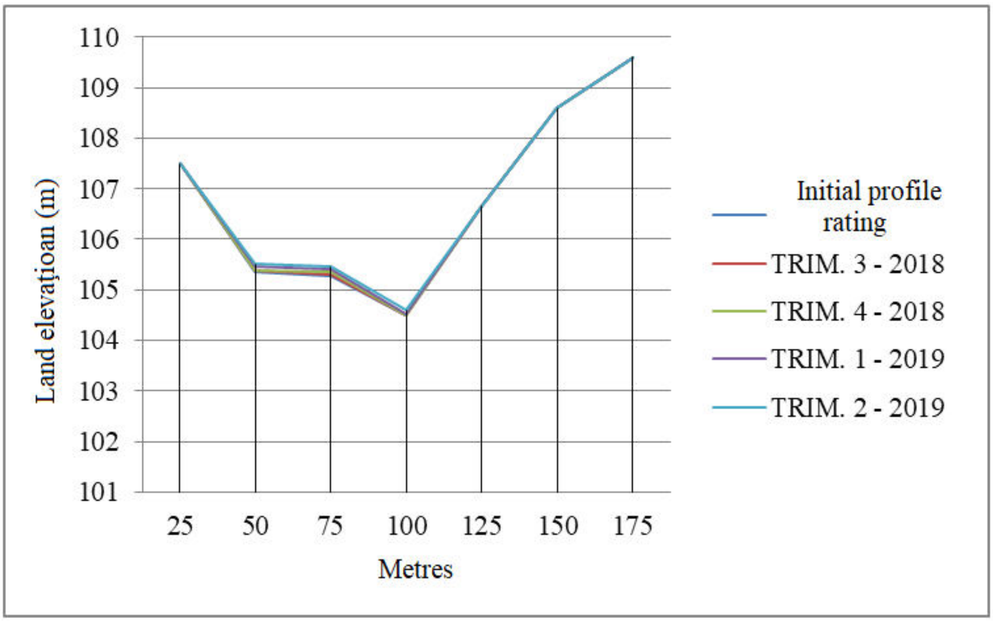


Figure 57. Variation of the profile of the riverbed clogged area, upstream

Basins profile elevations, intermediate:

Nr. crt	Land elevation
1	107,50
2	105,63
3	105,26
4	105,10
5	104,42
6	104,60
7	105,27
8	107,09

Table no.11. Land elevations in the studied area, intermediate

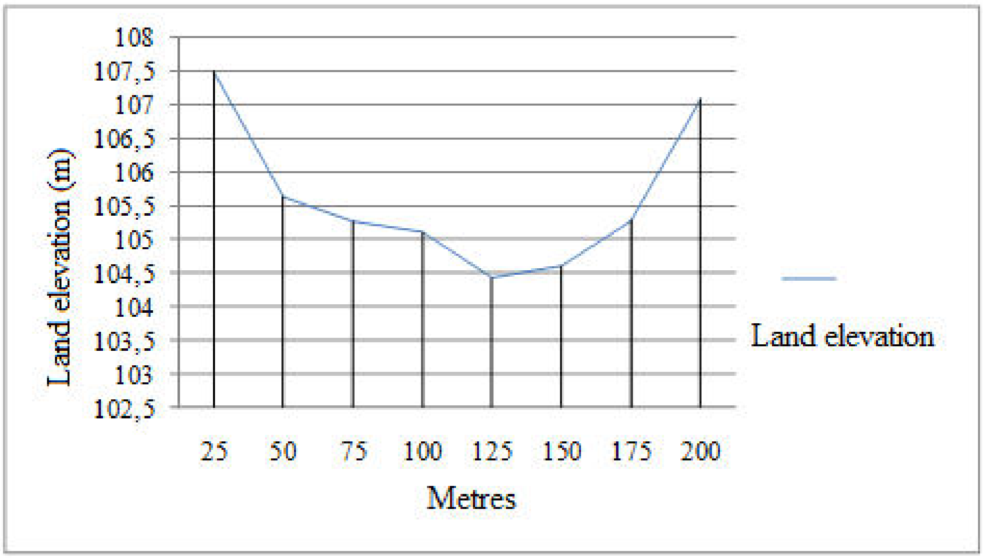


Figure 58. Riverbed profile in the studied area, intermediate

Nr. crt	Land elevation	Level Q 65,7m³/s	Level Q 70,7 m³/s
1	107,50	106	107
2	105,63	106	107
3	105,26	106	107
4	105,10	106	107
5	104,42	106	107
6	104,60	106	107
7	105,27	106	107
8	107,24	106	107

Table no.12. Land elevations and water flow levels in the profile section, intermediate

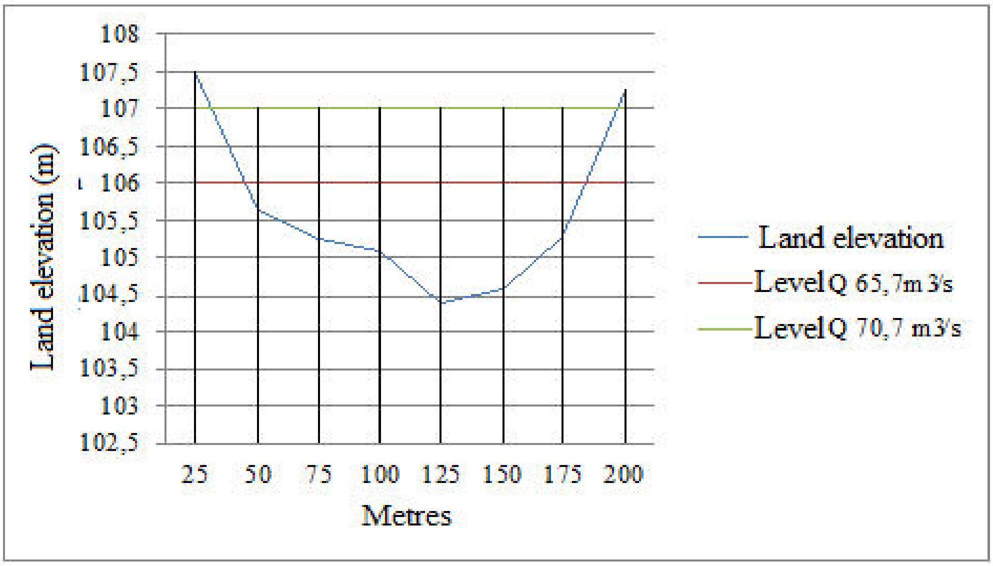


Figure 59. Land elevations and water flow levels in the profile section, intermediate

Levels of variation of the riverbed profile with the clogged area, intermediate

Nr. crt	LEVEL	INITIAL PROFILE LEVEL	TRIM. 3-2018	TRIM. 4-2018	TRIM. 1-2019	TRIM. 2-2019
1	WORKING LEVEL	107,50	107,50	107,50	107,50	107,50
2	FOUNDATION LEVEL	104,50	104,50	104,50	104,50	104,50
3	GEOCONTAINER WORK LEVEL	104,92	105,00	105,00	105,00	105,00
4	THE INITIAL LEVEL MONITORED	105,38	105,36	105,38	105,41	105,45
5	POINT LEVEL 1	105,38	105,36	105,28	105,43	105,47
6	POINT LEVEL 2	105,26	105,23	105,30	105,32	105,34
7	POINT LEVEL 3	105,10	105,14	105,19	105,22	105,27
8	LEVEL THALWEG	104,42	104,42	104,43	104,45	104,45

Table no.13. Levels of variation of the riverbed profile with the clogged area, intermediate

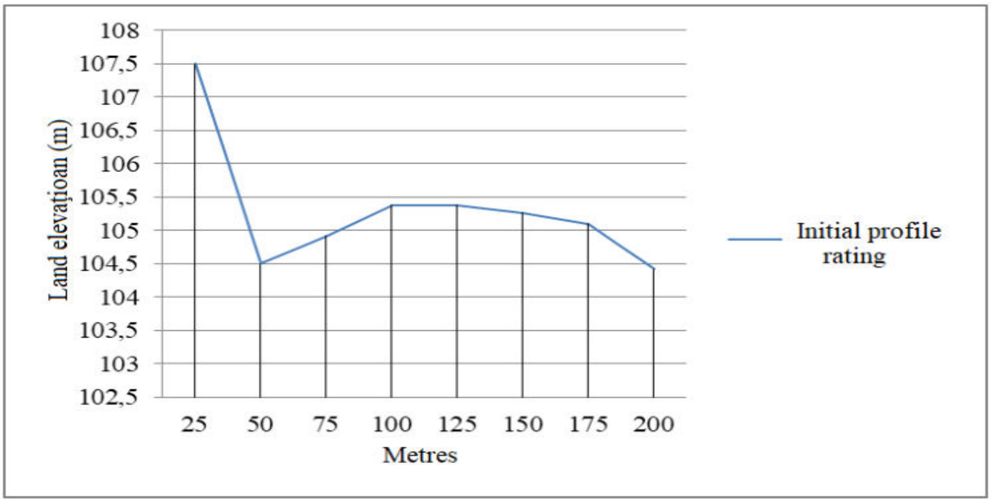


Figure 60. Profile levels intermediately tracked

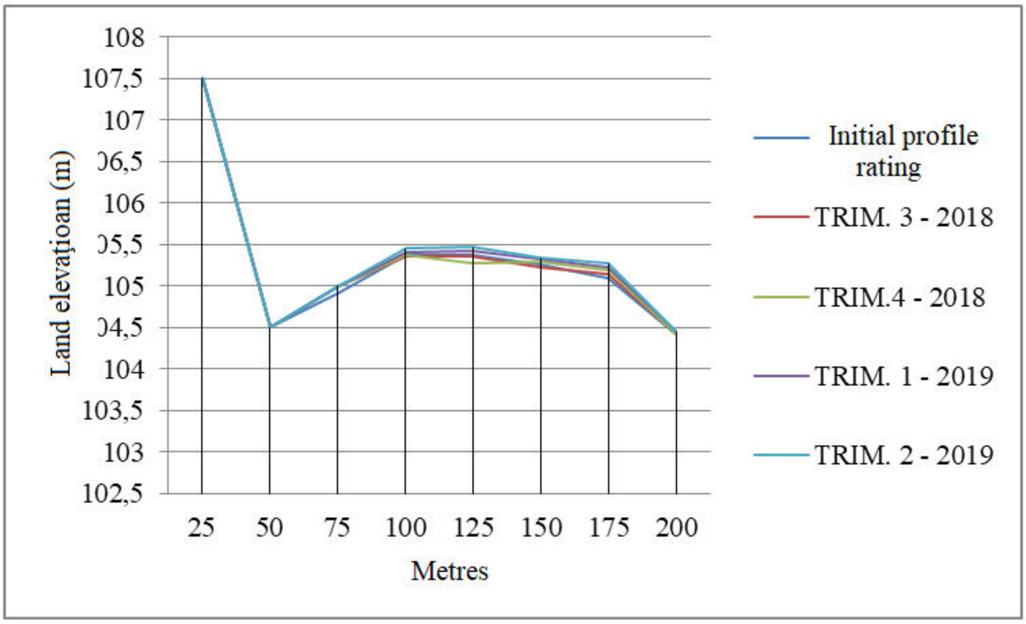


Figure 61. The variation of the profile of the intermediate riverbed, with the area clogged after the execution of the work in the period 2018-2019

Level variation after the execution of the work, intermediate:

Nr. crt	Initial profile level	TRIM. 3 - 2018	TRIM.4 - 2018	TRIM. 1 - 2019	TRIM. 2 - 2019
1	107,50	107,50	107,50	107,50	107,50
2	105,63	105,36	105,28	105,43	105,47
3	105,26	105,23	105,30	105,32	105,34
4	105,10	105,14	105,19	105,22	105,27
5	104,42	104,42	104,43	104,45	104,45
6	104,60	104,60	104,60	104,60	104,60
7	105,27	105,27	105,27	105,27	105,27
8	107,09	107,09	107,09	107,09	107,09

