Scientific Papers. Series E. Land Reclamation, Earth Observation & Surveying, Environmental Engineering. Vol. VII, 2018
Print ISSN 2285-6064, CD-ROM ISSN 2285-6072, Online ISSN 2393-5138, ISSN-L 2285-6064

APPLICATIONS OF GIS MODEL FOR WATER SUPPLY SYSTEMS

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Abstract

GIS models present a wide-ranging application of water supply and sewerage monitoring. In the last period, on national and international plans the administrations have expanded their applications. Thus, in Romania, most water-sewer company are using GIS applications in different programs to analyse water supply systems. This paper presents a GIS model in Iasi County that presents the advantage of a complex detail of the water supply system components. The model also allows data to be obtained for redesigning complex pipelines and installations or for re-engineering some rehabilitation works. GIS models can provide themed maps, work reports, and mathematical models for design and exposition in a relatively short time.

Key words*: real estate cadastre, hydrant, distribution network, database.*

INTRODUCTION

Applications of GIS models for monitoring water supply networks are used by water-sewer companies as well as by researchers to carry out case studies. GIS models along with water network sizing programs can help design and verify the operation of drinking water distribution networks. Thus, Montasir M. et al. (2013) used the EPANET program to assess existing capacities and limitations of the water supply system. A hydraulic simulation of the network parameters was also carried out by Ramesh H. et al. (2012), where census data were used for the study area, the model of the water supply network integrated in EPANET and data on the estimation of water consumption etc. Through the two programs a hydraulic simulation was carried out at different nodes in the network for flows and pressures in order to analyse the performance and behaviour of the pipeline network in various situations.

Using similar data, Brinda D. et al. (2015) conducted a study that determined the population's water consumption forecast and the future development of the water supply scheme. Also, using ArcMap, Marian R.A. et al. (2012) has developed scenarios where two hours damage affects households, crops and road routes etc.

The use of GIS models presents both advantages and disadvantages. Thus, the GIS models have the following advantages: facilitating the data interrogation process, shortening working time, reducing maintenance costs, upgrading and rehabilitating by combining textual and graphic data, simulating the various mathematical models needed to perform verification calculations, facilitating communication with authorities and customers.

Given today's technology developments, GIS models don't pose major drawbacks, but for implementing such a model it is necessary to purchase programs that may sometimes be costly. Also, these models must be developed and monitored by industry specialists, who must pursue the continuous improvement of the GIS model and endowment with advanced storage software.

THE CURRENT STATE OF GIS MODEL APPLICATION

The application of GIS models in monitoring water supply systems is carried out in a differentiated way, internationally and nationally. Thus, in countries such as Turkey, the Netherlands, France and USA, applications are good developed (Lates I., 2016). Although they have well-developed systems, they are still looking for ways to improve and develop them. In a number of countries around the globe, the application of GIS models has been achieved in only a few cities. Such a situation is mentioned in Kosovo, where the system is still at the project stage (Lates I., 2016).

Internationally, GIS models of water supply systems have evolved over Romania, although some countries have implemented advanced GIS models and they are in a continuous process of editing and improvement (Lates I., 2016).

At a national level, a number of localities use GIS models in water supply and sewerage companies. Water communities use different programs, platforms and applications: GIS NetSet, AutoCAD Civil 3D, Audesk, ArcGIS (Lates I., 2016). Not all Romanian water sewer company benefit from advanced GIS systems and some of the cities are still in the state of analogue maps and old databases that no longer meet modern technical requirements.

In the literature there are presented impact analyses on negative influences on water in the pipeline network, where GIS models were used (Lates I., 2016).

Also, case studies are carried out by corroborating the calculation programs specific to the GIS pipelines and the specific conditions of the pipeline location (geotechnical, hydrogeological, seismic etc.).

These studies have identified a number of operational problems and simulated exploitation processes for various situations that may occur in the water supply system

Particular importance for the correct and optimal functioning of the components and installations within the pipeline network is the monitoring of the whole system as a whole, as well as the monitoring on each component.

GIS models can monitor functional and time-related parameters (flow, pressure, residual chlorine content, turbidity etc.).

At the same time, the quantities of water distributed in the localities served by the water supply system and the accurate assessment of the water losses can be correctly read (Luca M., Alexandrescu S. A., 2010).

CASE STUDY FOR DISTRIBUTION NETWORK MONITORING

Documentary studies and researches conducted nationally and internationally in various watercourses and literature have shown the need to develop a more complex GIS model for monitoring the operation of water supply systems (Lates I., 2017).

