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# ADVANCE HYDRAULIC MODELING FOR IRRIGATION SYSTEMS, CASE STUDY SPP15 IRRIGATION PLOT HOTĂRANI - ROMANIA

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***Abstract***

*The numerical models commonly used for pressurized water distribution networks can also be adapted for modeling underground irrigation networks, which has also been done in this paper. Software packages such as Epanet, Mike Urban, etc. are usually designed for drinking water supply applications thus requiring adaptation of boundary conditions specific to underground irrigation networks. In this case study the hydraulic modelling of the irrigation network was done with the advanced Mike Urban software package. Following the modelling, the sizing of the newly designed pipeline network, the diagrams of pressures, speeds, flows, as well as the evolution in time in various operating scenarios were performed. The investment of the modernization and rehabilitation of OUAI Hotarani was financed currently through the 2023-2027 Strategic Program, intervention DR-25. In our paper we present the current nonfunctional and proposed rehabilitated functional situation of the SPP15 Hotarani irrigation system. Modernization by using new/modern mobile irrigation by sprinkling equipment ensures the operation at superior technical parameters, water, and energy saving.*

***Key words***: *head loss, hydraulic modelling, irrigation sprinkler system, pressure diagram, rehabilitation.*

## INTRODUCTION

Through its rural development policy, the European Union (EU) aims to help rural areas meet the multiple economic, social, and environmental challenges that the twenty-first century brings. This policy forms the second pillar of the Common Agricultural Policy (CAP), which includes specific measures and funding programs dedicated to rural development. DR-25, as outlined in Regulation (EU) 2021/2115 of the European Parliament and of the Council dated 2 December 2021, pertains to the upgrading of irrigation infrastructure. It aligns with the stipulations laid out in Articles 73 and 74 and supports the attainment of Specific Objective 5, which focuses on advancing sustainable development and effective management of natural resources like water, soil, and air. This objective includes endeavors to diminish reliance on chemicals. (AFIR, 2024).

Climate change poses significant challenges to existing water resources with implications for agricultural productivity, water security, and community well-being (UN, 2016; Sandu & Virsta, 2021). The adverse effects of climate change manifest through diminished crop yields and cultivated land, disruptions to both living and non-living components of ecosystems, financial setbacks, heightened labor demands, and escalated expenses for equipment. Agricultural irrigation stands as the primary consumer of water, representing over 70% of global water withdrawals, and plays a critical role in nourishing the world's populace. Water management in agriculture is very complex. Options in agricultural water management include a wide range of technical, economic, social and infrastructure factors (Çetin, 2023; Iglesias & Garroteb, 2015). Given the poor adaptation of existing infrastructure to new agricultural structures, the sector remains vulnerable to climatic conditions (frequent alternation, drought, and flooding), with significant economic effects on the economic viability of farms. Although the area arranged for irrigation has not decreased, the area irrigated differs from year to year, due to various causes, such as: weather conditions, lack of capital for investments in modernizing irrigation infrastructure, and implicitly lack of access to new technologies leading to improved energy efficiency and reduced water losses, as well as the cost of water due to the liberalization of electricity prices for irrigation. The adaptation of infrastructure to the new agricultural structure, as well as its efficient use, requires investments for modernization and development. Droughts, floods, and other threats related to climate change have a significant impact on production stability and national food security (Ivanescu et al., 2016). The lack of adequate infrastructure contributes to limiting opportunities for economic development despite the existence of agricultural potential. In order to adapt to the effects of climate change and protect the environment and for competitive reasons, it is necessary to modernize irrigation facilities to ensure efficient water use, using new technologies leading to a reduction in water consumption at investment level, and to reduce pressure on surface water bodies (ANIF, 2024).

Numerous mathematical models have been created to evaluate water resources management, such as MIKE SHE (Sandu & Virsta, 2015), RIBASIM (Van der Krogt, 2004), WEAP (Demertzi et al., 2013), and MIKE 11 (Madsen 2000; Ivanescu et al., 2014). These models play a crucial role in decision support systems for managing water resources.

