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IMPROVING UPSTREAM AND DOWNSTREAM FISH PASSAGE AT RETIS DAM ON HÂRTIBACIU RIVER - SIBIU COUNTY (TRANSYLVANIA)

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Abstract
Retis (dam Retis), hydro-technical development like many other transverse hydraulic structures cancel the longitudinal connectivity of Hârtibaciu water course, blocking the migration of different (migrating) species of fish in the river. Also, the lateral connectivity was heavily affected on this water course at a rate of 60%. Therefore, proposing engineering solutions to recover both (lateral and longitudinal) types of connectivity is vital to restore the local ecobiom. The purpose of this article is to establish longitudinal connectivity through an engineering solution that facilitates the fish migration upstream – downstream of Retis dam. This paper proposes an engineered fish passage solution for Retiș Dam on the Hârtibaciu River, using the criteria described in the Water Framework Directive 2000/60/EC document. Anthropogenic barriers located in the Hârtibaciu River disrupt and delay movement of local fish fauna including: *Alburnoides bipunctatus* (Bloch, 1782), *Squalius cephalus* (Linnaeus, 1758), *Alburnus alburnus* (Linnaeus, 1758), *Rhodeus amarus* (Bloch, 1782), *Gobio gobio* (Linnaeus, 1758), *Romanogobio kessleri* (Dybowski, 1862), *Barbatula barbatula* (Linnaeus, 1758), *Barbus meridionalis* Risso, 1827 *Misgurnus fossilis* (Linnaeus, 1758), *Cobitis taenia* Linnaeus, 1758, *Cobitis romanica* (Băcescu, 1943), and *Cobitis aurata* (De Filippi, 1863).
Keywords: fish migration, ecobiome's functionality, Hârtibaciu River, fish passage dam.

1.INTRODUCTION

Achieving longitudinal connectivity of watercourses is very important for the proper functioning of any lotic ecosystems. Hundreds of the solution proposed did not achieve the complete the lateral connectivity even when there was a certainty of their effectiveness. Many of the solutions in use today are outdated and have got an unsatisfactory performance. Therefore researchers in this field have started to create the designs and principles scientifically grounded, and then to put them into practice. Scientifically grounded principles and designs on solutions for fish migration over different transversal hydraulic structures on rivers can be achieved in any country, if there are any experts, even if there are no modern laboratories or necessary funds for development.

River continuity represents one of the hydro-morphological elements mentioned in the Water Framework Directive and should be considered for the process of the ecological status evaluation of rivers. In accordance with Annex V from WFD and in order to achieve a high ecological status, the river continuity is defined as "*undisturbed by anthropogenic activities and allows free movement of aquatic organisms and sediment transport*." This concept was approached in the '80s as the "the river continuum concept" (Vannote, 1980).

According to this concept, the hydro-morphological, physico-chemical and biological characteristics of the water course has got a continuous natural dynamics from spring to its mouth. This concept supports the idea that rivers and their corridors form a whole complex ecosystem that includes not only the river itself but also the adjacent land or riparian areas (subject to natural floods) with characteristic plant and animal species. One of the most obvious consequences of "the river continuum concept" is the migration of fish from downstream to upstream to spawn. The necessities of fish species regarding the habitat are different, depending on the stage of their evolution (embryonic, juvenile, adult). Fish species need a habitat for wintering, one for feeding and another for reproduction. Therefore they must be able to travel along the river.

All transverse hydraulic structures, including bridges, watercourses properly conducted should allow migration or have appropriate systems for fish or other aquatic organisms but in reality these building blocks migration ichtyofauna (Gillian O'Doherty, 2009). For redirecting fish downstream of dams and other barriers, mechanical devices are installed screens and system bypass (Enders, 2009)

Multiple hydro-technical developments, some particularly complex, have created anthropogenic barriers and changed the flow regime and ecology of the river (massive deforestation, intensive agriculture, hydro and civil engineering structures within the watercourse, etc.). This has impacted river dynamics (wetlands, riparian forests, floodplain connectivity) resulting in aquatic ecosystem fragmentation). Thus services and social systems relying on properly functioning ecosystems have experienced a loss of economic benefits (via ecosystem services). Where appropriate, engineering solutions should be implemented to restore fish passage between Hârtibaciu River and its tributaries (Voicu at al. 2017). Existing anthropomorphic channel-spanning features create unhealthy hydro- morphological stressors (Fehér et al. 2012), including defragmented habitats, intensive agricultural work, and industrial-scale activities. (Voicu and Bretcan 2014; Voicu and Voicu, 2015). Delaying or blocking passage at these structures presents a challenge for fish passage engineers wishing to facilitate native fish migration. (Kay and Voicu, 2013). Restoring floodplain connectivity will improve and restore riparian wetland function (Ickes et al. 2005, EPA 2015). Natural waterfalls and highly confined, high energy channels limit fish migration, but anthropogenic structures exclude fish from from historic areas of use (Thorstad et al. 2008).

Since the Hârtibaciu River belongs to RO04 typology specific for hills or plateaus, the dominant fish species is the chub (*Leuciscus cephalus*). According to specialists there is a large variety of fish, among which the following species are identified: *Alburnoides bipunctatus* (the schneider), *Chondrostoma nasus* (the common nase), *Barbatula barbatula* (the stone loach), *Barbus barbus* (the common barbel), *Scardinius erythrophthalmus* (the common rudd), *Silurus glanis* (the sheatfish) and *Cobitis taenia* (the spined loach).

