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# ADVANCE HYDRAULIC MODELLING OF IRRIGATION SYSTEMS, STUDY CASE PROTECT AGRO BABA ANA MIZIL IRRIGATION SYSTEM 1155 HA, ROMANIA

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**ABSTRACT. - Advance Hydraulic Modelling of Irrigation Systems, Study Case Protect Agro Baba Ana Mizil Irrigation System 1155 ha, Romania**. Investment "Modernization of irrigation system O.U.A.I. PROTECT AGRO BABA ANA MIZIL" is located in Prahova County, in the suburbs of the Mizil locality in the perimeter of the AHC Campia Buzaului complex development, in the irrigation system related to Plot SPP3 on Canal West 2. The total land area served by the SPP3/CV2 plot is 2171 ha, and the net area is 2076 ha. Through its rural development policy, the EU aims to help rural areas face the multiple economic, social and environmental challenges that the 21st century brings. This policy forms the second pillar of the Common Agricultural Policy (CAP). Climate change has an impact on existing water resources, especially in rural areas. Considering the poor adaptation of the existing infrastructure to the new agricultural structures, the sector remains vulnerable to climatic conditions (alternating drought and frequent floods), with significant economic effects on the economic viability of farms. This problem becomes much more acute in the context of global warming. Through their action, land improvement works (irrigation, drainage - drainage works and CES) contribute to the recovery of the land and induce beneficial effects on environmental factors: soil, water, air, supporting, once more, the inclusion of these works in the category those of public utility of national strategic interest. The case study is part of the National Strategic Program 2023-2027 - program financed by the European Union and the Government of Romania through measure DR-25 - Modernization of irrigation infrastructure The presented method allows the optimization of pipe dimensioning, respectively of the pressure and transported water discharge to irrigation capacity.

**Keywords**: irrigation system, numerical modeling, advance hydraulic, pressure system

## 1. INTRODUCTION

The investment "Modernization of irrigation system O.U.A.I. PROTECT AGRO BABA ANA - MIZIL" is in Prahova County, on the outskirts of Mizil and Baba Ana localities, in the perimeter of the irrigation system related to plot SPP3/CV2. The irrigation plot is located on the cadastral territory of Mizil city and Baba Ana commune (***, 2023).

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The total gross area of land served by the SPP3 plot is 2171 ha, and the net area is 2076 ha. The total area related to the location of the pumping station is 395.20 square meters.

The current project proposes the modernization of the irrigation system in the first stage to cover a net irrigable surface of 1154 ha (figure 1) including the partial pumping station.