The water supply system is a complex of buildings, installations and measures designed to ensure water quality and quantity required by a user (NP-133/2013).

For a better understanding of this complex it is necessary to schematize it, which includes: capture, pumping stations, treatment stations, adduction, storage tank, distribution network (Figure 1).

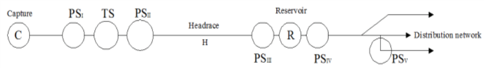

Figure 1. General scheme of water supply

The GIS model for an urban cadastre system is a schematic representation of all components of the water supply network and elements forming part of the real estate cadastre.

The elements that make up the network are transposed into the GIS environment using ArcMap to help integrate, interpret and simulate them.

The study area was located in the eastern city of Iasi. The water supply network introduced in the GIS model has attached site information, structural parameters (diameters, lengths, materials, groundwater presence, ground geotechnics etc.), functional parameters (flows, pressures, turbidity, concentration residual chlorine etc.), network installations and specific parameters (hydrants), network construction, reservoirs, pumping stations.

The study area has cadastral-related information about street names, landing numbers, parcel, address, coordinates x, y, z, level curves, building height regime, owners etc.

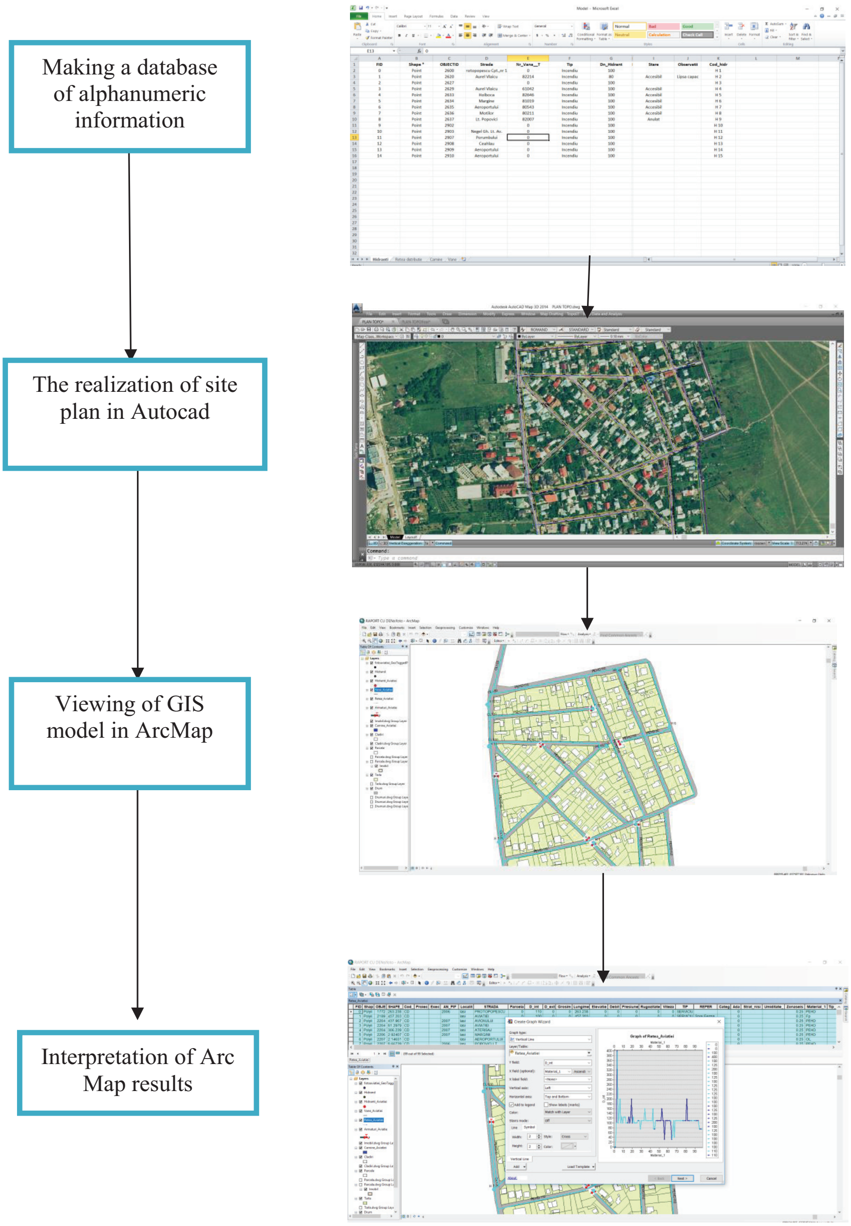

Figure 2. Scheme for the realization of a GIS model of a real estate

Several types of analyses have been carried out in the study area, which looked at different aspects of the social, economic, political and environmental aspects. The analyses were carried out for different components: distribution network, hydrants, manhole, street network, buildings etc.