Of the species listed above, the common nase and the barbell are migratory species. Bănărescu (1964) mentioned that the the common nase is not a migratory species, but rather sedentary, and it can be found in hilly areas all year round.

2.METHODS

Hârtibaciu sub-basin is located in the north-west of Olt basin having a surface area of 1025km^2, spread over Sibiu county in a proportion of 91.3% and the rest of 7.2% in Brasov County.

Hârtibaciu sub-basin hydrographic network is represented by the Hârtibaciu River which is 110 km long and spread over 1025 km^2 and by its 21 main tributaries, including Valea Morii (surface covered= 39 km^2, lenght = 18 km), Coves (surface covered= 31 km^2, length = 14 km), Birghis (surface covered= 53 km^2, length = 16 km), Albac (surface covered = 113 km^2, length = 28 km) and Zăvoi (surface covered = 105 km^2, length = 18 km).

Numerous works on regularization of riverbeds have been made in the Hârtibaciu River Basin. These works amount to a total length of 176 km, of which 80 km is the banking, 60 km riverbed re-grading and 36 km riverbed embankment.

Retis non-permanent body of water (Retis dam) is located on the Hârtibaciu River and was completed during 1985 – 1988. Eventually it was put into operation in 1988. It is located 21 km from the source of the Hârtibaciu River and 300 m upstream from Brădeni village.

The main function of this body of water is to protect villages and agricultural land downstream of the dam against flood (Bradeni, Agnita, Netus, Bradeni fish hatchery , DJ106 Sibiu - Agnita - Bradeni county road, agricultural lands without embankment in the valley of the river Hârtibaciu between Bradeni nd the city of Agnita) by ensuring the flood wave attenuation of 5%, and as a secondary function, the water body also provides the water supply for Brădeni fish hatchery by the means of the left bank water intake.

The Hârtibaciu River is largely managed and diverted for agricultural use (Figure 1a). At the Retiş Dam, infrastructure includes a breach (D1, Figure 1b, 1c) through which the Hârtibaciu River flows and a 20 cm-thick concrete pier set in the middle of the spillway. This concrete pier fits the breach both horizontally and obliquely.

Two flood control lakes, Retiş and Beneşti, on the Hârtibaciu River (springs - Cibin confluence) were constructed to absorb high flow events. Located upstream from Brădeni settlement, Retiş lake, (importance grade III) with a maximum volume of 7200 m^3, is designed to provide flood protection for settlements and other infrastructure and communal resources in the area including: Brădeni, Netuş, Agnita, Brădeni fish hatchery, DJ106 county highway Sibiu – Agnita – Brădeni, and at-risk Hârtibaciu River farmlands between the towns of Brădeni and Agnita.

Figure 1a. Retiş Dam located on the Hârtibaciu River (google earth.com)

3. RESULTS AND DISCUSSION

This paper proposes engineering solutions to address low-head dam fish passage at Retiș Dam. By the proposed solution there can be achieved the longitudinal connectivity of the Hartibaciu River both downstream and upstream of Retis dam (Brădeni village). This engineering solution is based on and complies with hydrotechnics and civil engineering principles and uses only the gravity of water through the proposed system. The experience of both American and foreign authors certifies the correctness of this solution. Using the D1 spillway for achieving the solution preserves the structure of the dam intact and the unsophisticated accomplishment of this solution (extension of the system slope adjustment) provides certain efficiency.

These proposed measures are purely local and are not part of a package of measures aimed at the entire basin. No such works are developed, the river still preserves its natural characteristics up to its source. No similar studies can be found in the country.

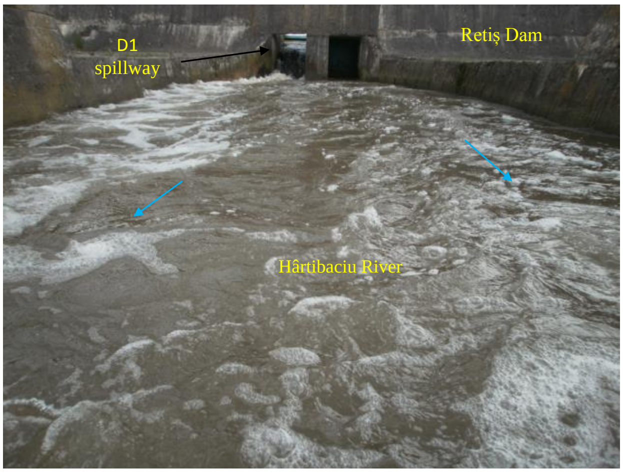

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Figure 1b si 1c Breach and trashrack D1 through which the Hârtibaciu River flows