Table no.14. Variation of the riverbed profile after the execution of the work, intermediate

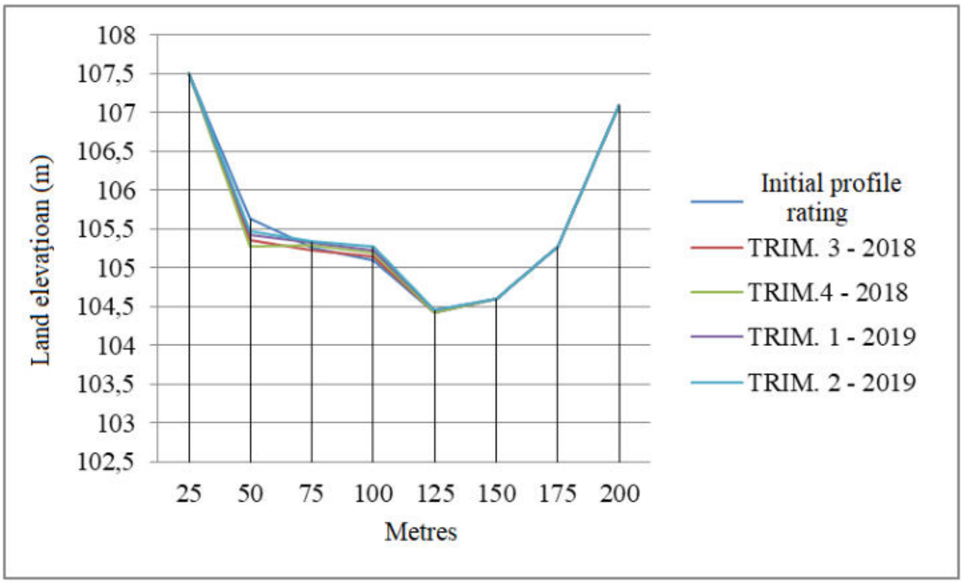


Figure 62. Variation of the riverbed profile of the clogged area, intermediate

Riverbed profile elevations:

Nr. crt	Land elevation
1	107,50
2	105,10
3	104,95
4	104,68
5	104,38
6	103,67
7	105,46
8	106,00

Table no.15. Land elevations in the studied area, downstream

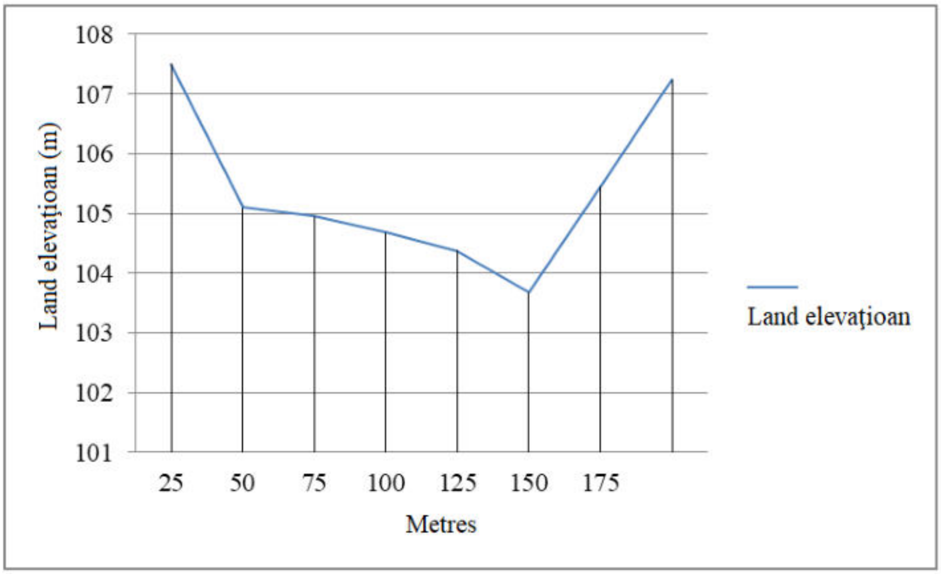


Figure 63. Riverbed profile in the studied area, downstream

Nr. crt	Land elevation	Level Q 65,7 m³/s	Level Q 70,7 m³/s
1	107,50	106	107
2	105,10	106	107
3	104,95	106	107
4	104,68	106	107
5	104,38	106	107
6	103,67	106	107
7	105,46	106	107

Table no.16. Land elevations and water flow levels in the profile section, downstream

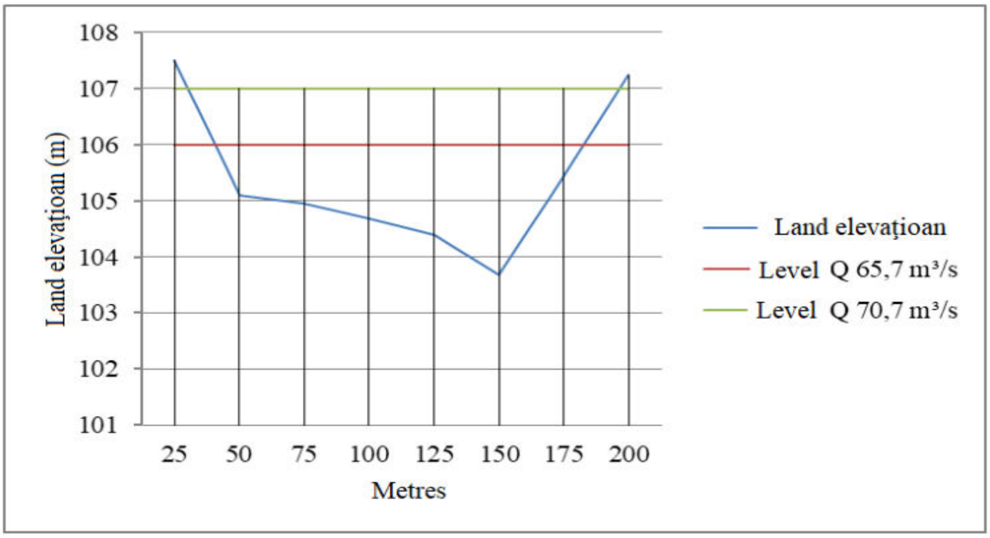


Figure 64. Land elevations and water flow levels in the profile section, intermediate

Levels of variation of the riverbed profile with the clogged area, downstream

Nr. crt	LEVEL	INITIAL PROFILE LEVEL	TRIM. 3- 2018	TRIM. 4-2018	TRIM. 1-2019	TRIM. 2-2019
1	WORKING LEVEL	107,50	107,50	107,50	107,50	107,50
2	FOUNDATION LEVEL	103,67	103,67	103,67	103,67	103,67
3	GEOCONTAINER WORK LEVEL	104,17	104,17	104,17	104,17	104,17
4	THE INITIAL LEVEL MONITORED	105,10	105,11	105,11	105,11	105,11
5	POINT LEVEL 1	105,10	105,10	105,10	105,13	105,16
6	POINT LEVEL 2	104,68	104,68	104,70	104,57	104,62
7	POINT LEVEL 3	104,38	104,43	104,46	104,49	104,52
8	LEVEL THALWEG	103,67	103,67	103,69	103,66	103,65

Table no.17. Levels of variation of the riverbed profile with the clogged area, downstream

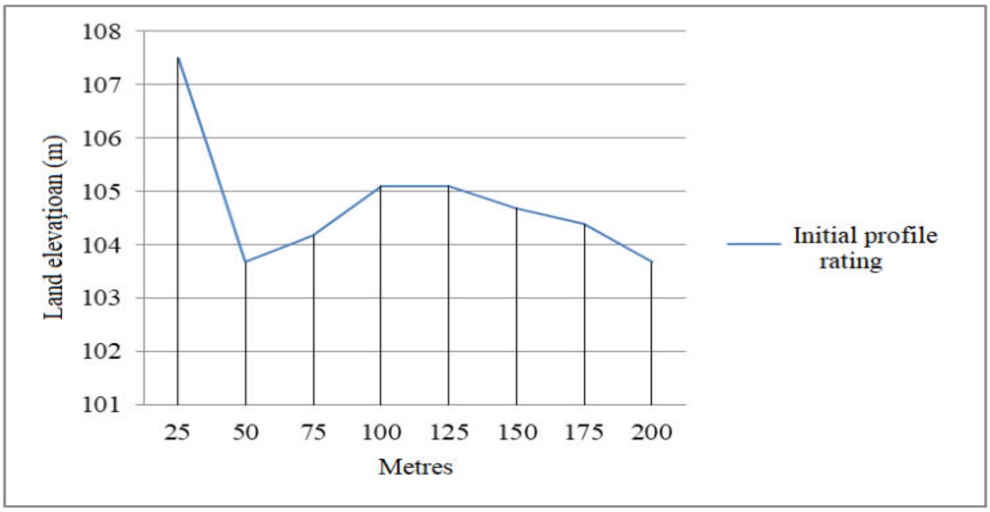


Figure 65. Profile elevations tracked downstream

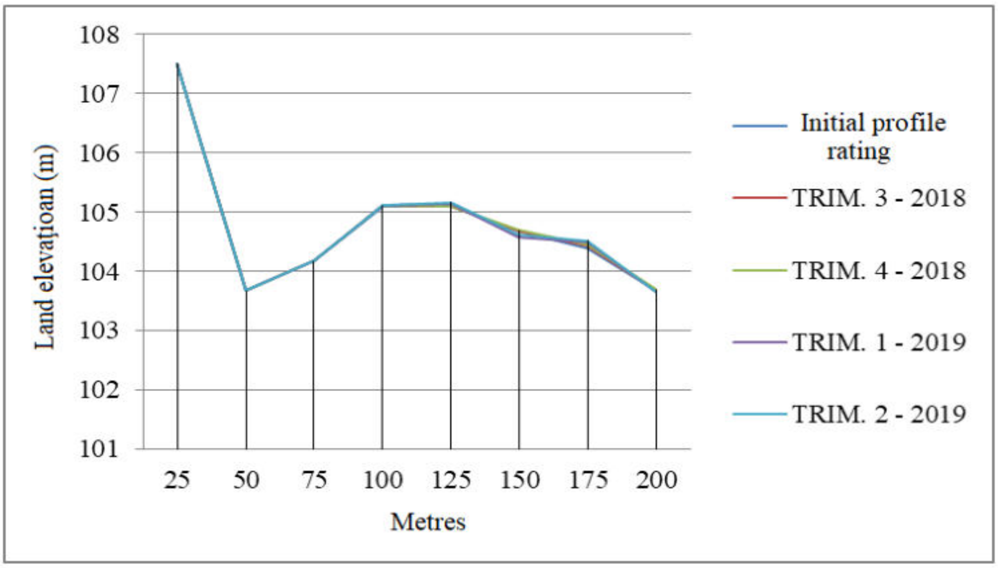


Figure 66. The variation of the downstream riverbed profile, with the area clogged after the execution of the work during the period 2018-2019

Levels of the variation of the riverbed profile after the execution of the work, downstream

Nr. crt	Initial profile level	TRIM. 3-2018	TRIM.4-2018	TRIM. 1-2019	TRIM. 2-2019
1	107,50	107,50	107,50	107,50	107,50
2	105,10	105,10	105,10	105,13	105,16
3	104,68	104,68	104,70	104,57	104,62
4	104,38	104,43	104,46	104,49	104,52
5	103,67	103,67	103,67	103,67	103,67
6	105,46	105,46	105,46	105,46	105,46
7	106,00	106,00	106,00	106,00	106,00