In the case of the distribution network, it was considered the analysis of the materials in the pipelines and the installations; this is important in knowing the structural and functional parameters (component life, behaviour over time etc.). The analysis carried out showed that three types of materials are present in the pipeline network; polyethylene, steel and cast iron.

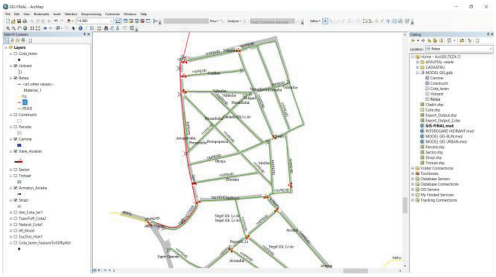

Figure 3. Viewing the pipes in ArcMap according to the used material

The analysis of the diameters that are part of the pipeline network for the transport and distribution of water is of great importance because it influences water speed, pressure losses, rehabilitation and modernization costs etc.

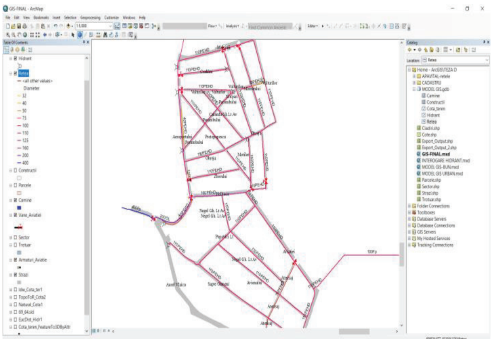

Figure 4. Viewing the pipes in ArcMap according to their diameter

For the manhole on the pipeline network, an analysis was carried out according to the constructional characteristics (material, installation rate in the field and on the surface, location) and the type of hydraulic installation (bypass, branch, ventilation, drainage, subtraction etc.)

In order to optimize pressure management in the pipeline network, the height regime of the constructions (P, P + 2, P + 4, P + 10 etc.) was identified. In figure 6 it shows the height regime of the constructions in the study area; there is a large proportion of buildings P + 1 (shown in blue).

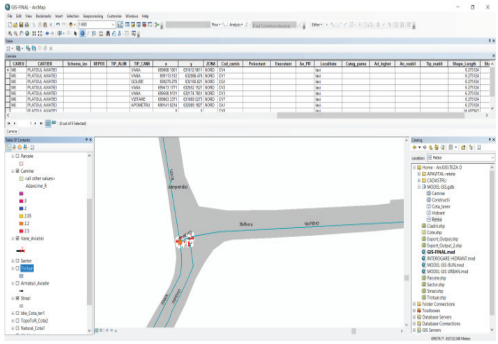

Figure 5. Viewing manholes in ArcMap according to the depth of location

The analysis shows the arrangement of plots of buildings with different regime of height and the influence on the functional parameters of the pipeline network (for example: in the plot CC 257 there is a P + 3 building on Marginii street, but also a P + 2 building).

The height regime of buildings is important in case of fire, in order to know the parameters of the pipeline network and the specific fire-fighting intervention measures (P118/2-2013).

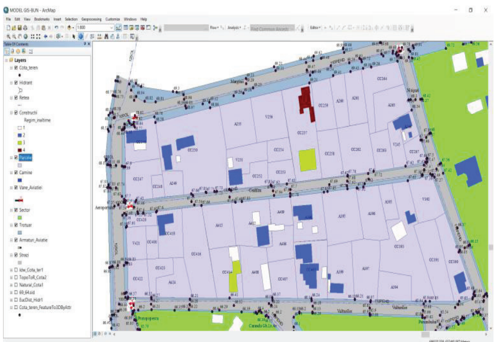

Figure 6. Identifying the height regime of buildings in ArcMap

Identifying buildings by number of occupants is of great importance, as fire intervention teams can approximate rescue measures and necessary equipment.

Buildings with tenants with different functions are classified by fire category and their importance in saving people and goods. All data is stored in specialized layers (Lates I., 2017).