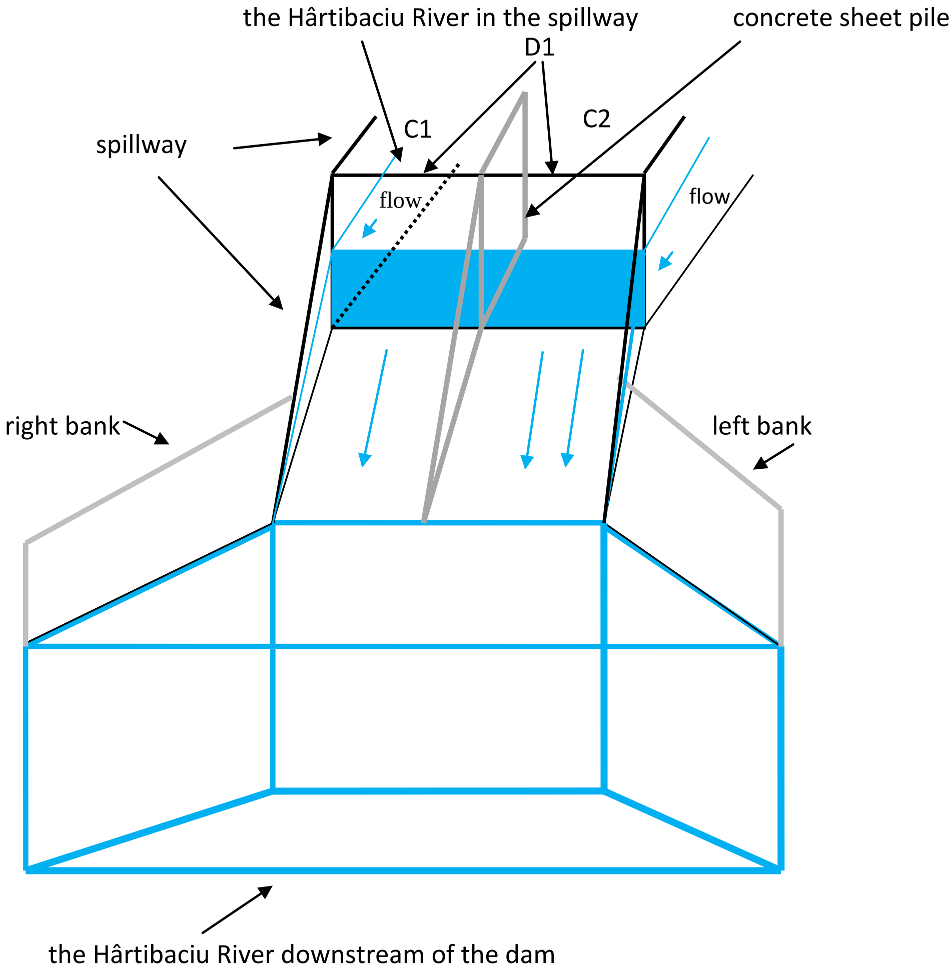
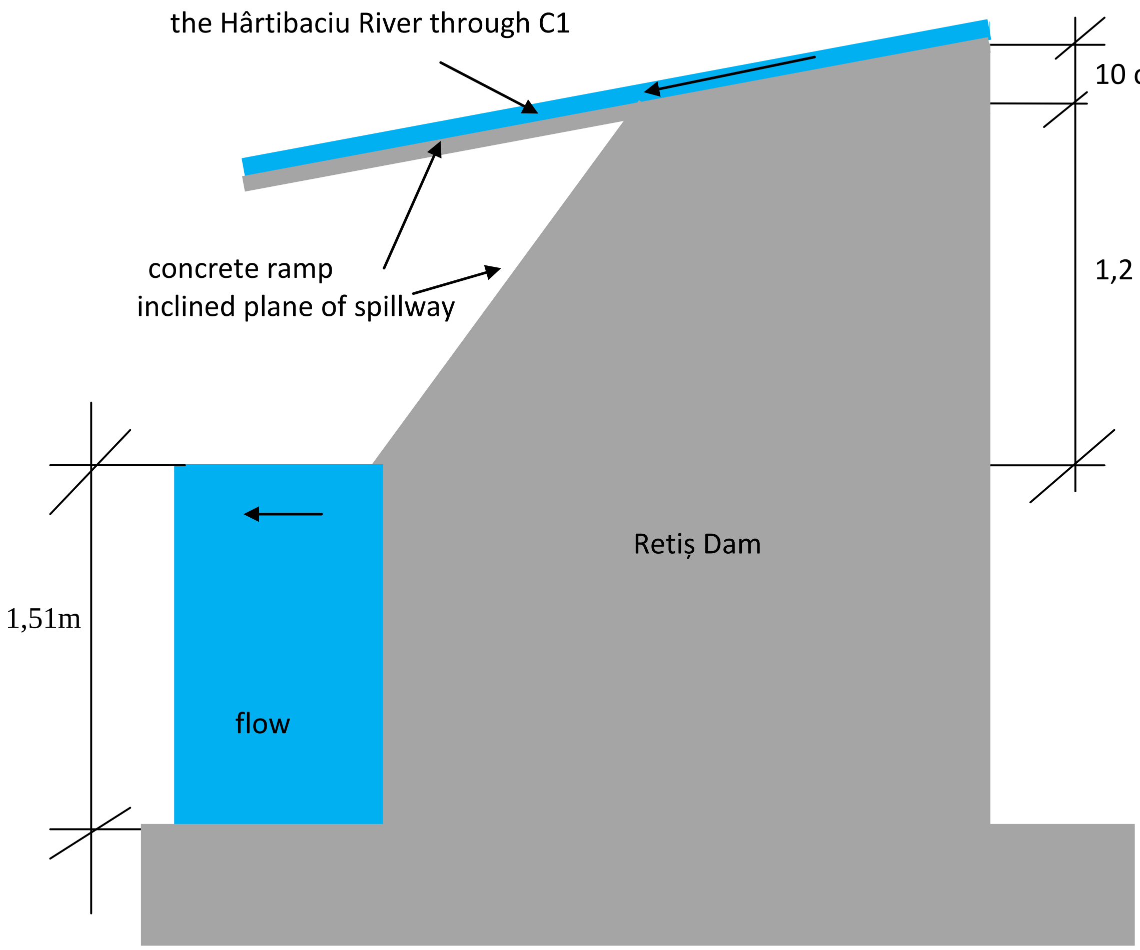


Figure 2 Position of the concrete pier situated in the middle of the breach D1 – indicative scheme

The concrete sheet pile splits the D1 breach (Figure 2) into two identical channels. Before the D1 breach inclined plane, a concrete ramp having a slope similar to the Hârtibaciu River's must be attached to channel C1 upstream from Retiș dam's right bank. The slope will be similar to the breach's C1 (low slope) until it reaches the inclined plane (high slope) (Figure 2). The difference in elevation between the upstream end and the downstream end of the breach is 1.30 m. Three concrete separators about 20cm above water level are situated 4 m downstream of the breach in the Hârtibaciu River bed.