Investment in modernizing irrigation infrastructure is necessary to improve the efficiency of these systems (reduced water losses, improved energy efficiency), reduce the dependence of agricultural production on weather conditions, increase farmers' competitiveness, and help the sector meet the long-term challenges posed by the effects of climate change (Cojocinescu, 2023). In this context, it is important that the rehabilitation solution is dimensioned so as to ensure the flow and pressure in the underground irrigation network, necessary for the efficient operation of the equipment.

## MATERIALS AND METHODS

The paper presents the solutions for modernization and refurbishment of the irrigation arrangement in plot SPP15 belonging to OUAI Hotarani, Mehedinti County (DALI, 2024). The study method is based on the use of Mike Urban software for hydraulic modeling of the underground irrigation pipeline network and the use of new / modern sprinkler irrigation equipment.

MIKE URBAN is a powerful water distribution modeling package that can analyze entire systems under various flow conditions and provide water quality analysis as needed. MIKE URBAN offers flexibility in water distribution model development, allowing users to import data from GIS databases, schematically draw pipe networks, or directly enter data using program editors. MIKE URBAN enables users to create network models for water distribution systems without detailed maps by defining components in interactive dialog boxes, allowing for accurate model definition when accurate maps are unavailable.

MIKE URBAN water distribution views the water distribution network as a collection of links connected by nodes, identified by ID numbers, and can be arranged in any way. The pipe data includes pipe length, diameter, roughness coefficient and minor loss coefficient, while the junction node data includes the water demand and elevation of the node for each network node. Control components consist of pumps, check valves, regulating valves, sustaining valves, flow control valves, and storage tanks. With the data entered, MIKE URBAN Water Distribution can perform a comprehensive check of the input data and geometric verification of the network connectivity after it has been entered (DHI, 2014). The pipe network can be analyzed after verification of the input data, ensuring that the results accurately define the model and appear reasonable.

The infrastructure owned and managed by O.U.A.I. SPP15 Hotarani, is part of the irrigation arrangement Crivina - Vînju Mare and serves the land area afferent to the plot SPP15 Hotarani, respectively a gross area of 1785 ha and a net area of 1605 ha (Figure 1) (Untaru et al., 2020).

The SPP15 Hotarani pump station is a pressure pump station, which sucks water from the CD5 irrigation channel and discharges it into the network of pressure pipes, main, secondary, and antennas located in the arranged agricultural area (Figure 1).

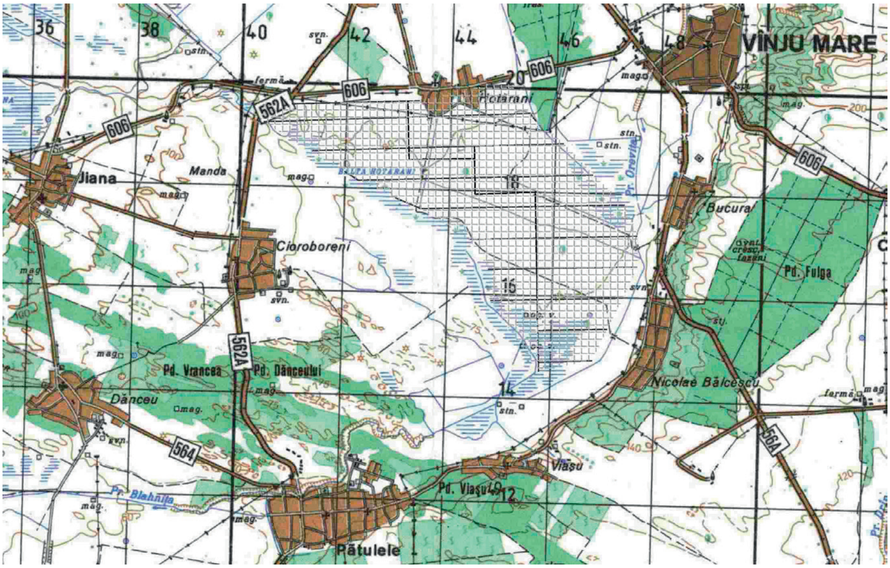


Figure 1. Location of the irrigation plot adjacent to the pumping station "SPP15 Hotarani", Mehedinti County

Within technical expertise, two variants of technical solutions for intervention works for the modernization and refurbishment of the irrigation system related to the OAU plot "SPP 15 Hotarani" were analyzed, regarding:

1. Modernization and renovation of the SPP15 pressure station belonging to OUAI SPP15 Hotarani, Mehedinti County;
2. Modernization and renovation of the irrigation pipeline network.