Table no.18. Variation of the profile of the riverbed clogged area, downstream

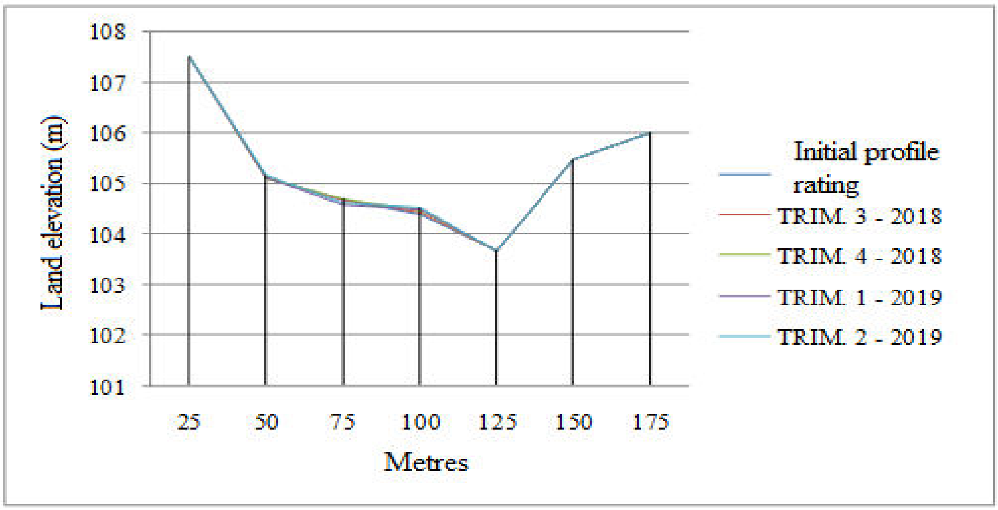


Figure 67. Variation of the profile of the riverbed clogged area, downstream

Figure 68. The evolution of alluvium deposits in the area with the work site (author's photo)

The evolution regarding the deposition of alluvium in the area with works

The average slope in the works area is 3% and allows the accumulation of thin but also coarse alluvium in the upstream region. The downstream area is vulnerable, the contribution of accumulated alluvium being smaller and varied depending on the flows through the watercourse.

The result of the volumetric calculation, in the variant of the geological blocks delimited by vertical sections, of the resources is presented in the table below:

Nr. crt	Section length (m)	Section width (m)	Distance between sections (m)	Middle section (m^2)	H medium section (m)	Volume accumulated by alluvium (m^3)
1	100	100	200	20.000	0,91	18,200

Table no.19. Cumulative volume of alluvium

The granulometric composition of the deposits in the studied area
- sands - 12%;
- gravel - 59 %;
- boulders - 29 %.

Figure 69. Granulometric composition of the alluvial deposit (author's photo)

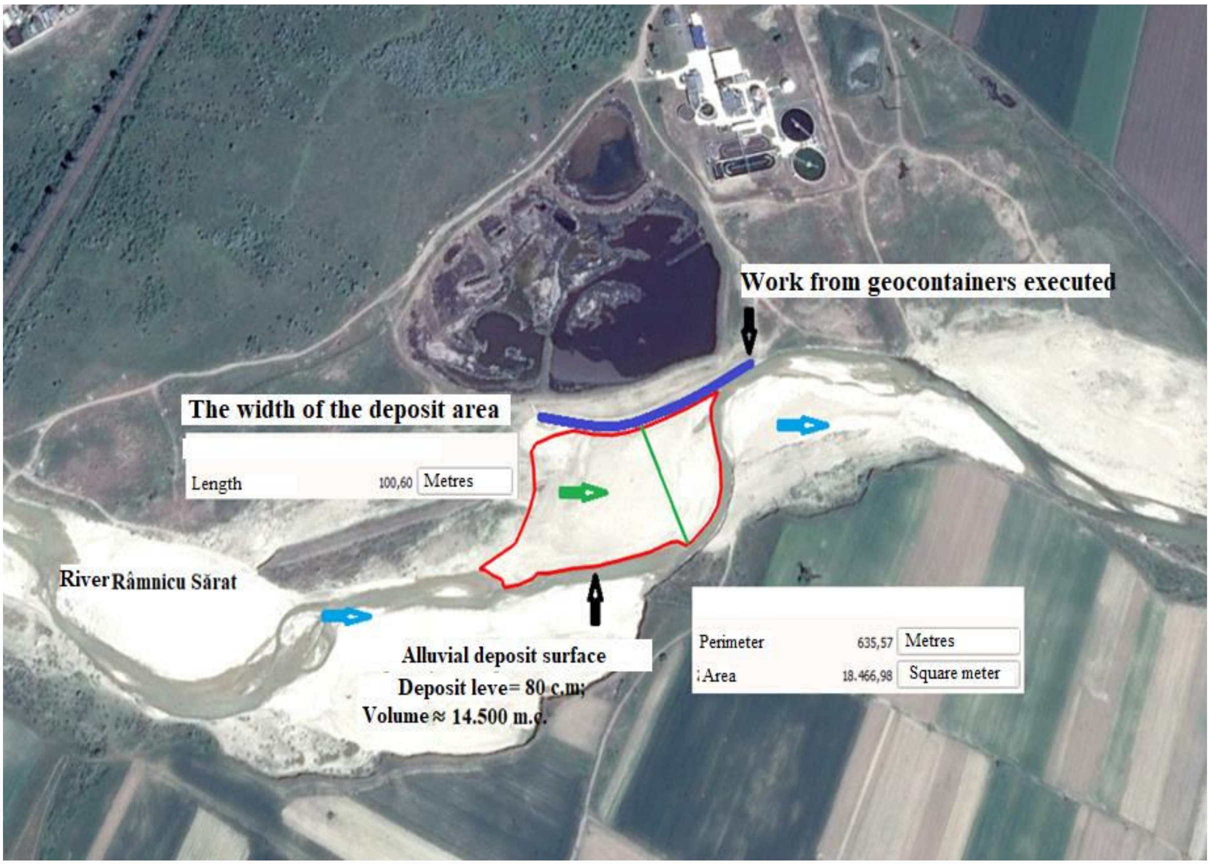


Figure 70. Appearance of alluvium deposits in the studied ar

6.2.2. Consolidation of the Milcov river bank, Odobeşti locality, Vrancea county
Analysis and evolution of erosion by the spatial method

Figure 71 shows the evolution of bank erosion and the profile of the Milcov riverbed in 2018-2019, in the area of Odobeşti.

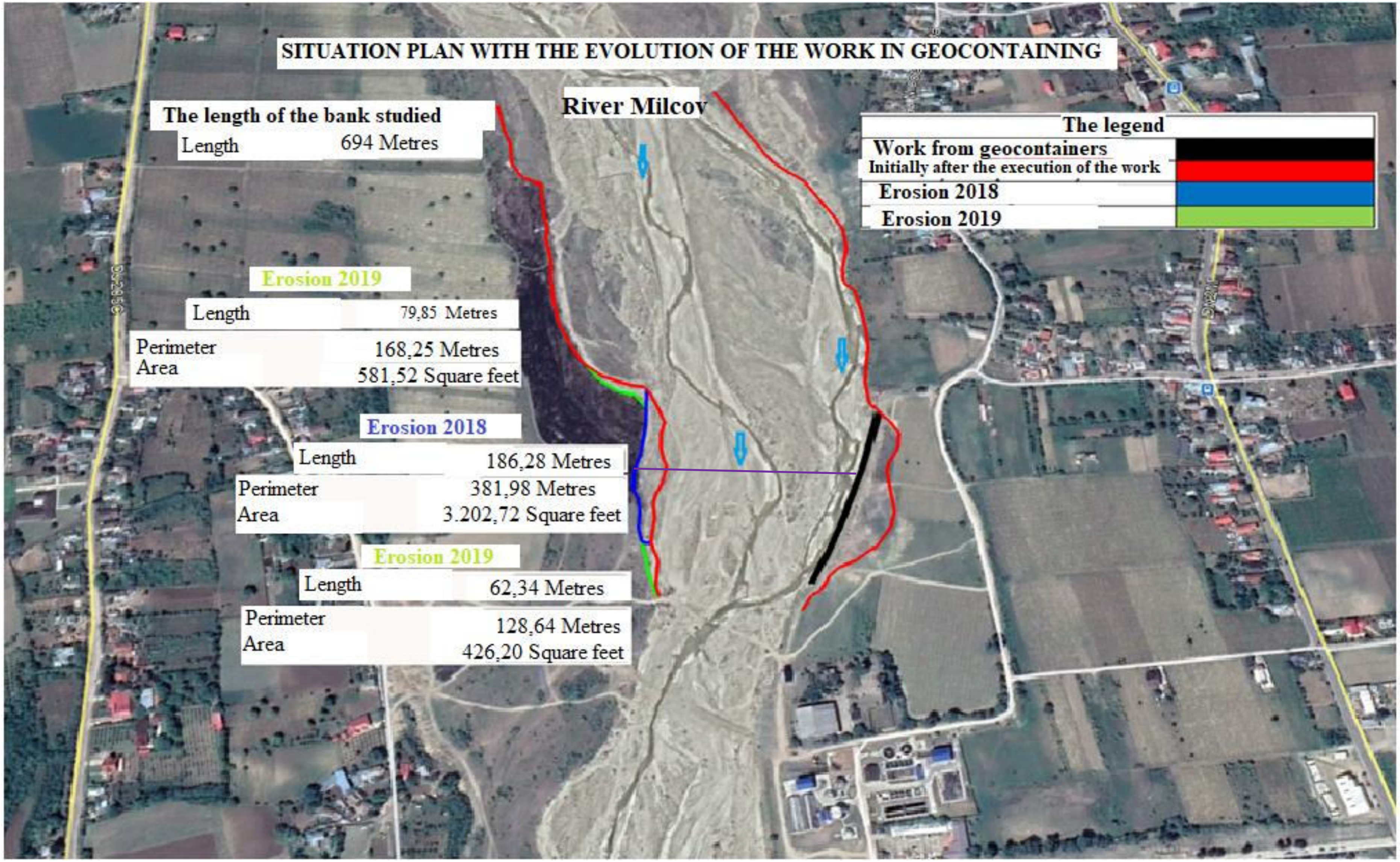


Figure 71. The evolution of works in geocontainers in the period 2018-2019

Following the execution of the work in geocontainers and the floods registered on the Milcov river, the right bank was eroded, the riverbed alternating at the base of the two banks, with a considerable depth towards the right bank area, alluvium in the riverbed accumulated.

The total eroded area is about 4,209 m2, with a total length of 523 m.

Figures 72, 73 and 74 show the configuration of the right bank, generated by the satellite following the evolution of the work in geocontainers in the period 2018-2019, where erosion has manifested itself in length in the area of the right bank.