The concrete ramp should have a thickness of about 20 cm. Some concrete piers of 30 cm height are fixed on both sides of the ramp. Also, a metal non-corrosive grille is attached above it (Figure 3). Fixing the concrete ramp inside the channel C1 will be achieved by using some metal rivets (Figure 3). The channel C1 will be about 50cm wide and 1.99m high.



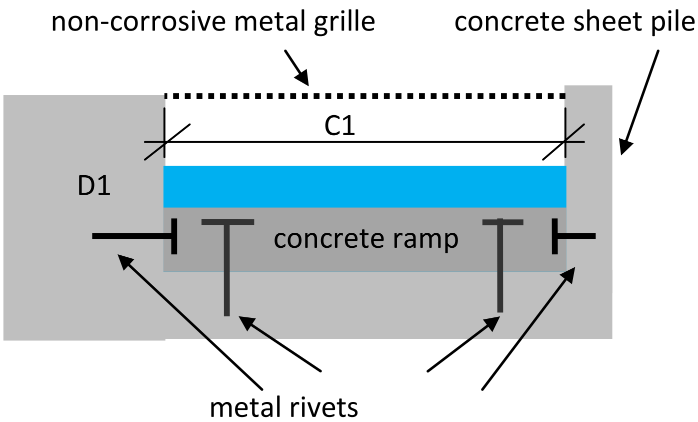


Figure 3. Positioning concrete the ramp – indicative scheme

After leaving C1, the concrete ramp will be fixed by the right abutment using metal support bars, but will also have some supporting concrete pillars fixed into the concrete riverbed (Figure 4).

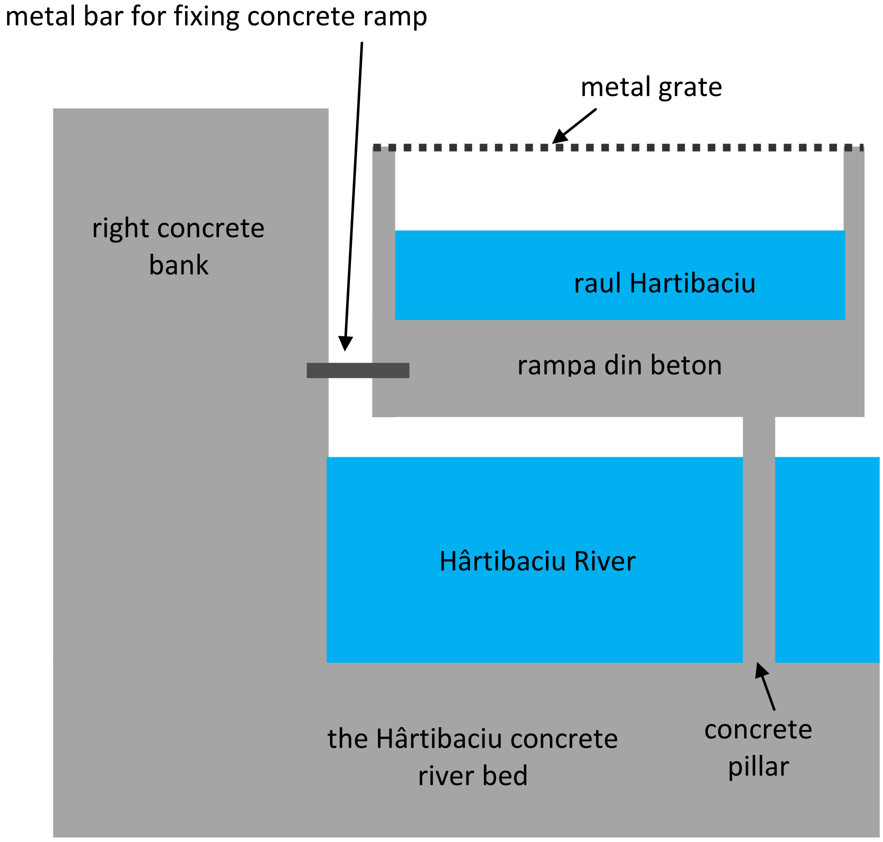
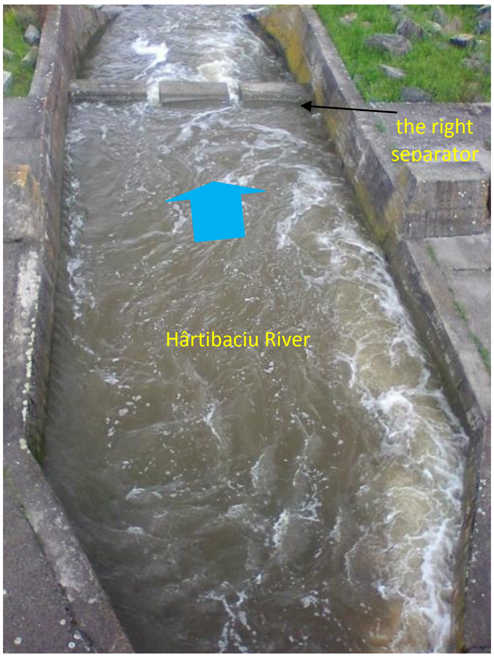


Figure 4. The concrete ramp will be attached to both the concrete right bank and the Hârtibaciu concrete river bed - Indicative scheme

About 14 m distance after leaving the breach, this concrete ramp will pass tangentially to the right separator that is fixed into the concrete right bank (Figure 5a and Figure 5b).