The recommended option involves the rehabilitation of the pumping station "SPP 15 Hotarani", of the suction basin and repairs to the distribution pipe network, metering the water consumption on discharge, keeping the utility of the building "SPP 15 Hotarani", which involves carrying out important repair works to the existing building (missing roof, exterior and interior plastering, repairs of the floor access staircase, new low voltage electrical installations, metal joinery (doors, windows), purchase of a new transformer station and medium voltage cells, purchase and installation of pump control and automation panels, replacement of existing pumping units to ensure: total installed flow: 1,238 $m^3$/sec and total installed station power: 1567.9 KW, installation of two ultrasonic flow meters for water metering on the two main pipes, new suction and discharge pipes from the pumping station, fencing.

Regarding the underground network of irrigation water transmission and distribution pipes, the main and secondary pipes and antennas will be replaced with new PEHD high-density polyethylene pipes, the ventilation installations will be replaced, the nodes on the main / secondary pipes, the anchorage massifs, manholes with line valves will be restored.

SPP15 is located on the CD5 bypass channel having the following characteristics: pumping units 9 pcs of which 7 type 8 NDS, with motor 200 kW speed 1500 rpm and 2 pcs type Cris125 with motor 75 kW speed 3000 rpm, post power supply 1600 kVA, 20/0 4kV, with an installed power 1550 kW specific consumption 350, ensuring a total flow of 1.24 $m^3$/s, at a pumping height of 62 mCA.

Figure 2. Overview of the SPP15 pumping station OUAI Hotarani Mehedinti County

The SPP15 pressure station SPP15 (Figure 2) is a pumping station with a closed above-ground building, with a ground floor and dry tank height regime and upstairs the energy annex transformer point. The station is of the type of closed reinforced concrete bowl with an eraser.

The procedure for the modernization / rehabilitation of an existing irrigation plot, which is in the patrimony of the OUA, includes the following steps (Man et al., 2023):

- drawing up expertise (with photo documentary and two proposed variants);
- preparation of intervention work authorization documentation (DALI, 2023);
- topographic studies in Stereo 70 coordinates;
- geotechnical studies;
- hydrological and/or hydrogeological studies;
- urbanism certificate, land book extract;
- environmental permit;
- opinions, as appropriate, from National Land Improvement Agency/Basin Water Administration (ANIF/ABA);
- PT + DTAC for building permit.

Based on the expert report, DALI documentation is developed, of which for the case study plot SPP15 Hotarani, for the recommended version, requires the following modernization works:

- reconstruction of the tank and roof at the SPP15 Hotarani pressure station SPP15 Hotarani;
- procurement and installation of new pumping technological lines (pumping aggregates, epuisment aggregate), with improved parameters to ensure the necessary flow and projected pressure;
- electric pumps shall be equipped with frequency converters to take over flow variations and to protect electric motors and their economic operation;
- restoration of the electrical connection and installation of newly designed electrical installations;
- repair of the electrical attachment;
- installation of new PVC doors and windows, with wire mesh protection grilles on the outside;
- installation of capture (suction) and discharge installations from pumping aggregates;
- mounting two ultrasonic flow meters on the main discharge pipes;
- electrical and automation installations will be replaced with new high-performance installations;
- fence with mesh fence on metal poles of the station enclosure, including access ridges.

Due to the superior efficiencies of new pumps installed in the station, the specific consumption of electricity with water pumping will be reduced, which will eliminate the payment of reactive current, and the automation of operation leading to the reduction of unnecessary water losses. The use of frequency converters to equip electric pumps has been proposed to take over flow variations and protect electric motors and their economical operation. The proposed technical solution ensures the functional safety of the entire irrigated area of the current irrigation system, starting from the distribution pipe network, necessary for water transport, and up to ensuring the operation of watering installations to its terminal end.