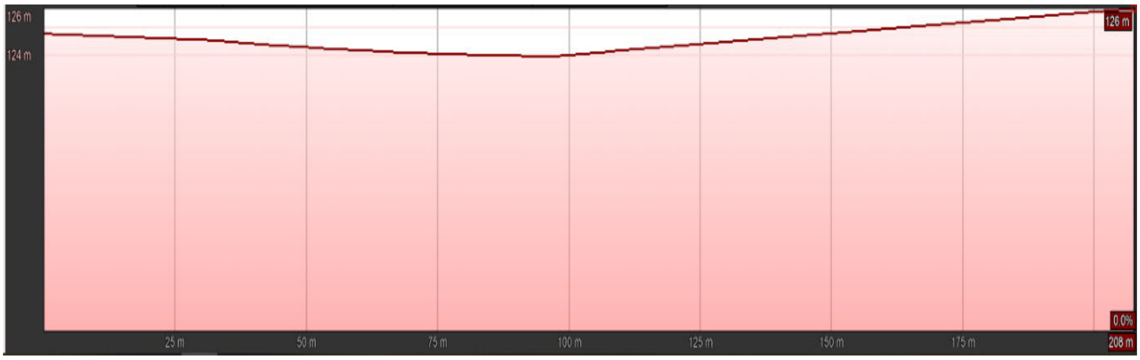


Figure 72. The cross-sectional profile of the erosion of the Milcov river bank in the area studied in 2017

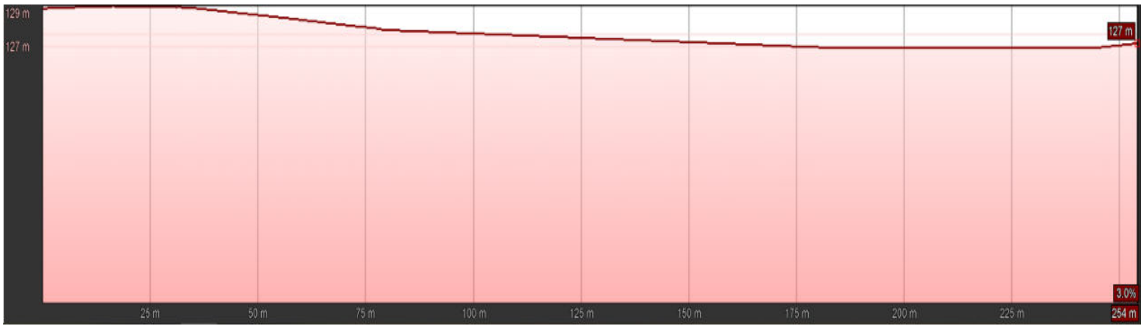


Figure 73. Transversal profile through the Milcov riverbed in 2018 after the execution of the work

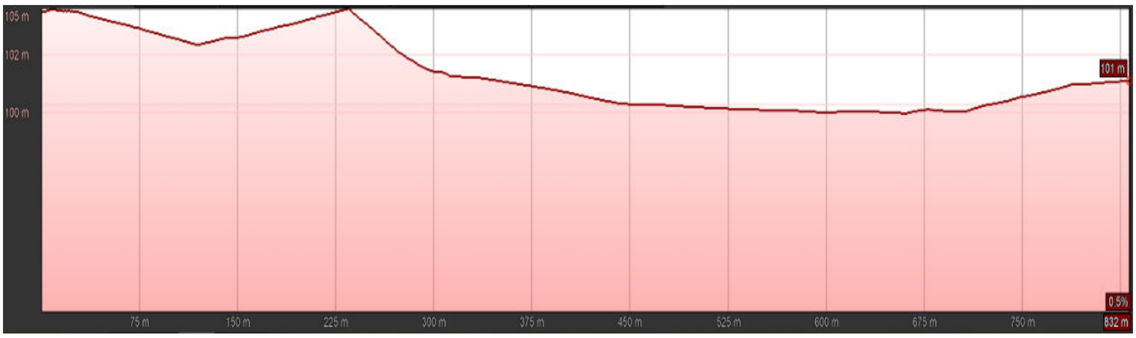


Figure 74. Transversal profile through the Milcov riverbed in 2019 after the execution of the work

Evolution by the method of analytical calculation

Following the overlapping of the topographic profiles, the level difference results which is the vertical distance between the level surfaces of two points A and B.

The interpretation of the data obtained from the field measurements are presented below.

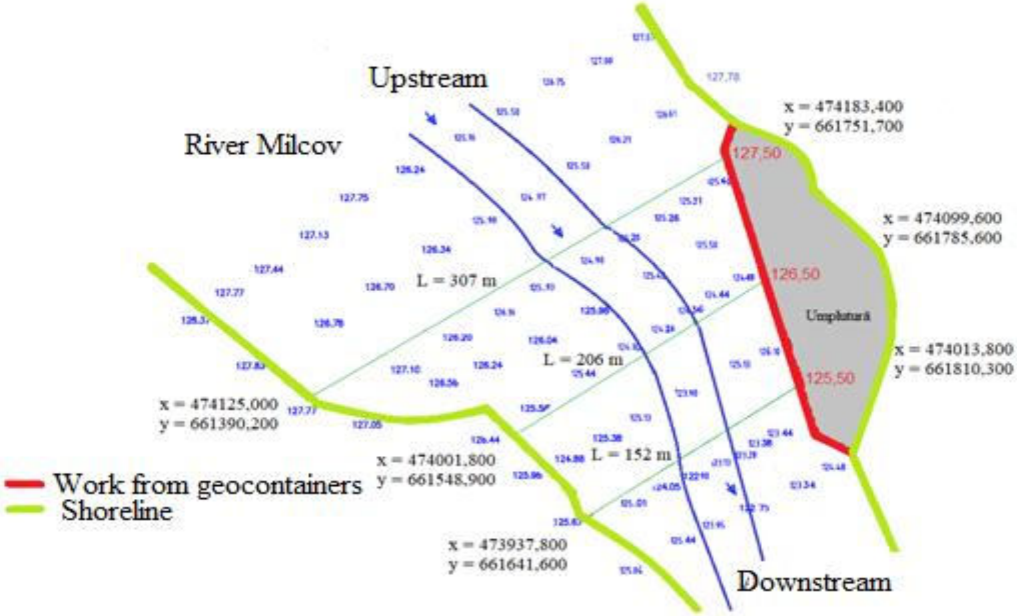


Figure 75. Situation plan with topographic measurements

Elevations of the riverbed profile, upstream

Nr. crt	Land elevation
1	127,50
2	125,31
3	125,26
4	125,20
5	124,90
6	125,93
7	126,16
8	126,20
9	127,10
10	127,77

Table no.20. Land elevations in the studied area, upstream

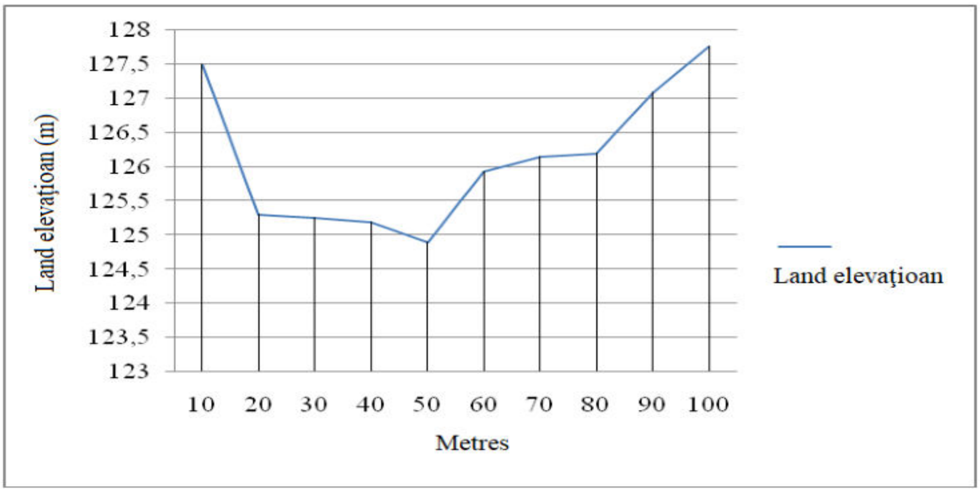


Figure 76. Riverbed profile of the studied area, upstream

Nr. crt	Land elevation	Level Q 12,5 m³/s	Level Q 15,8 m³/s	Level Q 17,4 m³/s
1	127,50	125,50	126,11	126,50
2	125,31	125,50	126,11	126,50
3	125,26	125,50	126,11	126,50
4	125,20	125,50	126,11	126,50
5	124,90	125,50	126,11	126,50
6	125,93	125,50	126,11	126,50
7	126,16	125,50	126,11	126,50
8	126,20	125,50	126,11	126,50
9	127,10	125,50	126,11	126,50
10	127,77	125,50	126,11	126,50

Table no.21. Land elevations and water flow levels in the profile section, upstream

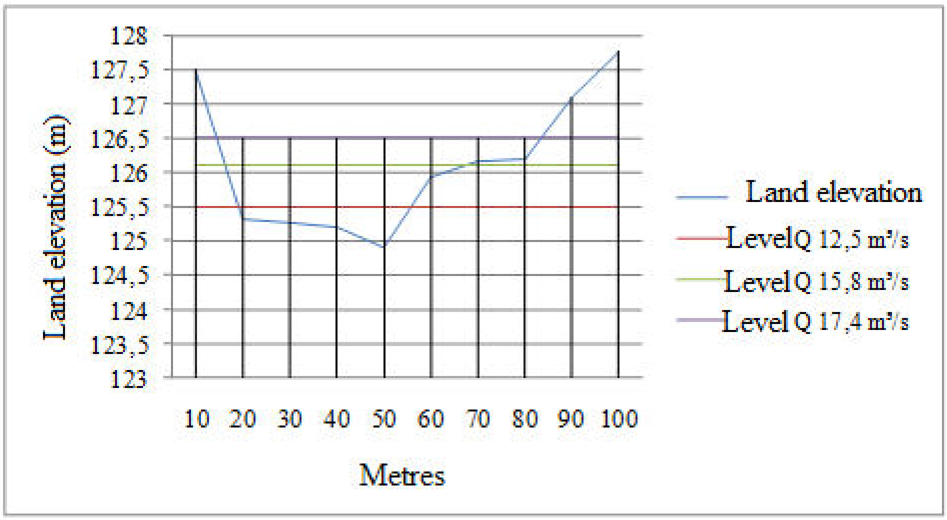


Figure 77. Land elevations and water flow levels in the profile section, upstream

The elevations of the variation of the riverbed profile with the clogged area upstream

Nr. crt	LEVEL	INITIAL PROFILE LEVEL	TRIM. 3-2018	TRIM. 4-2018	TRIM. 1-2019	TRIM. 2-2019
1	WORKING LEVEL	127,50	127,50	127,50	127,50	127,50
2	FOUNDATION LEVEL	125,00	125,00	125,00	125,00	125,00
3	GEOCONTAINER WORK LEVEL	125,40	125,40	125,40	125,40	125,40
4	THE INITIAL LEVEL MONITORED	125,40	125,40	125,40	125,43	125,46
5	POINT LEVEL 1	125,31	125,35	125,36	125,37	125,48
6	POINT LEVEL 2	125,26	125,27	125,31	125,35	125,45
7	POINT LEVEL 3	125,20	125,22	125,33	125,33	125,41
8	LEVEL THALWEG	124,90	124,90	124,90	124,95	124,95

Table no.22. The elevations of the variation of the riverbed profile with the clogged area upstream

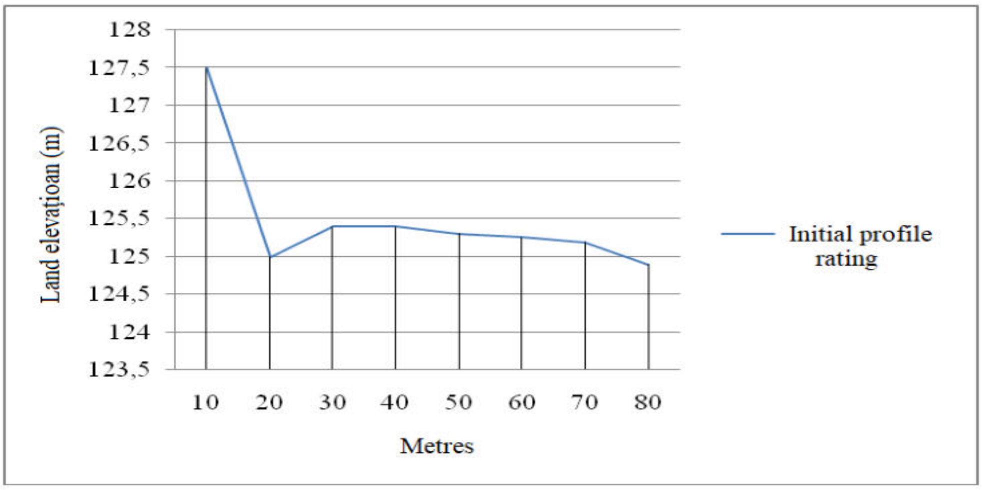


Figure 78. Profile elevations tracked upstream

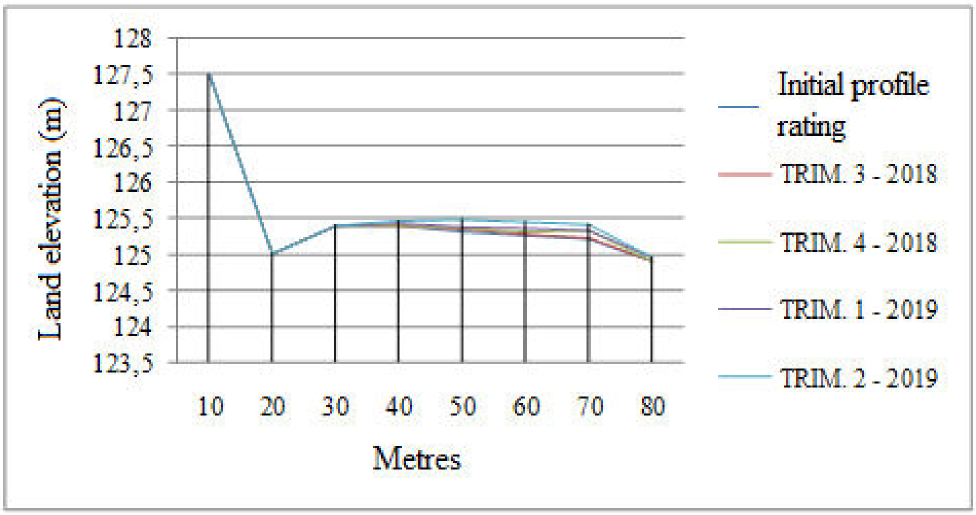


Figure 79. The variation of the upstream riverbed profile, with the area clogged after the execution of the work in the period 2018-2019