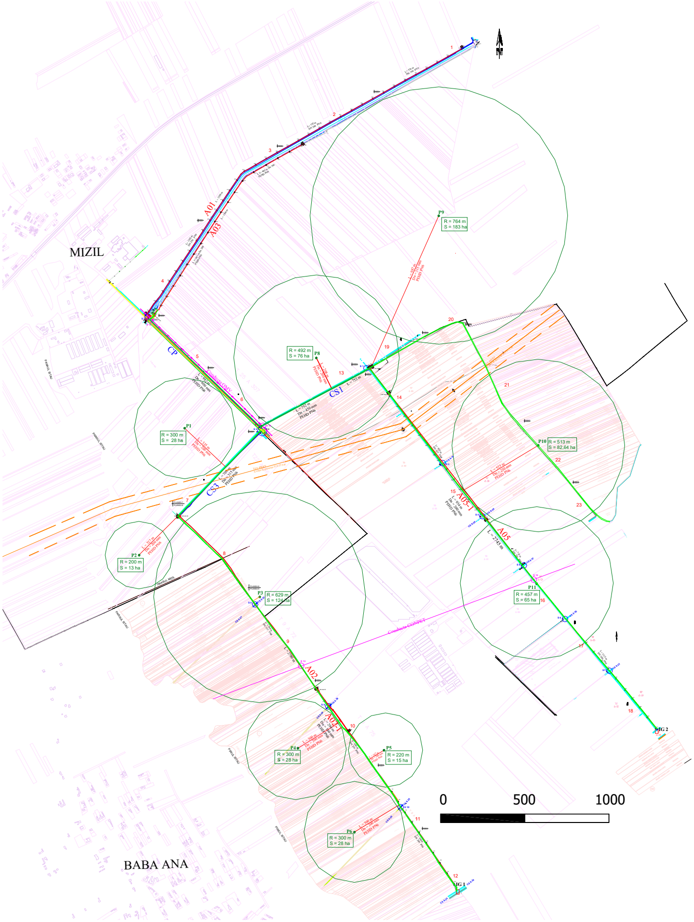

*Fig. 1. Area layout plan.*

Romania's rural development strategy for the coming years is part of the context of reform and development that the EU proposes. Pursuing the strategy's objectives for a smart, sustainable and inclusive economy, the strategy sets ambitious targets for member states in the fields of education, innovation, energy/environment, employment and social inclusion and improving competitiveness in general. Based on this document, each member state sets targets and action plans at the national level in the form of a National Strategic Plan that is periodically monitored.

The National Strategic Program for the period 2023-2027 contributes to the achievement of intelligent growth by supporting the forms of cooperation between research institutions and farmers and other actors of the rural economy, but also by supporting the component of professional training, acquisition of skills and dissemination of information. Also, the PNS envisages sustainable growth that emphasizes reducing carbon emissions and supporting environmentally friendly agricultural practices. Last but not least, the support given to investments in infrastructure and the rural economy leads to the reduction of poverty and the creation of jobs in rural areas, thus contributing to growth favorable to inclusion.

Through their action, land improvement works (irrigation, drainage - drainage works and CES) contribute to the recovery of the land and induce beneficial effects on environmental factors: soil, water, air, supporting, once more, the inclusion of these works in the category those of public utility of national strategic interest.

Although the area laid out for irrigation has not decreased, the actual irrigated area differs from year to year, due to various causes, such as: weather conditions, lack of capital for investment in the modernization of irrigation infrastructure and implicitly lack of access to new technologies to leads to improved energy efficiency and reduced water loss as well as water cost due to liberalization of electricity prices for irrigation.

In the pumping station SPP1, capital repair works are planned, the replacement of electric pumps, including the suction and discharge pipes. A new PEHD water distribution network is proposed that will feed the pivot type drip irrigation and drum irrigation installations.

## 2. PROPOSED WORKS AND METHODOLOGY

The dimensioning flow of the pipe sections was calculated (figure 2) based on the hydromodule of the flow, the land surfaces served and the yields of the irrigation equipment (Man T. E, at all, 2007).

| Pipe | | S (ha) | Hidromod (l/sxha) | Yeld (%) | Flow (mc/h) |
|---|---|---|---|---|---|
| SPP1 | A01 | 275.82 | 0.34937 | 0.9 | 385.45 |
| | A02 | 300.7 | 0.533611 | 0.9 | 641.818 |
| | A02-1 | 31.8 | 0.533611 | 0.9 | 67.8757 |
| | A03 | 147.75 | 0.34937 | 0.9 | 206.48 |
| | A05 | 296.91 | 0.533611 | 0.9 | 633.737 |
| | A05-1 | 101.03 | 0.533611 | 0.9 | 215.632 |
| | Stage 2 | 922 | 0.365783 | 0.9 | 1349.01 |
| Total | | 2076 | | | 3500 |
| Pivot | P1 | 28 | 0.55878 | 0.9 | 62.58 |
| | P2 | 13 | | | 29.06 |
| | P3 | 124 | | | 277.15 |
| | P4 | 28 | | | 62.58 |
| | P5 | 15 | | | 33.53 |
| | P6 | 28 | | | 62.58 |
| | P8 | 76 | | | 169.87 |
| | P9 | 183 | | | 409.03 |
| | P10 | 82.64 | | | 184.71 |
| | P11 | 65 | | | 145.28 |
| Total Pivots | | 642.64 | | | 1436.38 |
| Stage 1 without pivots | | 511.36 | 0.34937 | 0.9 | 714.62 |
| **TOTAL Stage 1** | | **1154** | | | **2150.99** |
| Stage 2 | | 922 | 0.365783 | 0.9 | 1349.01 |
| **TOTAL** | | **2076** | | | **3500.00** |