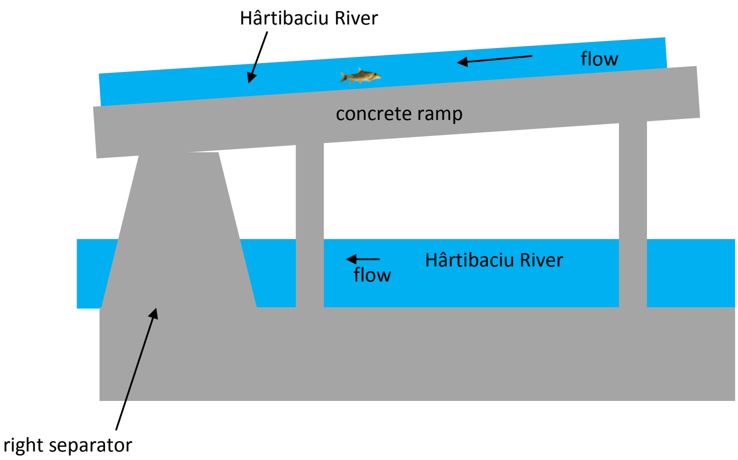


Figure 5 a The location of the right separator

Figure 5b Positioning the concrete ramp in relation to the separator – indicative scheme

The concrete ramp can have different forms (Figure 5c), but all these forms are designed as natural as possible so that the fish can climb up and down easily.

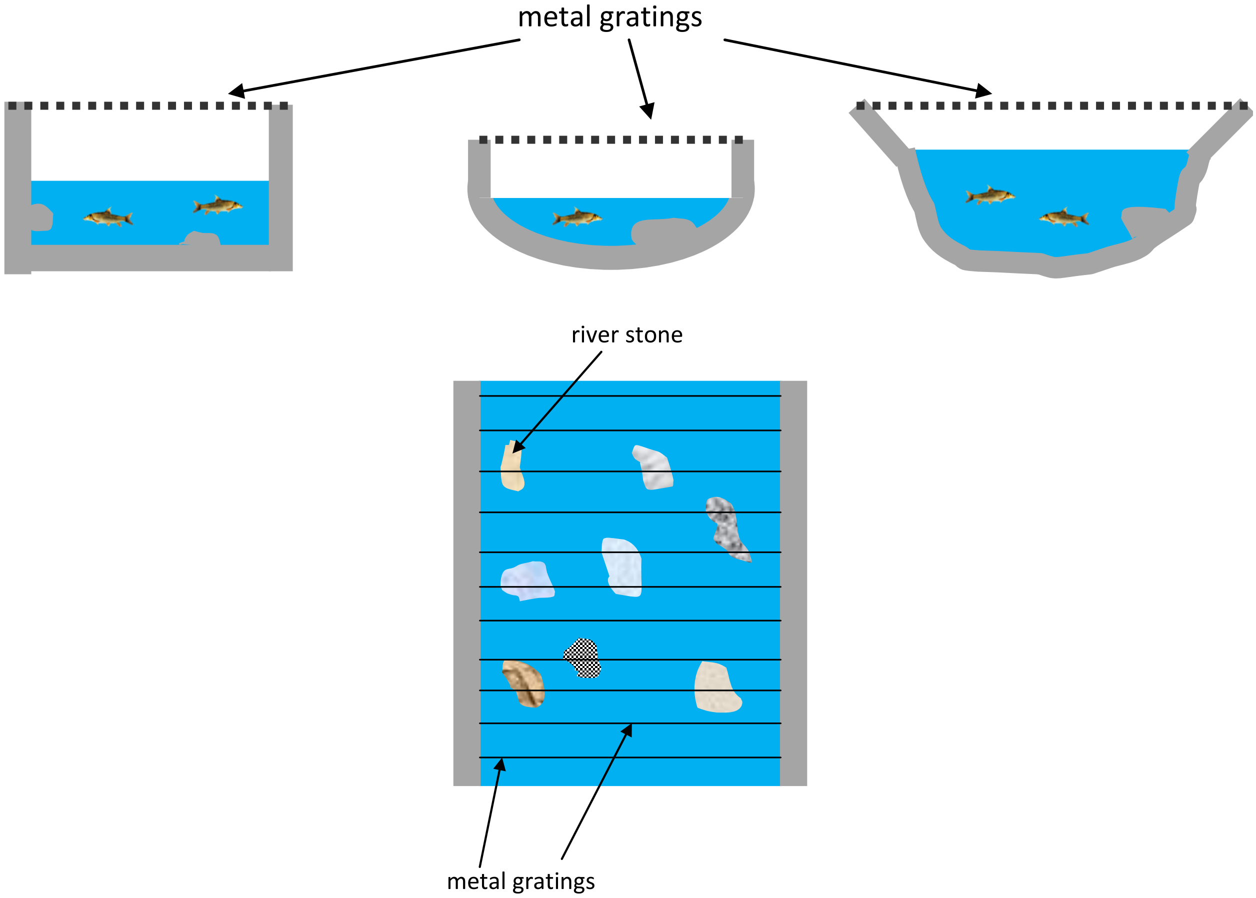


Figure 5c Various forms of the concrete ramp – indicative scheme

On some sectors in the middle of the concrete ramp, there must be some resting pools for fish fauna. They are made of concrete under the ramp (Figure 5d).