Levels of variation of the riverbed profile after the execution of the work, upstream

Nr. crt	Initial profile level	TRIM. 3 - 2018	TRIM.4 - 2018	TRIM. 1 - 2019	TRIM. 2 - 2019
1	127,50	127,50	127,50	127,50	127,50
2	125,31	125,35	125,36	125,47	125,48
3	125,26	125,27	125,31	125,35	125,45
4	125,20	125,22	125,33	125,33	125,45
5	124,90	124,90	124,90	124,95	124,95
6	125,93	125,93	125,93	125,93	125,95
7	126,16	126,16	126,16	126,16	126,16
8	126,20	126,20	126,20	126,20	126,20
9	127,10	127,10	127,10	127,10	127,10
10	127,77	127,77	127,77	127,77	127,77

Table no.23. The variation of the riverbed profile after the execution of the work, upstream

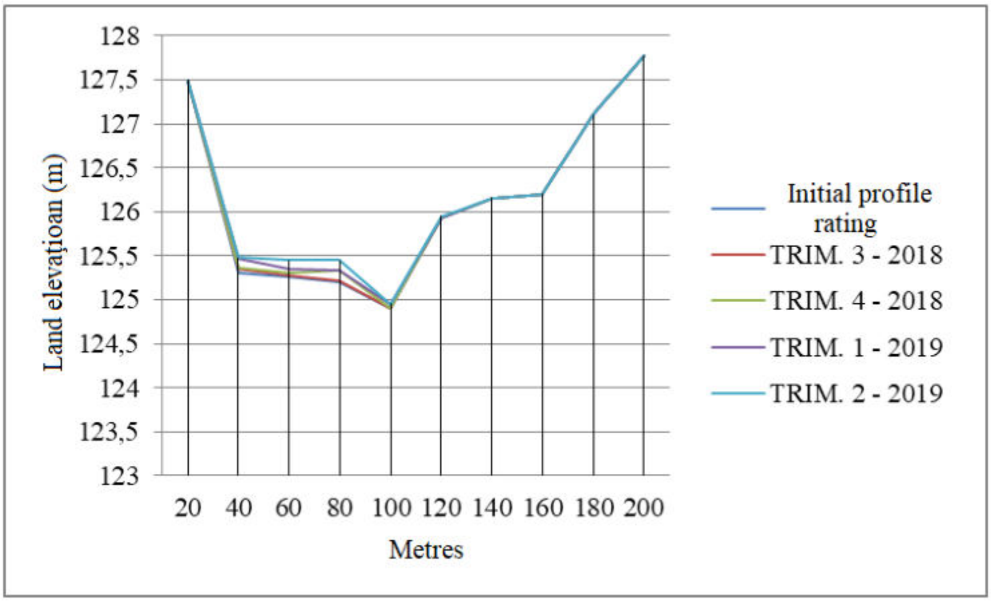


Figure 80. Variation of the profile of the riverbed clogged area, upstream

Basins profile elevations, intermediate:

Nr. crt.	Land elevation
1	126,50
2	125,40
3	124,36
4	124,24
5	124,10
6	125,44
7	125,56
8	126,44

Table no.24. Land elevations in the studied area, intermediate

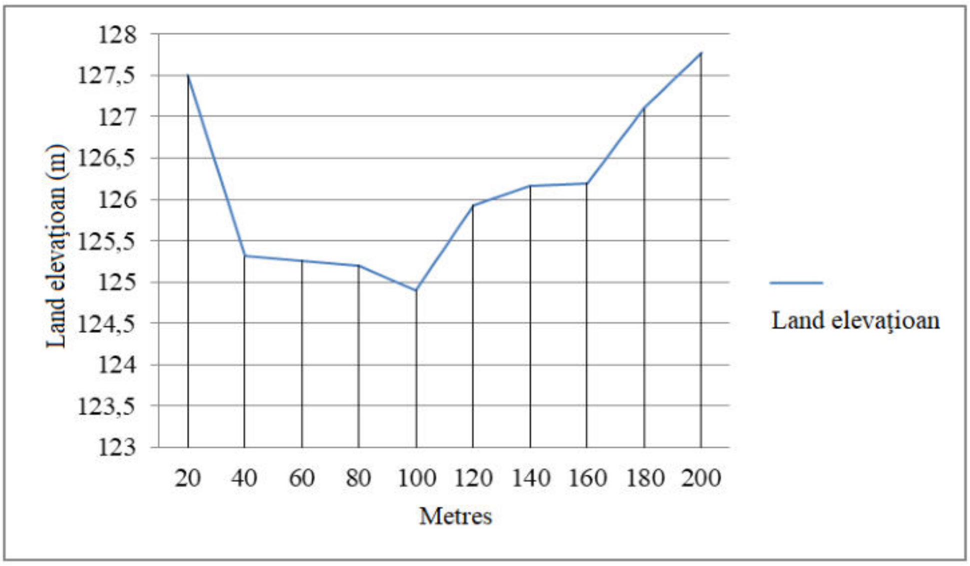


Figure 81. Riverbed profile in the studied area, intermediate

Nr. crt	Land elevation	Level Q12,5 m³/s	Level Q15,8m³/s	Level Q17,5m³/s
1	126,50	125,50	126,11	126,50
2	125,40	125,50	126,11	126,50
3	124,36	125,50	126,11	126,50
4	124,24	125,50	126,11	126,50
5	124,10	125,50	126,11	126,50
6	125,44	125,50	126,11	126,50
7	125,56	125,50	126,11	126,50
8	126,44	125,50	126,11	126,50

Table no.25. Land elevations and water flow levels in the profile section, intermediate

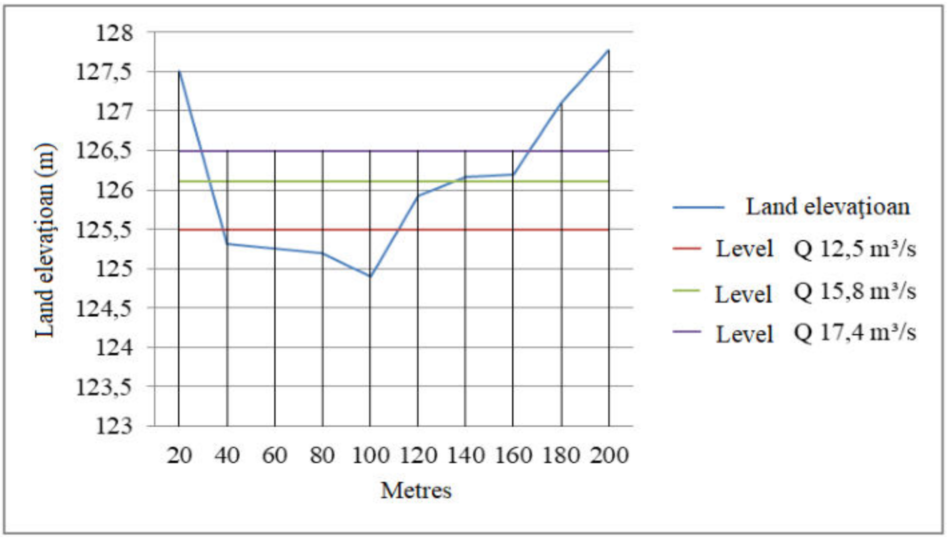


Figure 82. Land elevations and water flow levels in the profile section, intermediate

Levels of variation of the riverbed profile with the clogged area, intermediate

Nr. crt	LEVEL	INITIAL PROFIL E LEVEL	TRIM. 3-2018	TRIM. 4-2018	TRIM. 1-2019	TRIM. 2-2019
1	WORKING LEVEL	126,50	126,50	126,50	126,50	126,50
2	FOUNDATION LEVEL	124,00	124,00	124,00	124,00	124,00
3	GEOCONTAINER WORK LEVEL	124,48	124,48	124,48	124,48	124,48
4	THE INITIAL LEVEL MONITORED	124,48	124,48	124,49	124,51	124,51
5	POINT LEVEL 1	124,45	124,46	124,48	124,46	124,46
6	POINT LEVEL 2	124,36	124,40	124,34	124,40	124,39
7	POINT LEVEL 3	124,24	124,26	124,35	124,35	124,36
8	LEVEL THALWEG	124,10	124,10	124,12	124,12	124,13

Table no.26. Levels of variation of the riverbed profile with the clogged area, intermediate

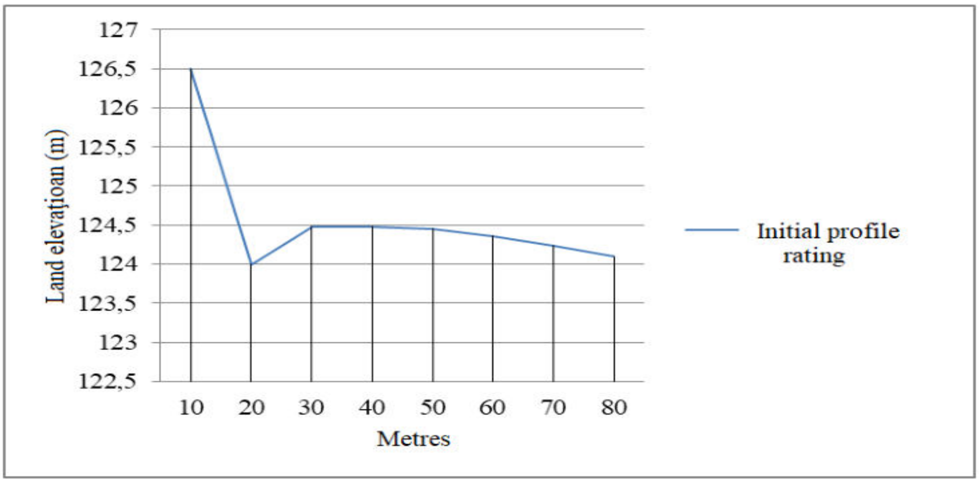


Figure 83. Profile elevations tracked intermediate

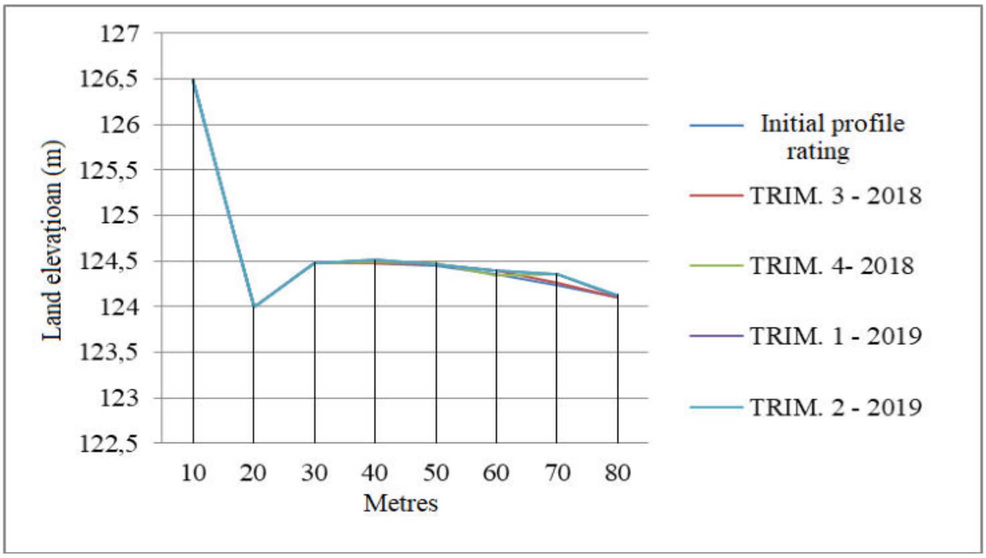


Figure 84. The variation of the profile of the intermediate riverbed, with the area clogged after the execution of the work in the period 2018-2019