*Fig. 2. Dimensioning flows*

The pressures (Fig. 3) were determined in the worst-case scenario when each main pipe section supplies water to all the downstream antennas (Louks D, at all, 2005). The basis for the theoretical calculation of load losses in general, in technical applications, Chezy-type formulas are currently used (David I, 1984).

| Pipe | L (m) | D (mm) | K (m3/s) | n | M (s2/m5) | Q (m3/h) | V (m/s) | hr (m) | Pressure (mca) | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | Upstream | Downstream |
| CP | 982 | 600 | 11.40 | 0.0070 | 7.55 | 2908.1 | 2.86 | 4.93 | 53.00 | 53.26 |
| CS1 | 752 | 450 | 5.29 | 0.0070 | 26.82 | 709.69 | 1.24 | 1.04 | 53.26 | 53.21 |
| CS3 | 709 | 315 | 2.05 | 0.0070 | 169.47 | 849.37 | 3.03 | 9.43 | 53.26 | 43.20 |
| 1 | 1182 | 250 | 1.10 | 0.0070 | 969.10 | 385.45 | 2.18 | 11.11 | 53.00 | 40.20 |
| 2 | 792 | 200 | 0.61 | 0.0070 | 2134.66 | 206.78 | 1.83 | 7.04 | 40.20 | 32.42 |
| 3 | 576 | 160 | 0.34 | 0.0070 | 5103.63 | 87.066 | 1.20 | 2.99 | 32.42 | 30.65 |
| 1 | 1564 | 315 | 2.05 | 0.0070 | 373.83 | 618.05 | 2.20 | 11.02 | 43.20 | 37.80 |
| 2 | 648 | 250 | 1.10 | 0.0070 | 531.28 | 270.34 | 1.53 | 3.00 | 37.80 | 37.99 |
| 3 | 568 | 200 | 0.61 | 0.0070 | 1530.92 | 126.28 | 1.12 | 1.88 | 37.99 | 38.81 |
| A02-1 | 294 | 160 | 0.34 | 0.0070 | 2604.98 | 67.876 | 0.94 | 0.93 | 37.80 | 38.12 |
| 1 | 881 | 200 | 0.61 | 0.0070 | 2374.54 | 206.48 | 1.83 | 7.81 | 53.00 | 43.50 |
| 2 | 485 | 160 | 0.34 | 0.0070 | 4297.32 | 73.311 | 1.01 | 1.78 | 43.50 | 40.34 |
| 1 | 1630 | 315 | 2.05 | 0.0070 | 389.61 | 270.47 | 0.96 | 2.20 | 53.21 | 52.51 |
| 2 | 1115 | 200 | 0.61 | 0.0070 | 3005.23 | 109.86 | 0.97 | 2.80 | 52.51 | 59.48 |
| A05-1 | 934 | 200 | 0.61 | 0.0070 | 2517.39 | 215.63 | 1.91 | 9.03 | 52.51 | 47.02 |
| P1 | 310 | 200 | 0.61 | 0.0070 | 835.54 | 62.583 | 0.55 | 0.25 | 43.20 | 41.97 |
| P2 | 327 | 200 | 0.61 | 0.0070 | 881.35 | 29.057 | 0.26 | 0.06 | 43.20 | 43.47 |
| P4 | 300 | 200 | 0.61 | 0.0070 | 808.58 | 62.583 | 0.55 | 0.24 | 38.12 | 37.74 |
| P5 | 107 | 200 | 0.61 | 0.0070 | 288.39 | 33.527 | 0.30 | 0.03 | 37.99 | 36.99 |
| P6 | 300 | 200 | 0.61 | 0.0070 | 808.58 | 62.583 | 0.55 | 0.24 | 37.99 | 38.27 |
| P8 | 208 | 200 | 0.61 | 0.0070 | 560.62 | 169.87 | 1.50 | 1.25 | 53.21 | 51.90 |
| P9 | 987 | 315 | 2.05 | 0.0070 | 235.92 | 409.03 | 1.46 | 3.05 | 53.21 | 47.37 |
| P10 | 513 | 250 | 1.10 | 0.0070 | 420.60 | 184.71 | 1.05 | 1.11 | 47.02 | 45.66 |

***Fig. 3. Pressure calculation.***

To meet these challenges, access to the right tools is essential. MIKE URBAN enables you to make sound decisions and create future concepts for urban storm water drainage networks and sewer collection systems - concepts that are cost-effective as well as resilient to change. The high degree of accuracy is achieved by using DHI’s computational engines, MOUSE and MIKE 1D – with unrivalled numerical stability and accuracy. Furthermore, it is achieved by simulating catchments based on their actual spatial geometry and the corresponding hydrological parameters (Gabor E, at all, 2018).

