Association For Science

Georgian Scientists

ქართველი მეცნიერები

Vol. 8 Issue 3, 2026

https://doi.org/10.52340/gs.2026.08.03.19

Seepage Loss from the Rioni HPP power channel and Its Influence on the Surrounding Area

Mirian Kalabegishvili[1]; Marekhi Sadunishvili[2]; Izolda Lekvinadze[3]; Avtandil Gogoladze[4]; Giorgi Noselidze[5]

[1]Doct. Of science, prof. of Georgian Technical University, faculty of Civil Engineering; [2]PhD. Prof. of Georgian Technical University, Faculty of Mining Geology and Mountain Sustainable Development; [3]PhD. Kutaisi A. Tsereteli State University, Department of Physics; [4]PhD. Prof. of Georgian Technical University, faculty of Civil Engineering; [5]PhD., Assistant prof. of Georgian Technical University, Faculty of Civil Engineering

Abstract

The work aims to assess the impact of seepage losses from the Rioni HPP power channel (with damaged concrete lining) on the surrounding buildings.

A series of calculations, taking into account local topographic and geological conditions, determined the critical value of the seepage flow, at which a phreatic surface can be created at the channel foundation. According to the results, the seepage losses from the channel are less than the critical value of the seepage flow and, accordingly, the impact of the channel on the surrounding buildings cannot be realized. Thus, the dampness developed on the surrounding building is not related to the Rioni HPP channel.

This study evaluated the impact of seepage losses from the Rioni HPP power channel—which currently features damaged concrete lining—on surrounding buildings. Hydrogeological calculations incorporating local topographic and soil conditions established the critical seepage flow required to elevate the phreatic surface to the channel foundation. Because actual seepage losses fall strictly below this critical threshold, hydraulic connectivity to surrounding foundations cannot materialize. Consequently, observed structural dampness in nearby buildings is unrelated to the Rioni HPP power channel.

Key word: Power channel, seepage losses, seepage area, seepage flow critical discharge, phreatic surface, groundwater table, boundary conditions, seepage pressure head, numerical modeling, FEM iterative solution, Laplace differential equation.

1. introduction

Water supply to the Rioni Hydropower Plant (HPP) is conveyed from the headworks via a non-pressure tunnel and a channel. The main design parameters of the channel are:

- Water capacity - 80 m^3/s;
- The length of the power channel - 5 km;
- The thickness of the trapezoidal concrete lining - 12 -:- 20 cm;
- Variation of the water depth in the channel - 4.95 -:- 5.5 m.

As a result of a general inspection of the power channel, it was revealed that the channel concrete lining (slopes and base) has various types of damage throughout the entire route. This contributes to the development of seepage losses from the channel to the foundation.

Design materials and the results of on-site measurements were used to assess the issue. Based on the studies conducted by spatial group, it was determined that the seepage loss along the entire length of the channel is 2.38 m^3/s. Thus, the specific seepage flow discharge reaches a rather small value - $q=4.76\ 10^{-4}\ m^2/s$.

The presented report aims to assess the possible impact of seepage losses from the Rioni HPP power channel on the university and other building, the basement of which is exposed to moisture.

2. Geological structure of the channel concrete lining foundation

The foundation of the power channel and adjacent structures consists of geological material referred to as "old alluvium."

Old alluvium comprises river- and stream-deposited sedimentary materials formed during past geological epochs. It typically consists of rounded debris (boulders, pebbles, and gravel), sand, clay, and silt, encompassing channel, floodplain, and oxbow deposits. The seepage coefficient (hydraulic conductivity) of this geological material varies across a wide range (0.05–50 m/day).

For design calculations, the seepage coefficient of the foundation soil was assumed to be 5 m/day.

3. Assessment of seepage loss from the power channel into the base soil and Scenario Calculation

To investigate this issue, seepage calculations were performed using the finite element method, which iteratively solves the Laplace differential equation [1, 2,3].

Generally, a seepage domain requires defined flow inlet and outlet zones with appropriate boundary conditions. In this case, the seepage flow enters along the perimeter of the channel lining and discharges either into the groundwater table or the adjacent river.

In the study area, the Tskaltsitela River represents the shortest pathway for the seepage flow originating from the power channel (Fig. 1).

Accordingly, the potential seepage area encompasses the existing bedrock massif between the power channel and the Tskaltsitela River, extending up to 400 m.

Fig. 1 Arrangement Rioni Hpp channel and r. Tskaltsitela.