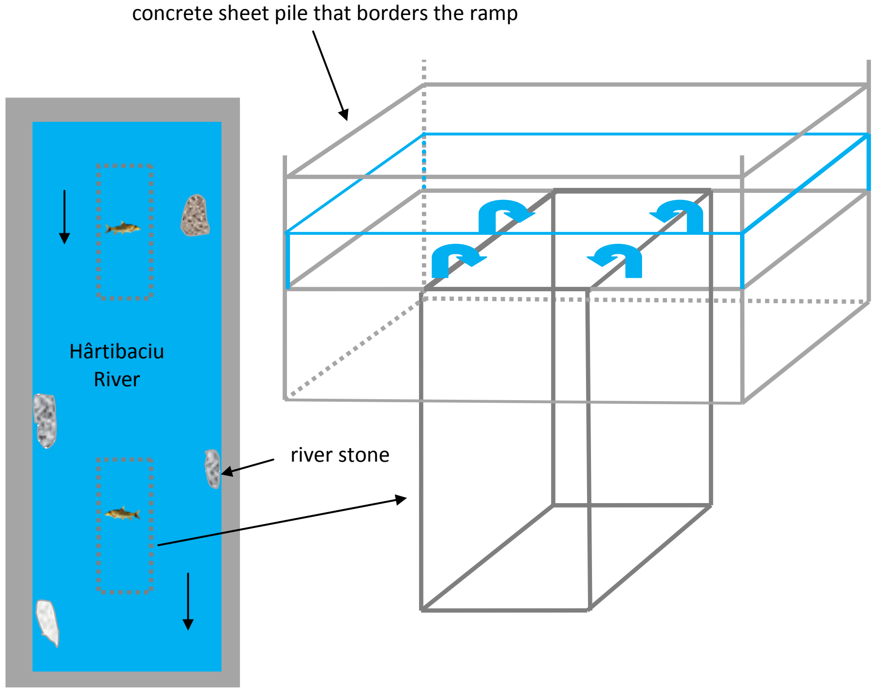


Figure 5 d Position basins for fish fauna resting – indicative scheme

These ramp pools provide hydrological complexity to increase passage success. During high flow events, these outer pockets provide refugia. To provide illumination within the fish ladder highly resistant transparent windows (Figure 5e) will be installed. On some sectors, the grating on the piers bordering the concrete ramp will be provided with windows and metal hinges that allow access for maintenance and sediment removal (Figure 5e).The trash rack upstream of the breach will remain unchanged as it is very effective in in excluding debris from the ladder (Figure 6a). Windows with metal hinges will be placed on the concrete ramp for maintenance and sediment removal.

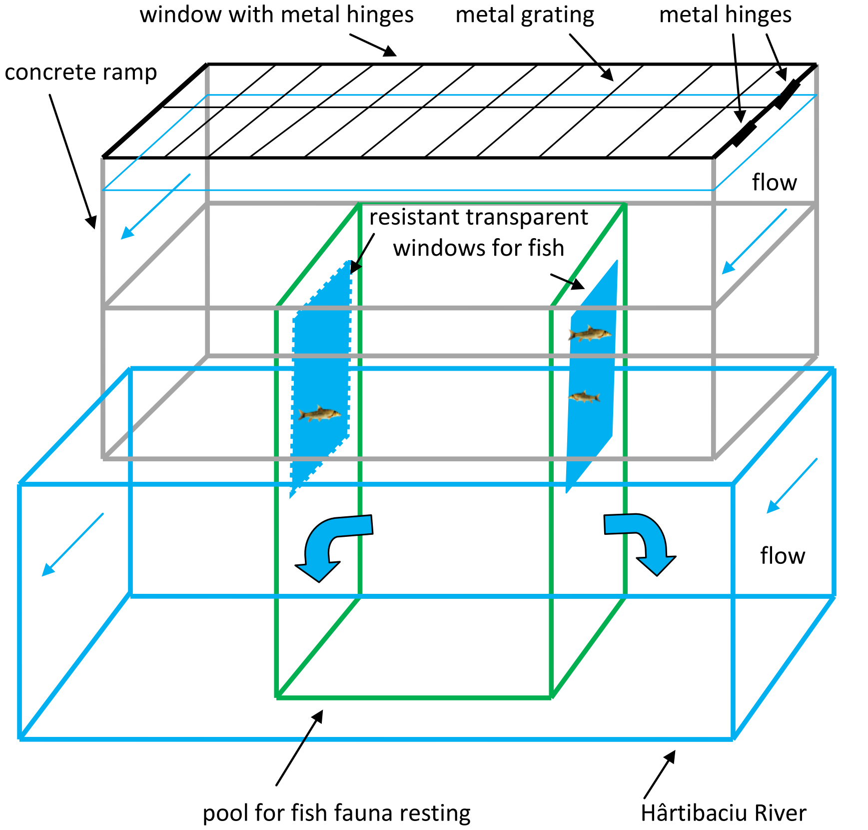


Figure 5e. Resting basins provide hydrological complexity to improve fish passage during high flow events – indicative scheme