Nr. crt	Initial profile level	TRIM. 3-2018	TRIM. 4-2018	TRIM. 1-2019	TRIM. 2-2019
1	126,50	126,50	126,50	126,50	126,50
2	124,40	124,46	124,48	124,46	124,46
3	124,36	124,40	124,34	124,40	124,39
4	124,24	124,26	124,35	124,35	124,36
5	124,10	124,10	124,12	124,12	124,13
6	125,44	125,44	125,44	125,44	125,44
7	125,56	125,56	125,56	125,56	125,56
8	126,44	126,44	126,44	126,44	126,44

Table no.27. Variation of the riverbed profile after the execution of the work, intermediate

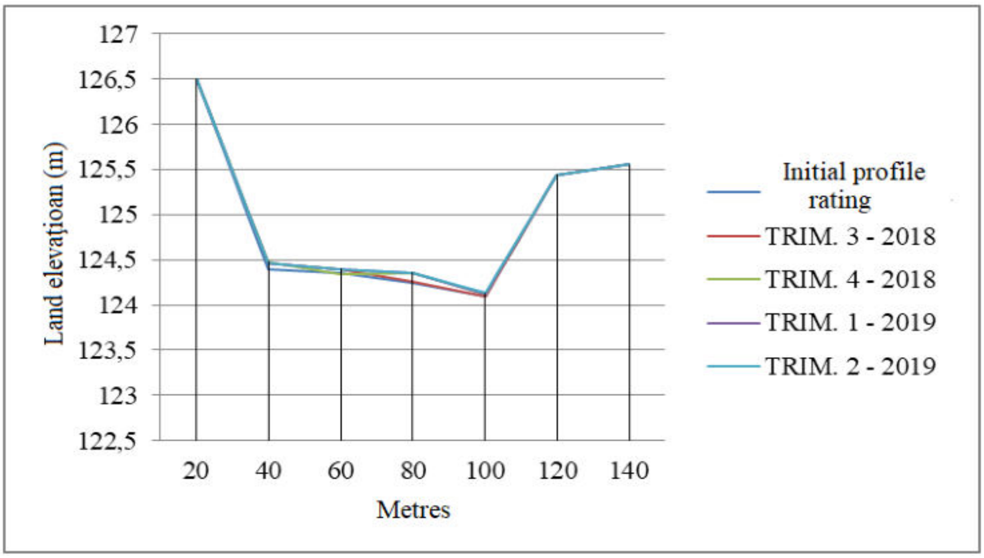


Figure 85. Variation of the riverbed profile of the clogged area, intermediate

Elevations of the riverbed profile, downstream:

Nr. crt	Land elevation
1	125,50
2	123,44
3	123,38
4	123,28
5	123,14
6	122,90
7	124,05
8	125,01
9	125,67

Table no.28. Downstream land elevations

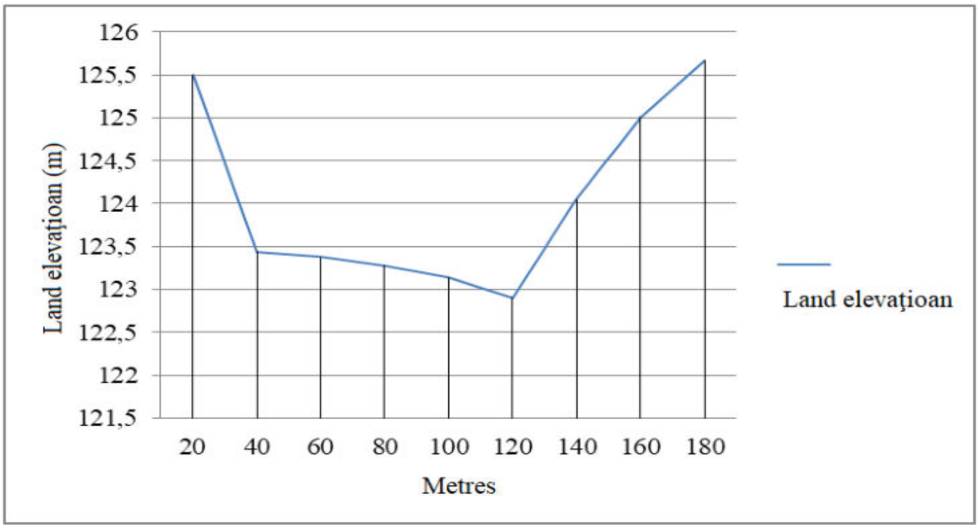


Figure 86. Riverbed profile in the studied area, downstream

Nr. crt	Land elevation	Nivel Q12,5m³/s	Nivel Q15,8m³/s	Nivel Q17,4m³/s
1	125,50	125,50	126,11	126,50
2	123,44	125,50	126,11	126,50
3	123,38	125,50	126,11	126,50
4	123,28	125,50	126,11	126,50
5	123,14	125,50	126,11	126,50
6	122,90	125,50	126,11	126,50
7	124,05	125,50	126,11	126,50
8	125,01	125,50	126,11	126,50
9	125,67	125,50	126,11	126,50

Table no.29. Land elevations and water flow levels in the profile section, downstream

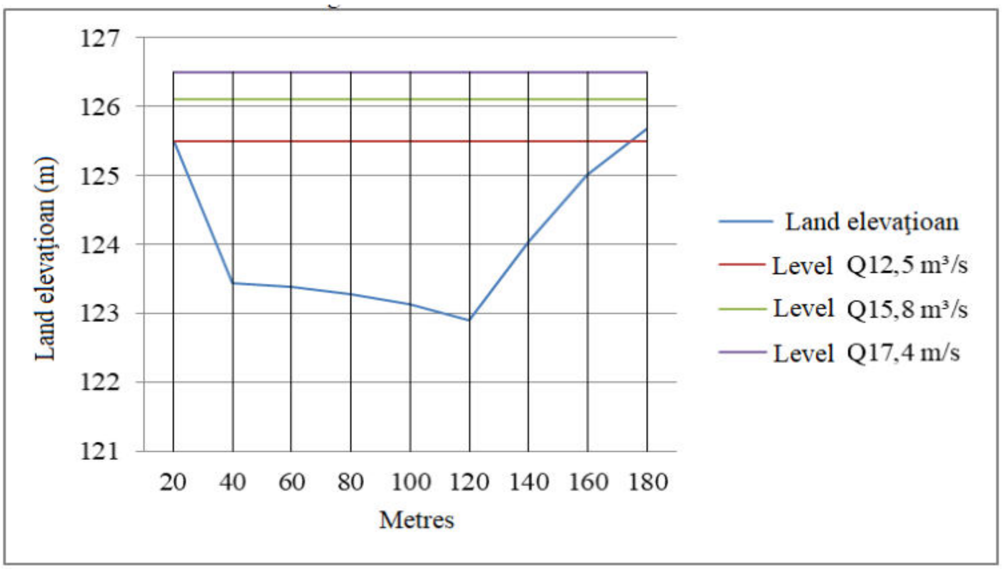


Figure 87. Land elevations and water flow levels in the profile section, downstream

Levels of variation of the riverbed profile with the clogged area, downstream

Nr. crt	LEVEL	INITIAL PROFILE LEVEL	TRIM. 3-2018	TRIM. 4-2018	TRIM. 1-2019	TRIM. 2-2019
1	WORKING LEVEL	125,50	125,50	125,50	125,50	125,50
2	FOUNDATION LEVEL	123,00	123,00	123,00	123,00	123,00
3	GEOCONTAINER WORK LEVEL	123,46	123,46	123,46	123,46	123,46
4	THE INITIAL LEVEL MONITORED	123,44	123,45	123,45	123,45	123,45
5	POINT LEVEL 1	123,38	123,39	123,39	123,40	123,40
6	POINT LEVEL 2	123,28	123,28	123,29	123,31	123,23
7	POINT LEVEL 3	123,14	123,16	123,18	123,24	123,24
8	LEVEL THALWEG	122,90	122,91	122,95	122,99	122,90

Table no.30. Levels of variation of the riverbed profile with the clogged area, downstream

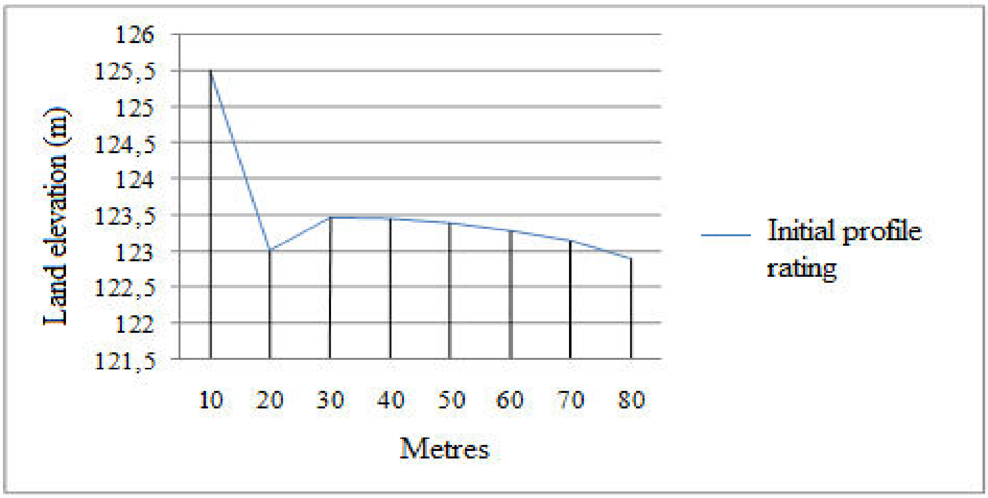


Figure 88. Profile elevations tracked downstream

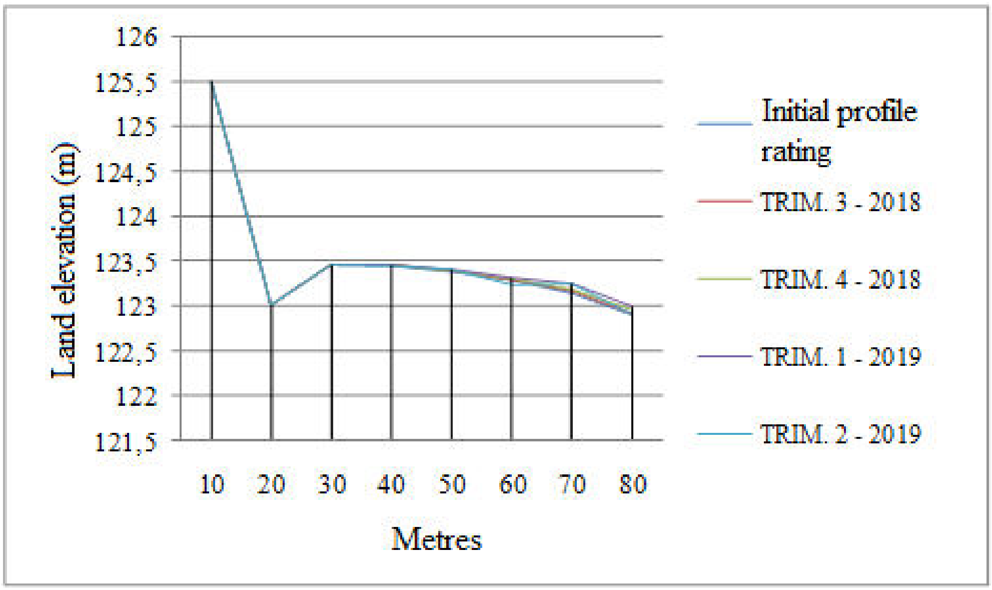


Figure 89. The variation of the downstream riverbed profile, with the area clogged after the execution of the work in the period 2018-2019