Seepage calculations were carried out for the worst-case scenario. Specifically, the damaged lining was completely ignored, assuming that seepage from the channel develops directly into the surrounding soil along the lining perimeter.
The seepage model encompasses the foundational rock array extending from the power channel to the Tskaltsitela River. The channel perimeter serves as the inflow boundary, while the Tskaltsitela River serves as the outflow boundary.
Several seepage calculations were performed using a mathematical model, evaluating two primary scenarios.

First Model

According to this model, the boundary conditions of the seepage domain are defined solely in terms of pressure head:

- The pressure head at the inflow section (corresponding to the headwater level in the power canal) is –150 m.
- The pressure head at the discharge section (corresponding to the confluence elevation of the Tskaltsitela River) is –100 m.

Thus, the total seepage pressure head acting on the foundation massif is 50 m.

Second Model

The boundary conditions of the seepage domain are specified using both pressure head and seepage flow rate:

- At the power canal surface (acting as the inflow cross-section), the boundary condition is defined by the specific seepage flow rate.
- At the Tskaltsitela riverbed cross-section (acting as the discharge cross-section), the boundary condition is defined by the pressure head.

1. **Calculation Results**

- First Model

Based on the calculation, the theoretical seepage area—along with the corresponding phreatic surface, which includes the foundation zone—was obtained from the power channel to the Tskaltsitela River (Fig. 2).
According to this model, the specific flow rate of the seepage flow in the channel cross-section amounted to 13^{-5} m²/s (11.25 m/d), which is twice the specific flow rate obtained through field measurements. Therefore, this calculated value is unrealistic. However, under this model, the seepage phreatic surface remains 8 m away from the basement of the university building, maintaining a sufficient distance.

- Second Model

Within the framework of this model, the critical value of the specific flow rate—at which a continuous seepage area in the channel foundation could form—was evaluated.
Using an iterative calculation based on varying seepage rates applied as boundary conditions at the power channel cross-section, the critical specific flow rate was determined to be $q_{cr} = 6.9 \cdot 10^{-4}$ m²/s (60 m²⁄d, fig.3). This critical value determines whether:

- A continuous seepage area and phreatic surface are established from the channel to the Tskaltsitela River, or
- The seepage flow from the channel connects directly to the underlying groundwater table at the foundation.

Specifically, the threshold condition indicates that:

- If $q_{cr} > 6.9 \cdot 10^{-4}$ m³/sec, - a continuous seepage area develops from the channel to the Tskaltsitela River (Fig. 5).

- If $q_{cr} < 6.9 \cdot 10^{-4}$ m³/sec, -, a continuous seepage area cannot form due to the low flow rate, causing seepage losses to recharge the deeper groundwater horizon at the foundation (Fig. 3).

The calculation results show that the critical specific seepage flow ($q_{cr} = 6.9 \cdot 10^{-4}$ m2/sec) is 1.5 times higher than the actual lining seepage loss ($4.76 \cdot 10^{-4}$ m²/sec,). Therefore, the volume of water lost through seepage is inadequate to sustain a continuous phreatic level reaching the Tskaltsitela River.

Note that the critical value of the specific flow depends on the soil seepage coefficient, which reaches up to 50 m/day per relevant standards. A higher seepage coefficient directly increases the critical flow threshold, widening the gap relative to the observed channel loss. As a result, higher soil permeability renders the formation of a hydraulic connection to the Tskaltsitela River even less feasible.