## RESULTS AND DISCUSSIONS

In order to carry out the modeling, the simulation model was created by introducing coordinates in stereo system 70, network nodes, and introducing pipe sections, specifying materials and diameters. This results in the situation plan shown in Figure 3.

The SPP15 pumping station was returned, supplied from the ANIF channel, with an installed flow of 3000 $m^3$/h. Following the calibration and running the model we obtained flow (Figure 4), speed (Figure 5), headloss (Figure 6), and pressure (Figure 7) on all pipes and nodes resulting in diagrams.

Therefore, we were able to make the pressure/velocity/headloss diagram in all sections which is presented in Figures 8 and 9 we in the directions SPP15 – A01 and SPP15 – A18, respectively.

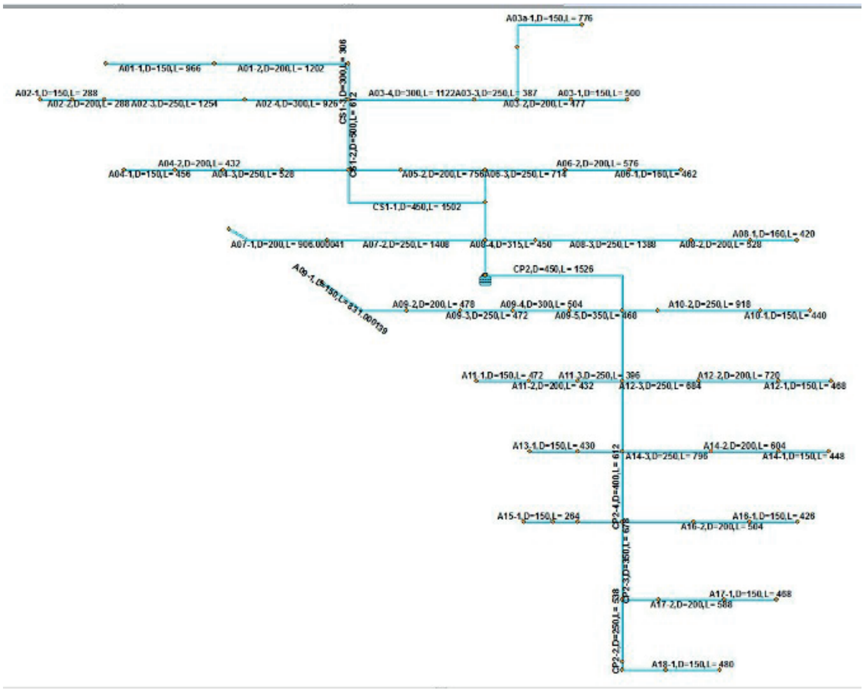