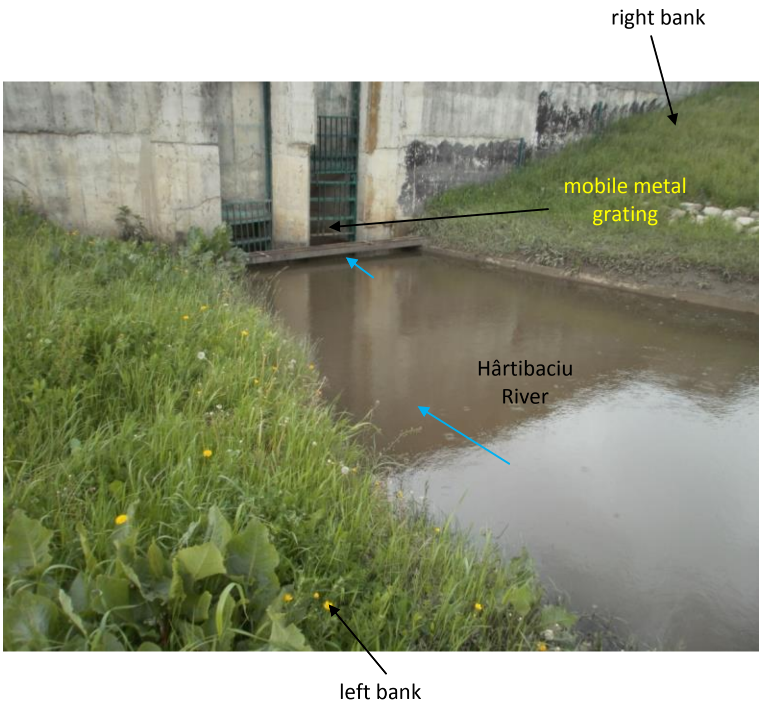


Figure 6a. Trashrack upstream of the dam (breach)

The ladder bypass channel directs fish over the right bank to several step pools (Figure 6).

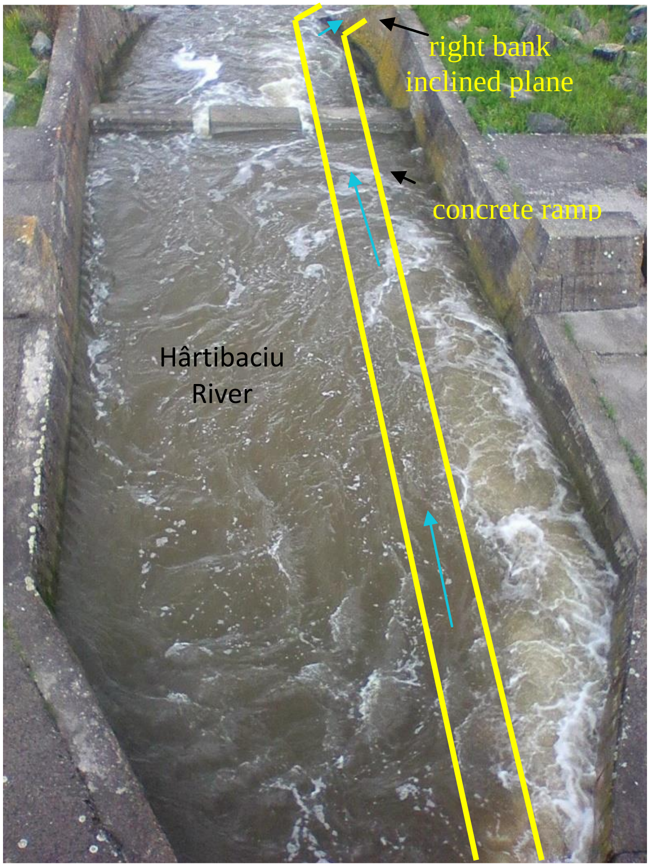


Figure 6b. Concrete ramp turning right

After passing the right bank, the concrete ramp forms a circular arc ending with two linking pools (B1 and B2), with hydraulic jumps (Figure 7).

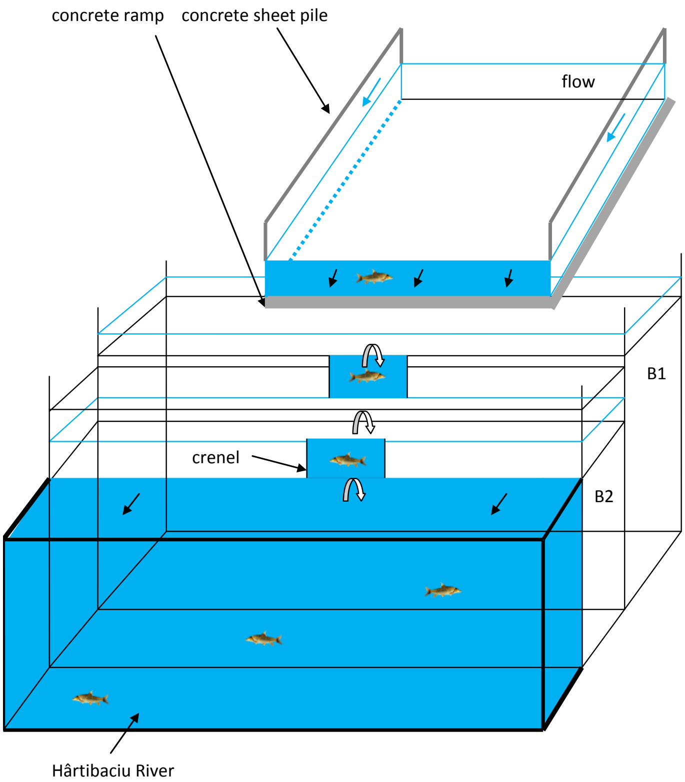


Figure 7. Positioning the downstream end of the concrete ramp and the two pools B1and B2 – indicative scheme