The collection system modules integrated in MIKE URBAN enable you to model:

- Hydrodynamic pipe flow
- Advanced real-time control strategies
- Pollutant transport
- Biological processes
- Rainfall runoff
- 2D overland flow

MIKE URBAN can import and export network data as ESRI ArcView shape files, allowing the network data to be directly imported and exported into and from ArcView (Armas A, at all, 2017).

MIKE URBAN WD is extremely flexible in how a water distribution model can be developed. The user can develop a model from scratch using a variety of input methods, including importation of data files from a GIS database or pre- existing water distribution models, schematically drawing the pipe network, or by simple data entry.

The function of a booster pump is to overcome the friction resistance and head loss in transporting water from one location to another. There are three types of booster pumps available in MIKE URBAN WD, including flow pumps, power pumps, and head pumps (***, 2011).

## 3. RESULTS AND DISCUSSIONS

Following the analytical calculations of the pressure losses, the available pressures on the ends of the pipes were obtained. With their help, the pressure diagram (figure 4) was drawn on the pipeline sections.

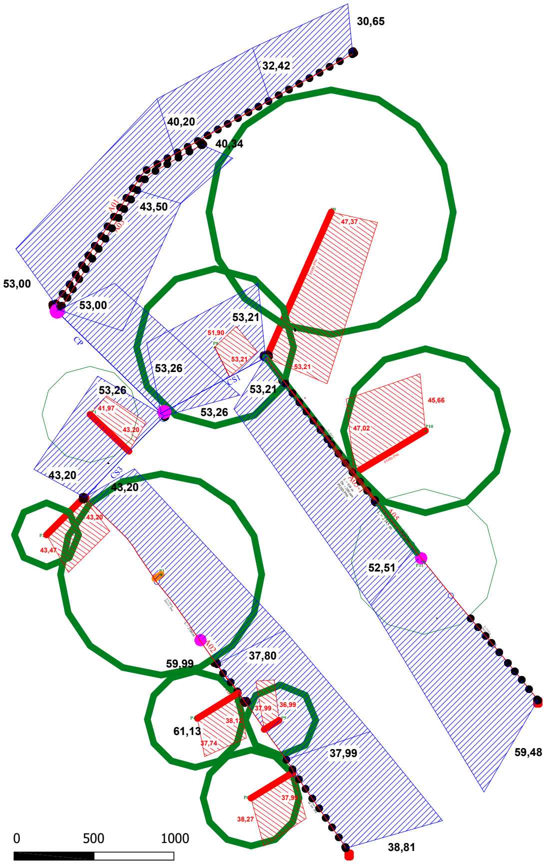

Fig. 4. Pressure diagram.

After running the hydrodynamic model with the help of the MIKE URBAN software, the pressure losses on the pipes were obtained, resulting in the available pressures along the entire length of the pipe network (figure 5).