Figure 3. Plan view model

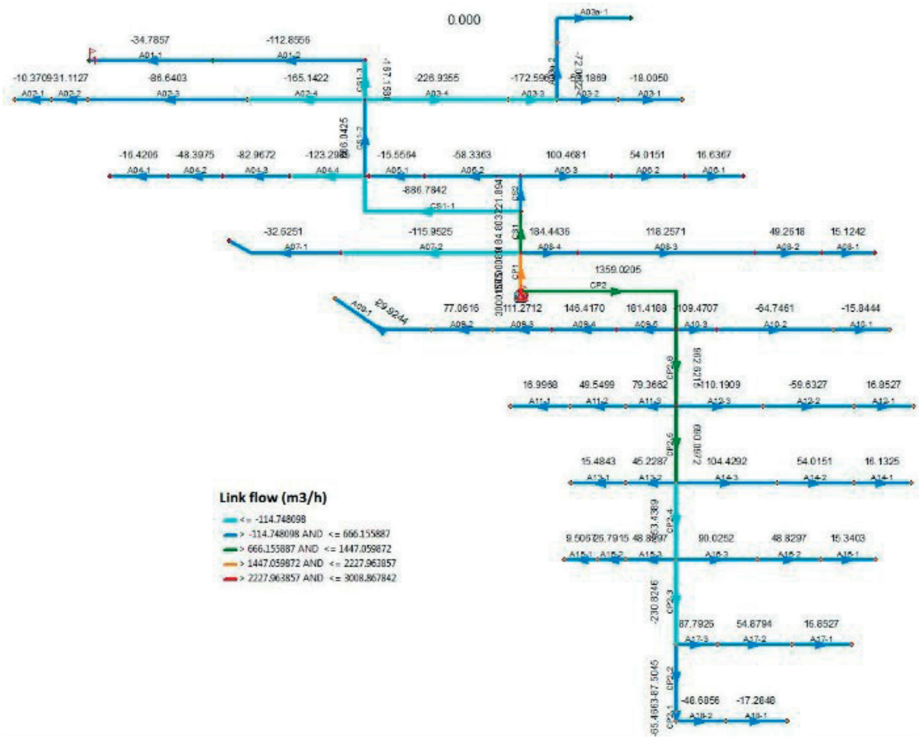


Figure 4. Pipe flows

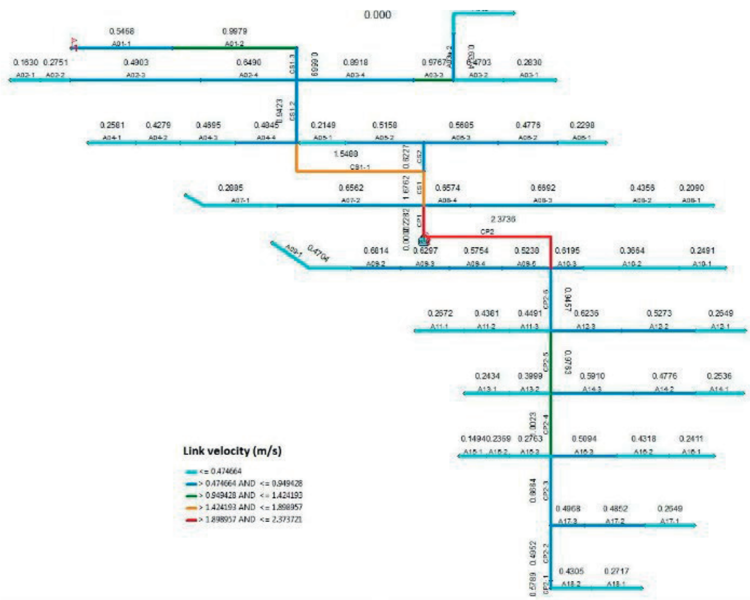


Figure 5. Pipe velocity


Figure 6. Pipe headloss

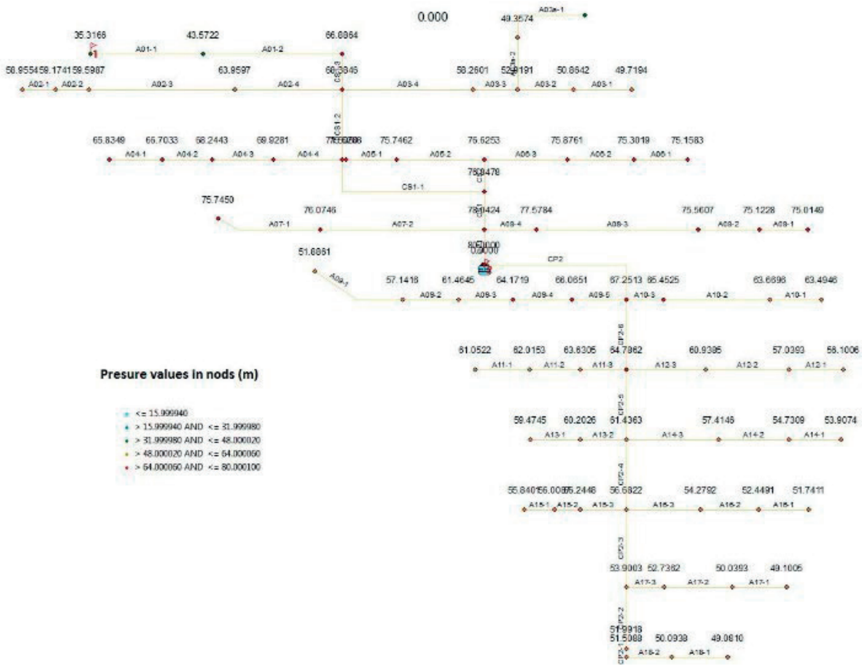


Figure 7. Pipe pressure

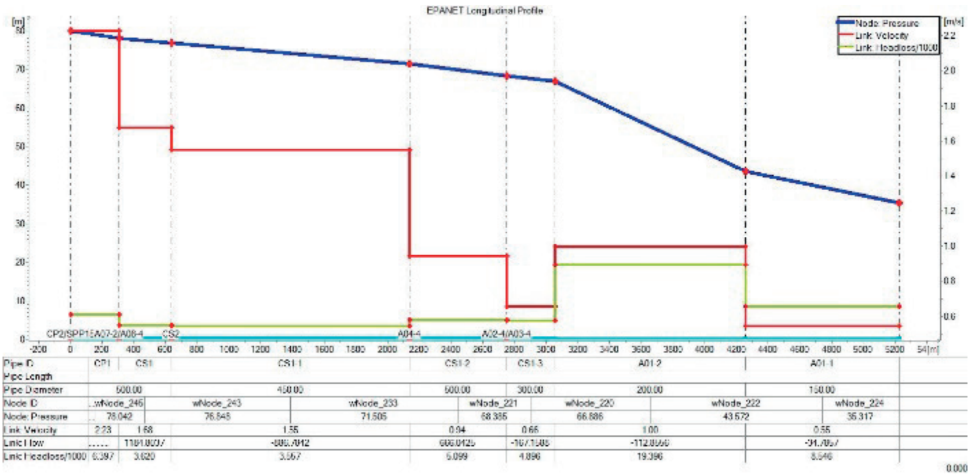


Figure 8. Section pressure diagram SPP15 – A01

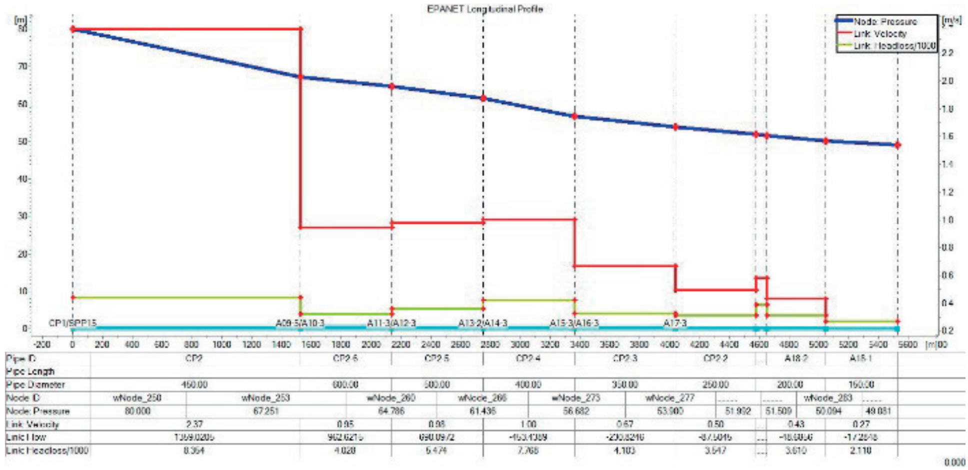


Figure 9. Section pressure diagram SPP15 – A18

## CONCLUSIONS

The application of hydraulic modelling led to the pressure diagram diagrams from Figures 8 and 9 which are fundamental to dimensioning underground pipeline network for irrigation and ensuring the pressure and flow necessary for the efficient operation of sprinkler watering equipment.

Modernization scenarios proposed for the optimal operation of the irrigation system are mainly concerned with the SPP15 pressure pumping station and the irrigation pipe network for the transport of water that supplies the irrigation installations of landscaped agricultural land.

The installation of new equipment to measure flows and volume of water distributed for watering agricultural plants will allow a correct relationship based on the contract between the water supplier, the ANIF Territorial Branch for Land Improvements Mehedinti and its user OUAI SPP15 Hotarani, eliminating possible conflicts in the event of lack of measuring equipment.

State-of-the-art efficient automation is proposed, so that during the exploitation period of the irrigation system, it is necessary to have as little staff as possible in the pumping station.

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