There is a hydraulic jump (3-8 cm) between the concrete ramp and the basin B1 and between the basin B1 and the basin B2 which is expected to be passable by the identified native species during most flows. After completing the design, calculations will be carried out carefully to verify that the design will not impede fish passage. Modifications to add the fish passage structure to Retiș Dam (Fig. 8) will not affect Retiș dam’s structural integrity.

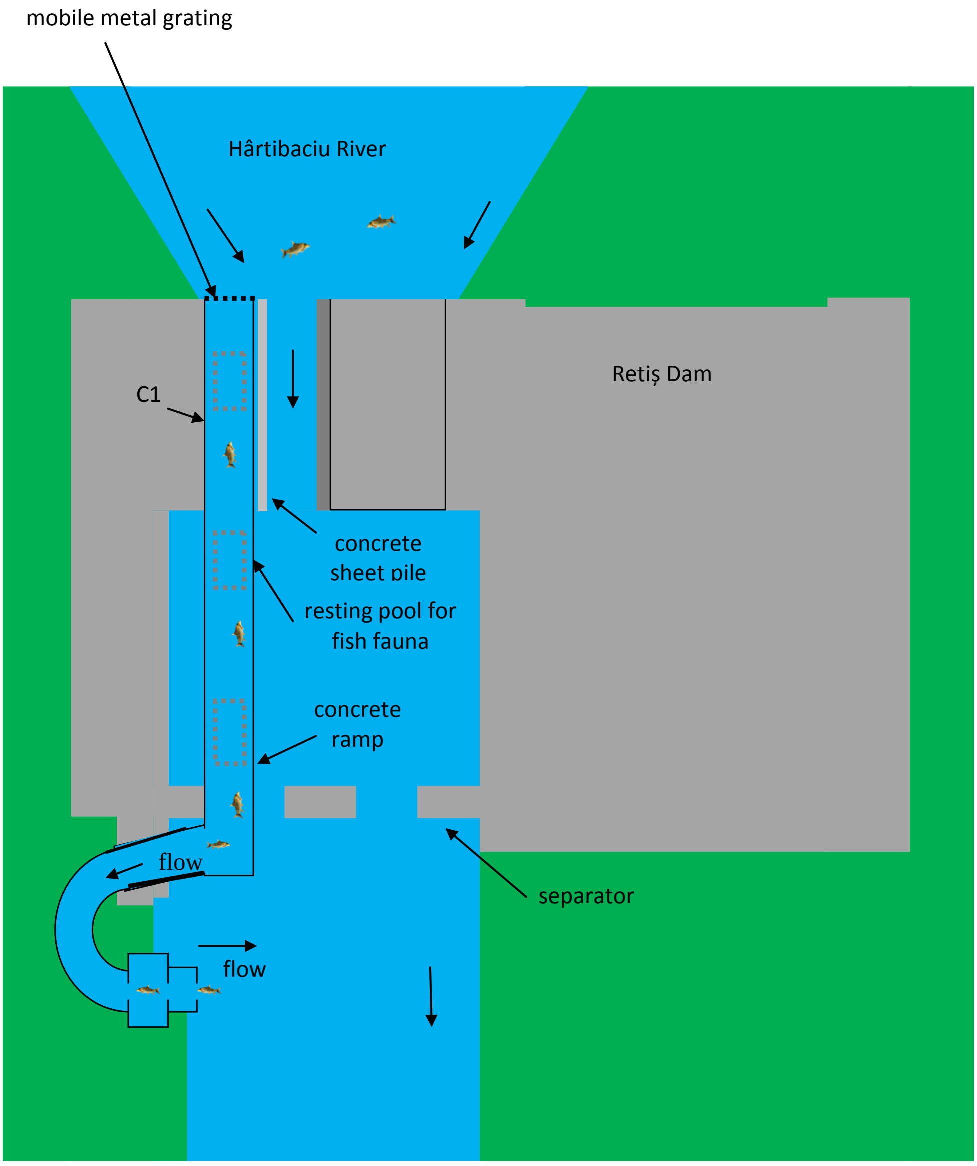


Figure 8. General scheme of the fish migration system – indicative scheme

4. CONCLUSIONS

This scientific concept (principles and design) requires a feasibility study related to calculations before being put into practice. Going through modern laboratories, where possible, represents a necessity, but all must comply with the principle and the correct design of the solution – which has already been achieved through this solution – supporting fish migration upstream – downstream from Retis dam.

The proposed fish ladder retrofit is expected to provide improved upstream and downstream passage for native fish in the Hârtibaciu River. Fish passage will likely be excluded at high flows. The system presented here can be essential as there are many migratory species in the Hârtibaciu River. Construction is dependent on identifying funding to build and test the system. A fish passage retrofit is expected to improve ichthyofauna migration on the Hârtibaciu River.

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