EVALUATION OF HYDRAULIC INFRASTRUCTURES IN THE HEADWATERS OF THE BARRA NOVA STREAM – APUCARANA, PR

Segantim, L. P.*., Ueda, A. C.*, Prates, K. V. C.** and Jabur, A. S.*

*Federal University of Technology – Paraná, Campus Apucarana
Marcilio Dias St, 635, Jardim Paraíso, 86812-460, Apucarana – PR - Brazil
**Federal University of Technology - Paraná, Campus Londrina
João Miguel Caram Av, 3131, Jardim Morumbi, 86036-370, Londrina – PR - Brazil

Highlights:

- The city of Apucarana is located over three major hydrographic basins.
- Hydraulic structures were built for the junction of neighborhoods, through culverts, bridges and small dams.
- Currently, these constructions present problems of erosion and silting.

Keywords: waterbody, hydraulic structures, urbanization.

INTRODUCTION

As cities expand, urban growth occurs unsustainably and changes in the natural environment become evident. As pointed out by Poleto (2019), urban occupation modifies the environment by means of the creation of impermeable areas, such as paving streets, buildings, roofs, parking lots, sidewalks, among others. This results in decreased concentration times and increased flow peaks, affecting the hydrological cycle and the dynamics of water resources.

According to the Federal Highway Administration (FHWA), an unstable stream is defined as having a notched channel, deficient or absent riparian vegetation, high and vertical banks, which are susceptible to undermining and prevent periodic flooding of the alluvial plain (JOHNSON, 2006). Unstable streams often face problems with siltation, environmental degradation and flood risk (BORTOLUZZI; FERNANDEZ, 2017). Thus, frequent management and restoration are essential to improve the stability of these streams.

The collection of data on the conditions of water bodies in the vicinity of bridges and culverts is of great importance to assess the vulnerability of these structures during periods of heavy rainfall. This information is useful in helping authorities take appropriate preventive and maintenance measures to ensure safety and avoid potential flood impacts.

The focus of the research was the sub-basin of Barra Nova Stream, located in the urban area of the municipality of Apucarana – PR, in which the main channel under study has some hydraulic structures that were evaluated.

METHODOLOGY

To define the level of stability of the hydraulic structures, the evaluation protocol proposed by the Federal Highway Administration (FHWA) of the United States (JOHNSON, 2006) was adopted. In the method presented, there are thirteen stability indicators, which were used as parameters for assigning points to the data collected in the field (BORTOLUZZI, FERNANDEZ, 2017). These indicators are the most used variables in the literature to evaluate the stability conditions of river courses. The score is stipulated in the categories: "Excellent" (1 to 3 points), "Good" (4 to 6 points), "Fair" (to 9 points) and "Poor" (10 to 12 points). For the sum, the ranking was considered the stream with overall rankings for pool-riffle, plane-red, dune-riple and engineered channels.

Table 1. Overall rankings for pool-riffle, plane-red, dune-riple and engineered channels.

Category	Ranking, R
Excellent	$R < 49$
Good	$49 \leq R < 85$
Fair	$85 \leq R < 120$
Poor	$120 \leq R$

RESULTS AND CONCLUSIONS

Evaluations were carried out on the engineering structures present along the Barra Nova Stream sub-basin through the application of the evaluation protocol proposed by the FHWA (JOHNSON, 2006), presented in Table 2.

Table 2. Stability indicator scores according to FWHA (2006).

Location	Stability Indicators													Total	Stability Status
	1	2	3	4	5	6	7	8	9	10	11	12	13		
1	12	12	1	10	10	10	1	2	3	10	6	6	1	84	Good
2	12	12	1	10	9	7	12	2	3	9	12	12	03	104	Fair
3	7	10	4	7	10	7	9	2	3	10	7	7	1	84	Good
4	12	12	6	9	6	6	2	3	12	10	7	12	10	100	Fair

Regarding the shape of the section, hydraulic culverts can be defined basically as tubular (T) because they have circular sections or cellular (C) because they have a rectangular or square cross-section (BRASIL, 2006), in Table 3. In addition to these most common forms used, tubular and cellular, there are other configurations, such as lenticular, elliptical, arch and others, which, despite being little used, may be more suitable for certain situations (BAPTISTA; COELHO, 2006).

Table 3. Hydraulic infrastructures evaluated in Barra Nova stream.

Location 1		Concrete Triple Tubular Culvert
Location 2		Concrete Quintuple Tubular Culvert
Location 3		Concrete Bridge (22m width)
Location 4		Concrete Double Celular Culvert

Among the 4 devices inspected, 2 were classified as good level of stability and 2 as regular. In addition, natural and/or anthropic environmental impacts cause instability in streams, such as construction of bridges and culverts can be considered an element that introduces changes in the dynamics of the flow, affecting erosive and depositional processes (COSTA, 2011).

In Locations 1, 2 and 3, a smaller spacing is observed due to the presence of dense urban regions. This urbanization imposes restrictions on the river channel as it is compressed by buildings and urban infrastructure. However, as we move away from urban areas (represented by Location 4), the distance between structures increases, indicating less urbanized areas where the river has more space to flow naturally. This difference in spacing reflects directly the impact of urbanization on the morphology of rivers.

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REFERENCES

BAPTISTA, M. B.; COELHO, M. M. L. P. Fundamentos de Engenharia Hidráulica**.** 2. ed. Belo Horizonte: UFMG, 2006. 437 p.

BORTOLUZZI, L.; FERNANDEZ, O. V. Estabilidade de canais fluviais em torno de pontes e bueiros na bacia hidrográfica do paraná III, oeste do Paraná. Raega - O Espaço Geográfico em Análise, v. 39, p. 219-235, 2017.

COSTA, M. S. Sistemas deposicionais e petrologia da sucessão siliciclástica do Gráben de Jaibaras (cambro-ordoviciano), Província Borborema, NW do Ceará. 2011. Trabalho de Conclusão de Curso (Bacharelado em Geologia) - Universidade Federal do Pará. Marabá, 2011.

JOHNSON, P. A. Assessing stream channel stability at bridges in physiographic regions. United States. Federal Highway Administration. Office of Infrastructure Research and Development, 2006.

BRASIL. MINISTÉRIO DOS TRANSPORTES. NORMA DNIT 023/2006 - ES: Drenagem – Bueiros tubulares de concreto - Especificação de serviço. Revisão da norma DNIT 023/2004-ES ed. Rio de Janeiro: Dnit, 2006. 8 p. Disponível em: http://ipr.dnit.gov.br/normas-emanuais/normas/especificacao-de-servicos-es/dnit023_2006_es.pdf. Acesso em: 18 de junho 2023.

POLETO, C (Org.). Bacias hidrográficas e recursos hídricos. Rio de Janeiro: Interciencia, 2019.