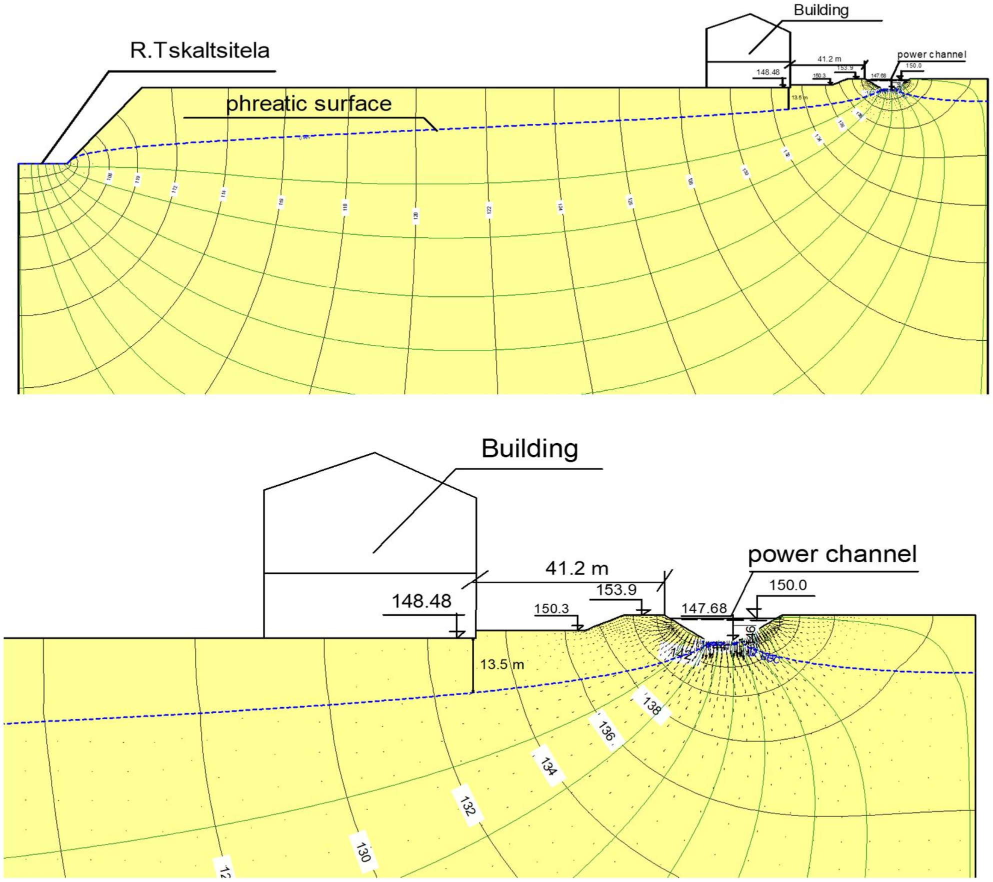

Fig. 2. Seepage mesh with a phreatic surface by First model.
Boundary conditions with total pressure head:
- in the channel section - 150 m; - in the Tskaltsitela river section - 100 m.

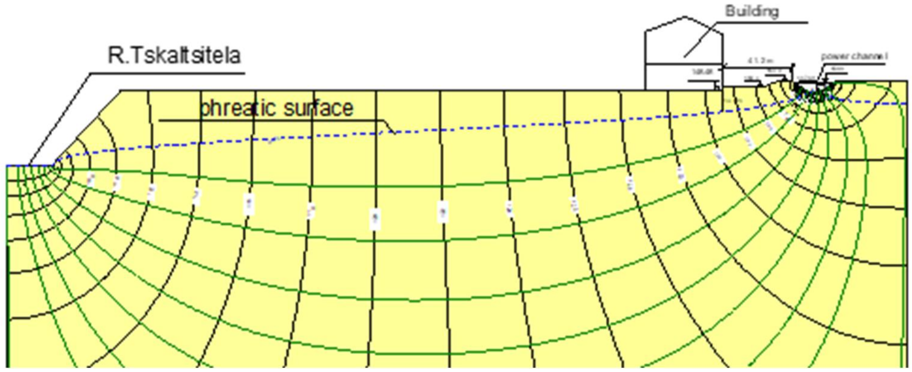

Fig. 3. Seepage mesh with a phreatic surface, when of the specific flow reach to c ritical value ($q_{cr} = 6.9 \cdot 10^{-4}$ m^3/sec).