| Pipe | | L (m) | D (mm) | Analytical Pressure (mca) | | Numerical Pressure (mca) | | Error (%) | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | Upstream | Downstream | Upstream | Downstream | Upstream | Downstream |
| CP | CP | 982 | 600 | 53.00 | 53.26 | 53.00 | 55.53 | 0.00% | 4.26% |
| CS1 | CS1 | 752 | 450 | 53.26 | 53.21 | 55.53 | 54.36 | 4.26% | 2.16% |
| CS3 | CS3 | 709 | 315 | 53.26 | 43.20 | 55.53 | 41.57 | 4.26% | 3.76% |
| A01 | 1 | 1182 | 250 | 53.00 | 40.20 | 53.00 | 41.51 | 0.00% | 3.25% |
| | 2 | 792 | 200 | 40.20 | 32.42 | 41.51 | 33.80 | 3.25% | 4.25% |
| | 3 | 576 | 160 | 32.42 | 30.65 | 33.80 | 29.58 | 4.25% | 3.49% |
| A02 | 1 | 1564 | 315 | 43.20 | 37.80 | 41.57 | 36.26 | 3.76% | 4.07% |
| | 2 | 648 | 250 | 37.80 | 37.99 | 36.26 | 39.30 | 4.07% | 3.45% |
| | 3 | 568 | 200 | 37.99 | 38.81 | 39.30 | 40.45 | 3.45% | 4.23% |
| A02-1 | A02-1 | 294 | 160 | 37.80 | 38.12 | 36.26 | 39.12 | 4.07% | 2.62% |
| A03 | 1 | 881 | 200 | 53.00 | 43.50 | 53.00 | 42.23 | 0.00% | 2.92% |
| | 2 | 485 | 160 | 43.50 | 40.34 | 42.23 | 41.61 | 2.92% | 3.16% |
| A05 | 1 | 1630 | 315 | 53.21 | 52.51 | 54.36 | 50.29 | 2.16% | 4.23% |
| | 2 | 1115 | 200 | 52.51 | 59.48 | 50.29 | 60.89 | 4.23% | 2.36% |
| A05-1 | A05-1 | 934 | 200 | 52.51 | 47.02 | 50.29 | 48.67 | 4.23% | 3.51% |
| P1 | P1 | 310 | 200 | 43.20 | 41.97 | 41.57 | 43.96 | 3.76% | 4.75% |
| P2 | P2 | 327 | 200 | 43.20 | 43.47 | 41.57 | 44.61 | 3.76% | 2.62% |
| P4 | P4 | 300 | 200 | 38.12 | 37.74 | 39.12 | 36.45 | 2.62% | 3.43% |
| P5 | P5 | 107 | 200 | 37.99 | 36.99 | 39.30 | 38.52 | 3.45% | 4.14% |
| P6 | P6 | 300 | 200 | 37.99 | 38.27 | 39.30 | 40.15 | 3.45% | 4.92% |
| P8 | P8 | 208 | 200 | 53.21 | 51.90 | 54.36 | 53.44 | 2.16% | 2.96% |
| P9 | P9 | 987 | 315 | 53.21 | 47.37 | 54.36 | 45.58 | 2.16% | 3.78% |
| P10 | P10 | 513 | 250 | 47.02 | 45.66 | 48.67 | 47.31 | 3.51% | 3.61% |

***Fig. 5. Analytical and numerical results comparation***

Based on the obtained results, the pressure diagram was drawn in all nodes of the pipeline network based on the analytical and numerical results (figure 6).

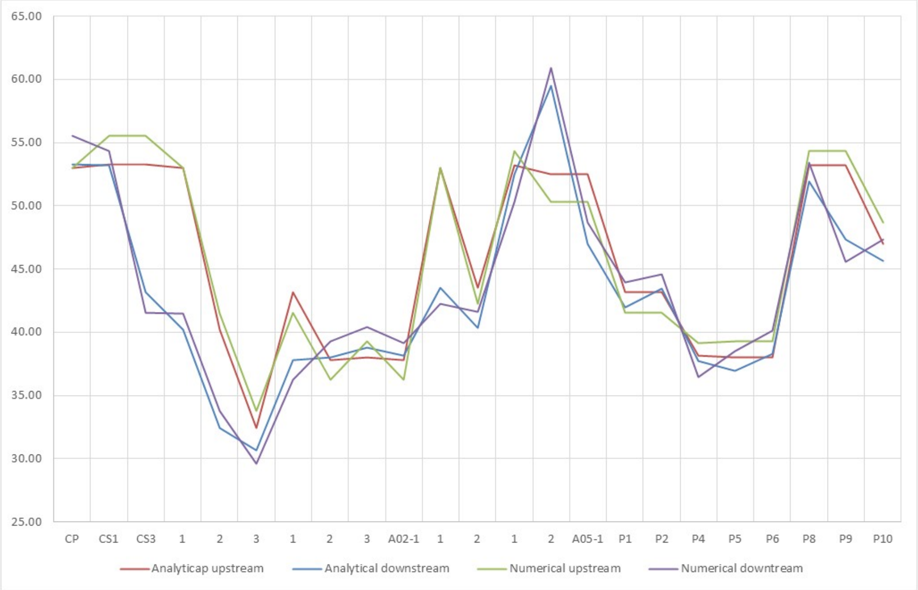

***Fig. 6. Analytical and numerical Pressure diagram***

With the help of the results obtained by the two methods, the error variation diagram was drawn (figure 7).