Levels of variation of the riverbed profile after the execution of the work, downstream

Nr. crt	Initial profile level	TRIM. 3 - 2018	TRIM. 4 - 2018	TRIM. 1 - 2019	TRIM. 2 - 2019
1	125,50	125,50	125,50	125,50	125,50
2	123,44	123,45	123,45	123,45	123,45
3	123,38	123,39	123,39	123,40	123,40
4	123,28	123,28	123,29	123,31	123,23
5	123,14	123,16	123,18	123,24	123,24
6	122,90	122,91	122,95	122,99	122,90
7	124,05	124,05	124,05	124,05	124,05
8	125,01	125,01	125,01	125,01	125,01
9	125,67	125,67	125,67	125,67	125,67

Table no.31. Variation of the profile of the riverbed clogged area, downstream

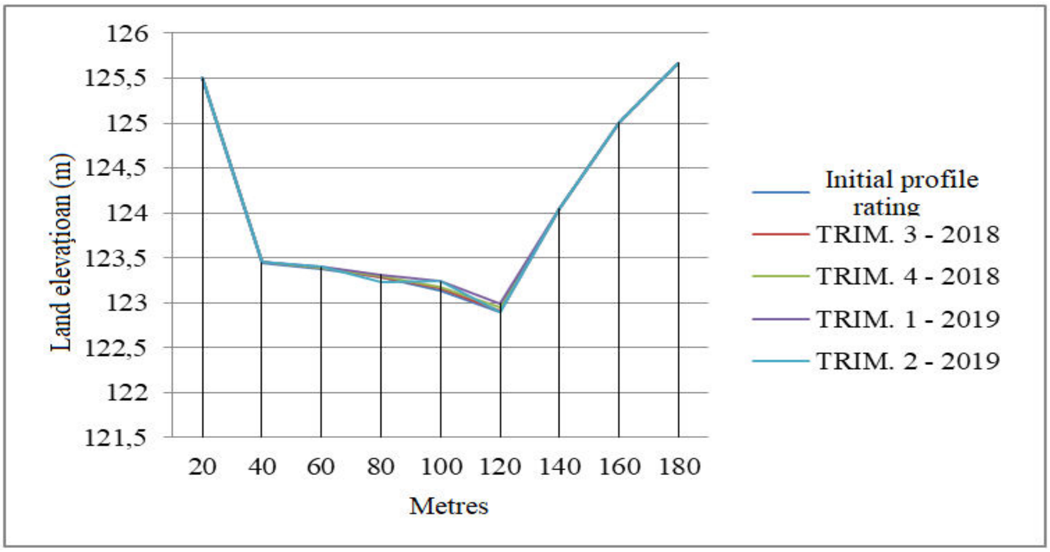


Figure 90. Variation of the profile of the riverbed clogged area, downstream


Figure 91. The evolution of work in geocontainers during floods

The evolution regarding the deposition of alluvium in the area with work sites

The average slope in the area of the works is 1.2% and allows the accumulation of fine and coarse alluvium.

The result of the volumetric calculation, in the variant of the geological blocks delimited by vertical sections, of the resources is presented in the table below:

Nr. crt	Section length (m)	Section width (m)	Distance between sections (m)	Middle section (m^2)	H medium section (m)	Volume accumulated by alluvium (m^3)
1	40	80	160	6.400	125,24	801.500

Table no.32. Volumetric calculation of alluvium deposits

The granulometric composition of the deposits in the studied area:

- sands - 18 %;
- gravel - 50 %;
- boulders - 32 %;

Figure 92. The granulometric composition of the deposits in the studied area

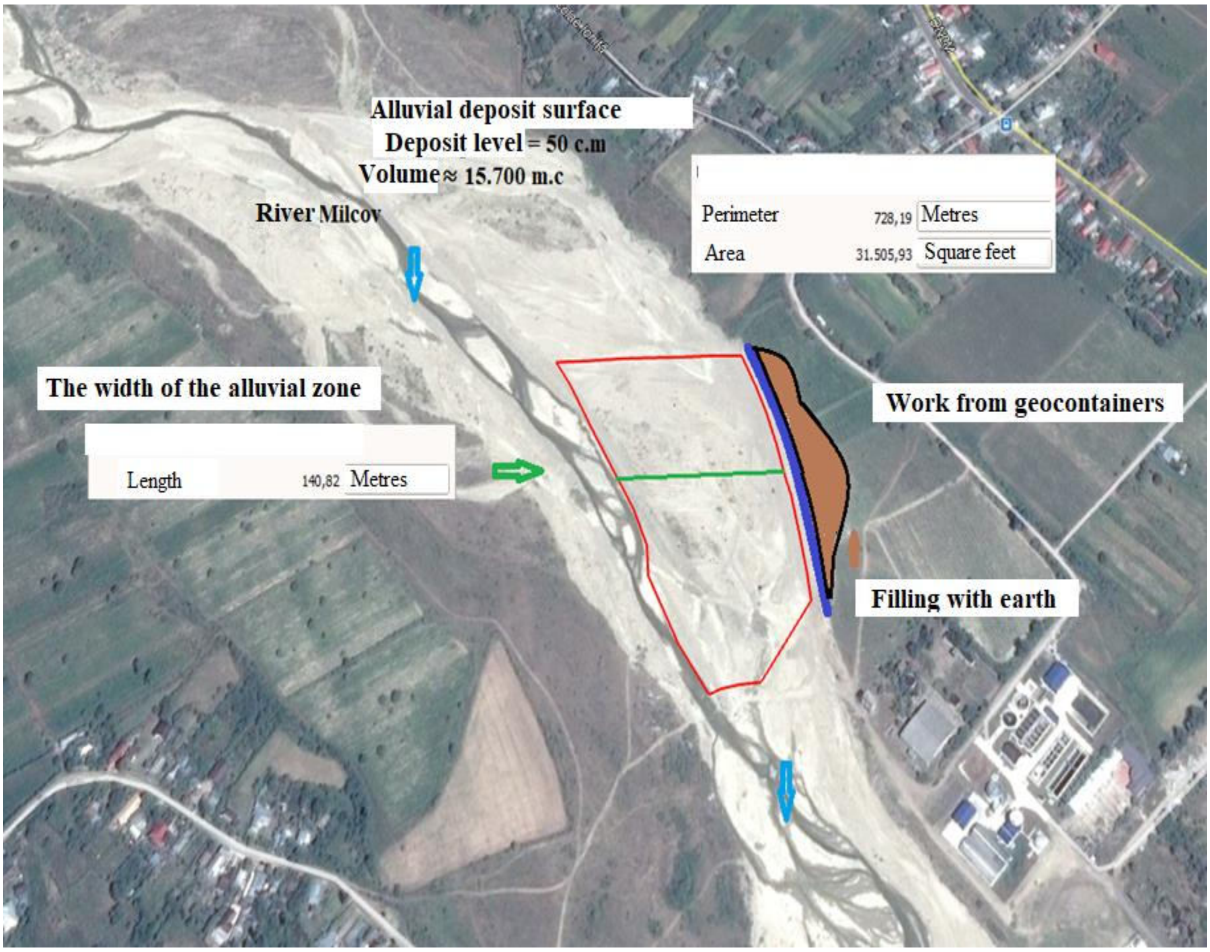


Figure 93. Appearance of alluvium deposits in the studied area

6.3. Evolution and analysis of works in geocontainers on the environment

The need for biodiversity conservation is objective and stringent because human communities cannot live and develop outside and independent of natural ecosystems.

Saving nature means saving the human species in the first place.

The natural environment and the environment created by man are indispensable for the evolution of man and first of all for his survival. Mankind is at a crossroads of decision for the fate of the Earth and the life of every species on the planet, to resolve the contradiction between the development of human societies and nature conservation.

In nature, plants and animals live everywhere, populating all living environments (terrestrial, aquatic, aerial). They carry out their life cycle under the influence of environmental factors. During the historical development of plants and animals (therefore a long time) they were subjected to large variations of abiotic factors.

To survive, plants have changed their structures, the shape of their organs, and their appearance over time, this being the adaptation of plants and animals to the living environment. [20]

Figure 94 shows some aspects of the development of grassy and woody vegetation in the works and the area of works in geocontainers.

These works allow the development of vegetation and do not harm the environment, but they are also not affected by the development of vegetation as in the case of gabion works and retaining walls.

Figure 94. Development of spontaneous plants and shrubs in the area of works with geocontainers (author's photo)

7. COMPARATIVE ANALYSIS OF THE RESULTS OF VARIOUS MONITORING METHODS

The methods approached in the analysis of the evolution of works in geocontainers is a combination of traditional methods based on measurements made in the field and modern ones based on spatial analysis. Spatial analysis was performed based on morphometric maps from Google Earth, and the classical one was performed by field measurements using GPS Hi-Target and Leica Total Station, the interpretation of data from field measurements being performed by the method of analytical calculation with the AutoCAD and ProgeCAD programs on georeferenced maps in the ArcGIS and Orthophotoplan program.

Following the analysis of the results obtained from the satellite measurements and those performed in the field, a difference of values regarding the transversal profile, on height, results. Satellite measurements round the values of the elevations in the field, the difference being 1 - 2 m, compared to the classic measurements.

In a longitudinal profile, the values being approximately equal to the values obtained from the classical field measurements.

Satellite measurements are approximate with the reality on the ground, but in areas where the flows of the watercourse are with high values and vary during floods, the morphology of the terrain changes slightly and does not correspond to the reality on the ground with satellite images.

In areas where the flows of the watercourse are with small and medium values, they vary slightly during the floods, the morphology of the terrain does not change much and corresponds to the reality on the ground with satellite images.