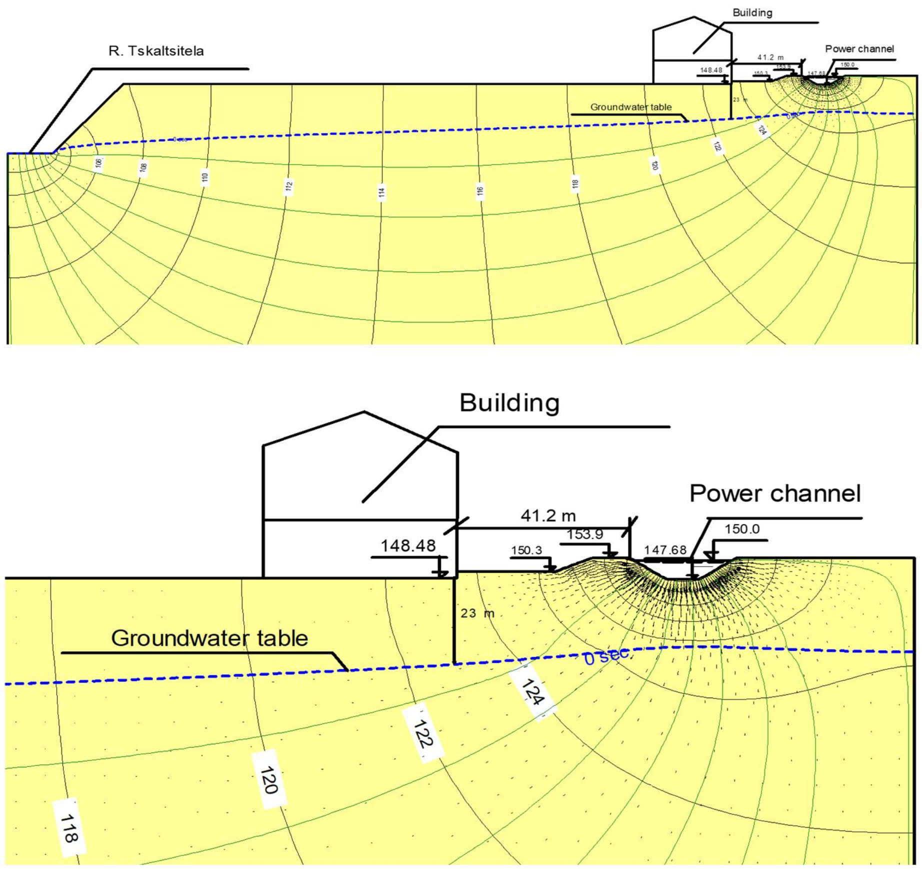

Fig. 4. Seepage loss from the power channel (4.76 10^{-4} m^2/sec) connected to the groundwater table.

2. **Calculations incorporating existing channel seepage losses**

In line with the above, calculations were also carried out using the seepage loss values provided by initial studies.

The results indicate that the existing low flow rate is insufficient to create a seepage area with a corresponding phreatic surface extending from the power channel to the Tskaltsitela River. Consequently, seepage from the power channel merely merges with the groundwater table, which remains a considerable distance (23 m) from the base of the university building (Fig. 4).

Conclusion

- Based on a series of numerical iterative calculations, a theoretical seepage spread area was established. This area encompasses the section of the soil foundation between the power channel and the Tskaltsitela River (the shortest path for seepage) where seepage could potentially occur in the event of high channel losses.

- The calculated critical value of the specific seepage flow from the power channel addresses a key question:
  - Whether a continuous seepage area and phreatic surface can form from the channel to the Tskaltsitela River, or
  - Whether the seepage flow simply joins the existing groundwater table below the base.

- The calculation results indicate that, due to its low magnitude, the specific seepage flow developed at the channel's foundation is insufficient to form a continuous seepage area and phreatic surface extending to the Tskaltsitela River zone. Under these low seepage losses, the flow from the channel recharges the local groundwater horizon, which sits significantly below—approximately 23 meters away from—the foundation of the university building.

  Consequently, the calculation results confirm that the foundations (and basements) of the university and adjacent buildings do not fall within the seepage influence zone caused by damage to the power channel lining.

References

BOUWER, HERMAN. “Theory of Seepage From Open Channels.” *Advances in Hydroscience*, 1969, 121–72. https://doi.org/10.1016/b978-1-4831-9936-8.50008-8.

Kasimov, A. R. “Optimization of Irrigation in a Hydrodynamic Filtering Model.” *Journal of Applied Mathematics and Mechanics* 55, no. 2 (1991): 273–76. https://doi.org/10.1016/0021-8928(91)90097-e.

Khristianovich, S. A. “Fundamentals of Seepage Theory.” *Soviet Mining Science* 25, no. 5 (1989): 397–412. https://doi.org/10.1007/bf02528249.

Mai, Zijun, Yupu He, Chen Feng, Congying Han, Yuanzhi Shi, and Wei Qi. “Multi-Objective Modeling and Optimization of Water Distribution for Canal System Considering Irrigation Coverage in Artesian Irrigation District.” *Agricultural Water Management* 301 (August 2024): 108959. https://doi.org/10.1016/j.agwat.2024.108959.

Najimuddin, Didin, Imam Wahyudi, and Soedarsono Soedarsono. “Analysis of Water Loss Due to Seepage in the Irrigation Channel of Batu Bulan Dam Sumbawa NTB.” *Journal of Social Research* 3, no. 8 (2024). https://doi.org/10.55324/josr.v3i8.2218.

Pelizzoli, Luigi Nascimento, William Fedrigo, Luiz Antônio Bressani, and Diones Uiliam Barboza. “Hydro Geotechnical Assessment and Seepage Analysis of the Dom Marco Ring Dam.” *Geotechnical and Geological Engineering* 44, no. 5 (2026). https://doi.org/10.1007/s10706-026-03757-8.

Šindler, Martin, Maroš Kubala, Dušan Senko, et al. “Implications of Climate-Change-Induced Stressors and Water Management for Sterlet Populations in the Middle and Upper River Danube.” *River Research and Applications* 41, no. 2 (2024): 448–65. https://doi.org/10.1002/rra.4361.