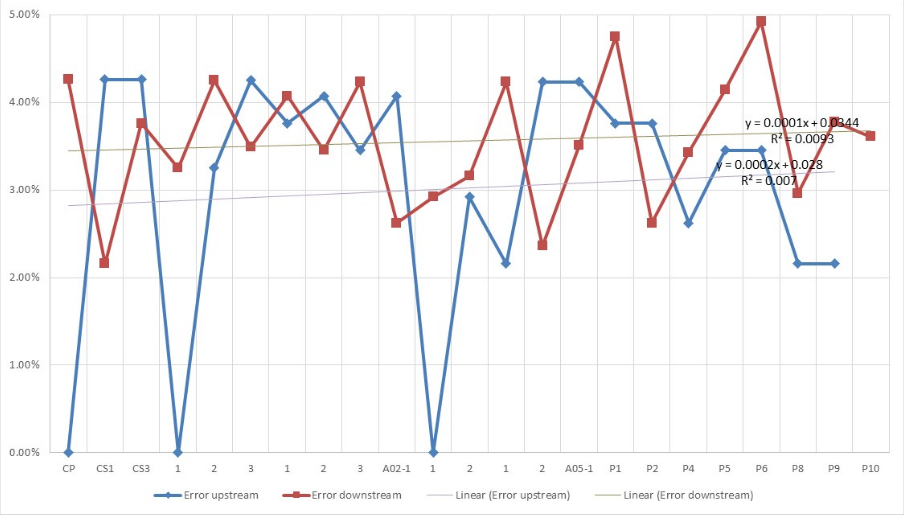

***Fig. 7. Error variation diagram***

From the visual correlation between analytical and the numerical method, it can be seen that the errors in the upstream nodes have an average value of 2.8% and the errors in the downstream nodes have a value of 3.4%. Overall, the errors are in the range of 0-5% with an average value of 3.1%.

Climate change has an impact on existing water resources, especially in rural areas. Considering the poor adaptation of the existing infrastructure to the new agricultural structures, the sector remains vulnerable to climatic conditions (alternating drought and frequent floods), with significant economic effects on the economic viability of farms. This problem becomes much more acute in the context of global warming. In the context of medium- and long-term climate scenarios, according to which increases in the average annual temperature are expected, extreme climate phenomena (drought, floods, etc.) will increase. In addition, the existing land improvement infrastructure (irrigation, drainage, drainage) in Romania is outdated in terms of resource efficiency (Armas A, at all, 2016).

## 4. CONCLUSIONS

The obtained results show a good correlation between the analytical method usually used and the advanced numerical method of the MIKE URBAN software.

The obtained results show a good correlation between the analytical method usually used and the advanced numerical method of the MIKE URBAN software.

The analytical method involves detailed calculations to find out the pressures at all points on the pipeline route. The numerical method through the visualization process instantly shows all the values of these pressures, and it is also possible to introduce a time-varying flow rate at the pumping station.

Development and rehabilitation of irrigation systems can pose major challenges to planners and engineers. The systems must be cost-effective, yet also sufficiently resilient to handle the effects of demographic processes as well as the consequences of climate change. Neither of these processes are easily predictable.

Changing climatic conditions can lead to increased incidence of pest and disease attacks and reduced natural productivity of agricultural and forest lands. In order to adapt to the effects of climate change and improve environmental resilience to them, it is necessary to modernize efficient irrigation facilities, promote new technologies and agricultural management practices to manage the phenomenon of increasing incidence of pest and disease attacks and reduce the amount of water evaporated from the soil , supporting the use of precision agriculture, adopting measures for risk management and informing farmers about the best agricultural practices, for example about the varieties used (drought tolerant) or water consumption.

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