Figure 95. Field image with the evolution of the work in geocontainers (author’s photo)

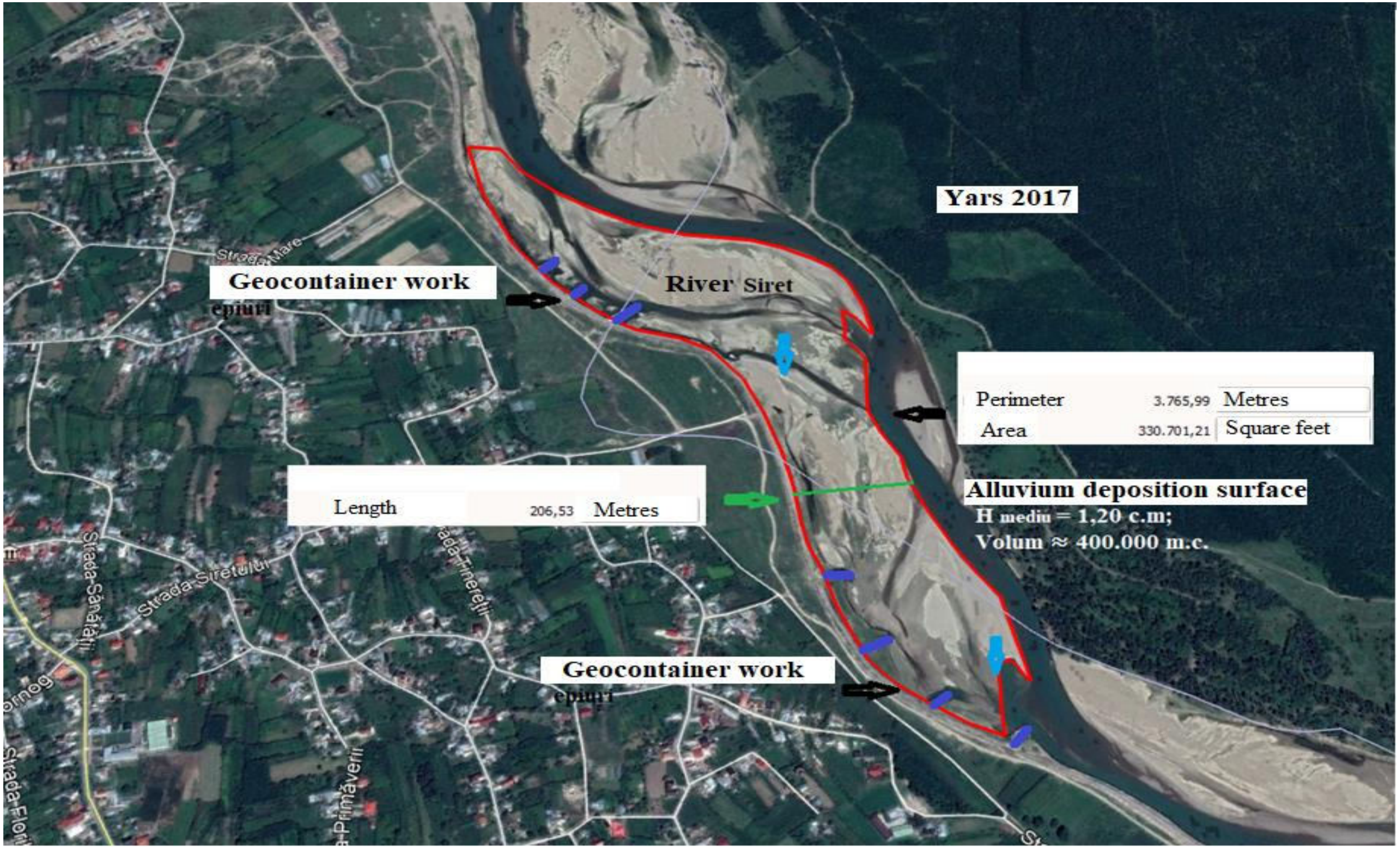


Figure 96. Satellite image with the evolution of the work in geocontainers

8. PROPOSALS FOR NEW TYPES OF GEOCONTAINERS FOR INTEGRATION IN THE NATURAL ENVIRONMENT - CASE STUDY

To carry out works that are integrated into the natural surroundings, it is necessary to develop and use new models of geocontainers to combat erosion and restore the environment, as well as the transformation and use of recycled materials in the development of technical solutions to combat erosion.

8.1. Geocontainer with double perforated wall

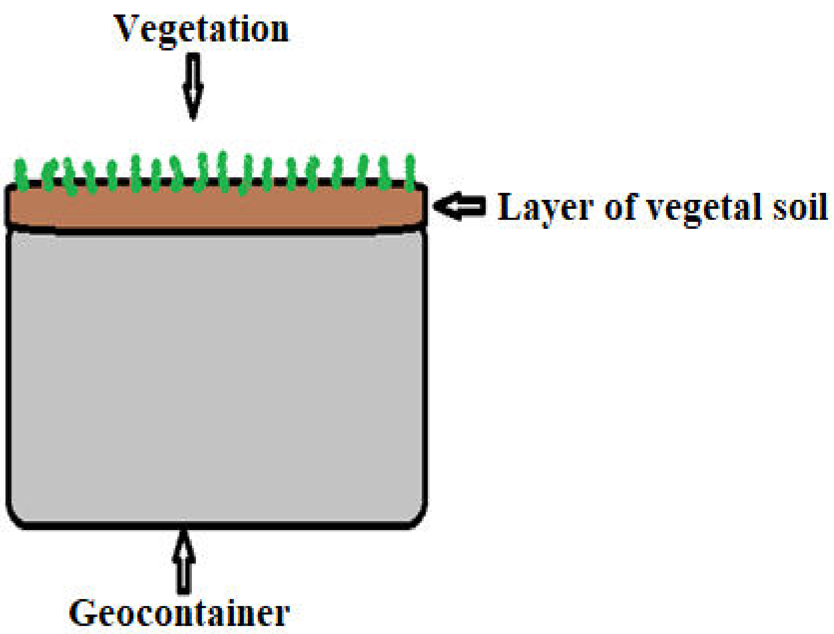


Figure 97. New geocontainer model

8.2. Type X geocontainer for gliding trees between gaps

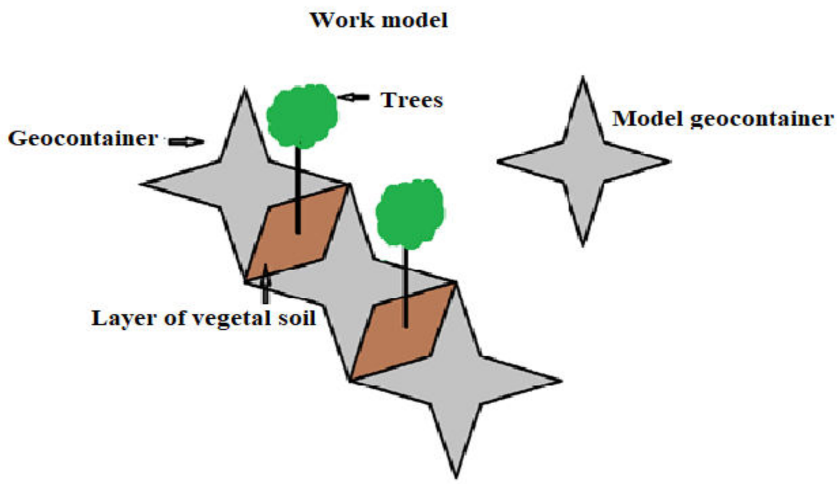


Figure 98. Type X geocontainer

8.3. Use of recycled materials in the erosion control materials

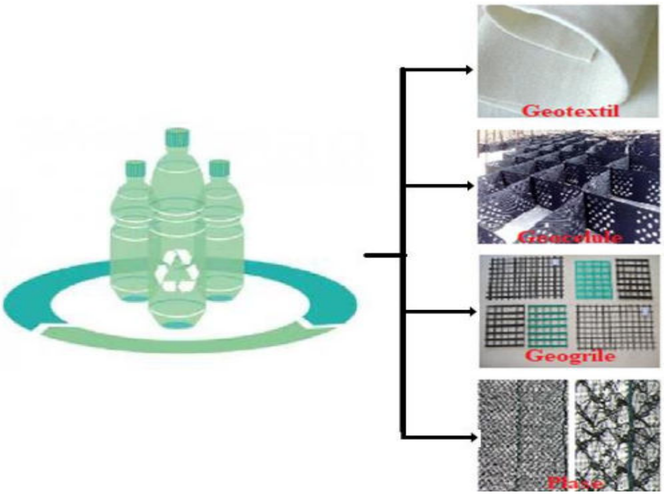


Figure 99. Use of plastic to make geosynthetic materials

Figure 100. Use of debris to fill geocontainers

CONCLUSIONS

The analysis, monitoring, and modeling of the studied erosion areas are a combination of traditional (classical) methods based on field measurements and the modern one based on spatial analysis.

The use of classical measurement methods provides high accuracy, are relevant to the field situation, but requires travel to the field each time measurements are made.

Human errors can occur in classical measurements.

The use of innovative measurement methods does not require field travel. They can be performed on a large scale and over very long distances, but they are relative and, in some cases, do not match the reality on the ground.

The use of innovative methods requires a connection to the Internet and requires software for interpreting data and may be influenced by weather conditions.

Geosynthetics are made of synthetic polymers, unlike natural materials, which are not subject to biological degradation.

The use of geosynthetic products is a high-performance and affordable solution, compared to classical methods. These materials do not pose a danger to the environment and human health, they have a long lifespan, so they do not require frequent replacements.

Polymers used as raw materials have chemical stability to acids, bases, oxidizing agents and solvents, but can sometimes be degraded by intense and prolonged solar radiation.

Micro-organisms that enter the pores of geotextiles cause biological clogging, but the phenomenon does not change the water characteristics of the textile material if the micro-organisms do not secrete aggressive chemicals. If micro-organisms secrete substances, the fibers degrade over time.

Geotextiles are a favorable environment for the development of micro-organisms but do not provide nutrients for them.

The hydro-technical works in the gabions are laborious to carry out and require a specialized team for laying the stone, and the costs and duration for the execution are very high.

There are many forms of degradation of gabion works, and natural or anthropogenic factors can be the cause.

The wire and net used for gabions can be destroyed by transporting alluvium and floats during floods, but also environmental factors favor their degradation.

In acidic or saline environments, gabions cannot be used due to the rapid degradation of the materials from which they are made.

Work with damaged gabions can no longer be repaired or reused and does not allow the development of fauna and flora.

Hydrotechnical works in geocontainers can be used in many forms and different types of longitudinal, transverse works and are easy to implement, and the costs and execution time is short.

Filling geocontainers is made with local material and does not require additional transport costs. It can be used in saline regions, and are not vulnerable to environmental factors. The work of geocontainers is elastic due to the flexibility of the geotextile and the characteristics of the material with which they are filled.

Work in geocontainers is not vulnerable to the transport of coarse alluvium.

As with gabion work, work in geocontainers can be degraded, but structures are not destroyed.

Total degradation of structures in geocontainers can be caused by vandalism, by cutting or burning the bags.

Work in geocontainers allows the rapid installation and development of plants and trees in the area where they are located, but they do not cause their degradation.

It is recommended to avoid the use of geocontinents in areas with a high slope of the land and where the transport of floats is frequent. These floats can cause cuts to the geocontainers and, as a result, the material inside is washed, and the work can also be degraded.

Longitudinal works in geocontainers are indicated to be carried out in areas where there are no accumulations so that there is no risk of lowering the elevation of the trough, and the work may collapse.

In the case of works in stone dam type geocontainers, they must be as short as possible and as close as possible to each other to favor rapid clogging, and the erosion phenomenon must not appear behind the work.

Geocontainer works perform well on rivers not exceeding a Q 500 m^3/s.

In carrying out the works in geocontainers, it is necessary to execute the fascine mattress, founded under the level of the trough in order not to appear the leaking phenomenon.

It is recommended to arrange a slope of 1/2, 1/3 when carrying out the work in geocontainers.

When filling geocontainers, sharp or angular materials should be avoided as it may cause them to break.

The migration of sand in geocontainers determines the "caterpillar" mechanism. It has a significant influence on the stability of geocontainers, therefore, it is recommended that the geocontainer be 90% filled, and with a material with a particle size between 0.2-5 cm, so that the sand does not pass through the geocontainer and the geotextile is not broken.

In the area where there are transverse clogging works, active production occurs behind the last spike, or in the area where the spikes are closer. Downstream the clogging is reduced in the case of rivers with high flows.

In the case of longitudinal works, the clogging is done heavily in the upstream area. In the areas with a lower slope, observation is made following the measurements and monitoring of the area.

The transport of coarse alluvium consisting of gravel and boulders is easier to retain in the case of longitudinal works, and in the area of rivers with medium flows, it does not affect the material from which the geocontainer is made.

To avoid the degradation of the geotextile by UV rays, it is indicated to cover the geocontainers with vegetal soil. It allows the development of the plants but also avoids degradation of the work by vandalism.

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