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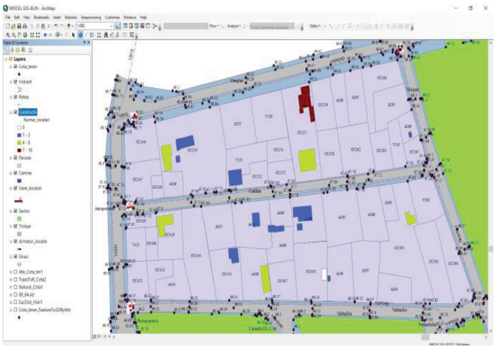

Figure 7. Identify the number of occupants in ArcMap

The identification of the constructions after the observation field, as can be seen in Figure 8, is done by colour code. For example, the green code indicates buildings with children or clusters of children; the red colour code indicates the buildings where people with locomotor disabilities are located. These categories of people move much harder and require special measures in the internal and external fire action. There is also a priority in how to save people in the area and buildings affected by fire.

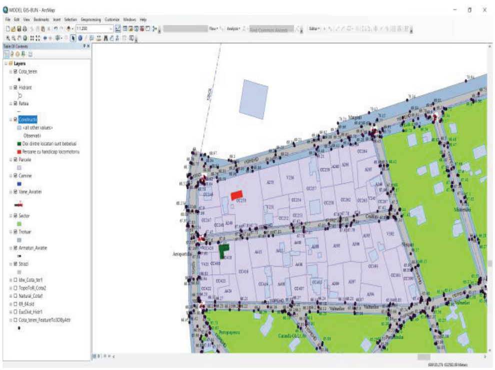

Figure 8. Identifying by the ArcMap observation field

The identification of the buildings embedded in the study area (Figure 9) was done by considering two sectors. In the analysed case the existence of nine buildings registered in the land register was found.
The analysis of this situation results in the need to accurately complete the real estate cadastre, with data acquisition and import into the GIS monitoring model.

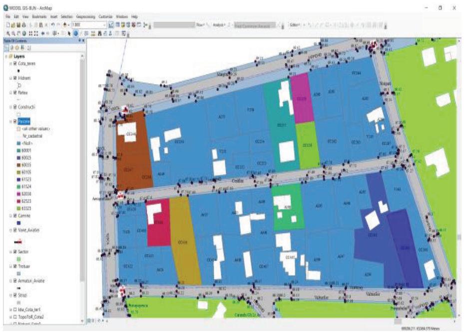

Figure 9. Identify buildings in ArcMap

Making a street name query is necessary if a particular street in the GIS model is to be identified, or you want to know how it is arranged (asphalt/unpacked). The map outlines the streets that cross the study area by colour code for a faster identification, but also their classification. You can also set the name of the streets or other attributes of interest in water distribution management in the program interface.

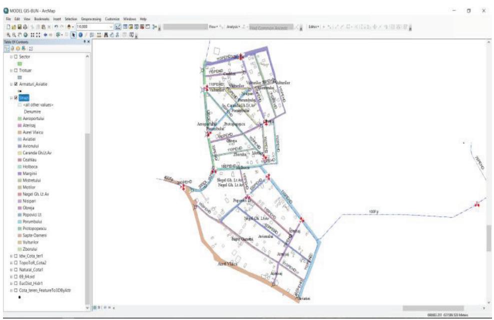

Figure 10. Identifying of the streets by colour

The monitored GIS model allows data to be imported continuously, but also processed by using specialized programs in the field of water supply.
A water supply system becomes effective through rehabilitation, refurbishment, upgrading and automation work. Improving the process is made easier by creating a database to facilitate the design/redesign and management of water networks.
With the help of analysis functions, GIS models facilitate the inspection, maintenance and monitoring of water supply systems (Ramesh H. et al. 2012).

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CONCLUSIONS

GIS models are used both for the entire water supply system and separately for each component of the system, with structural and functional features.

The analysis of the special urban constructions and installations is made according to the data attached to them.

GIS models for monitoring water supply systems need to be improved by interconnecting different databases and updating work schedules at the level of modern technology.

The presented GIS models use a series of programs to identify structural and functional problems, to predict operational situations, and to simulate water supply system components in the process.

GIS models use queries to create digital maps and reports that facilitate communication between the water channel and the administrative authorities as well as with customers.

GIS models identify problems and help find solutions to solve them by working with hydraulic models specific to water supply systems design, while addressing and interpreting real estate issues.

REFERENCES

Brinda D., Gargi R., Ajay P., Kalubarme M.H., 2015. Analysis of Continuous Water Distribution System in Gandhinagar City Using EPANET Software: A Case Study of Sector-8, National Conference on „Transportation and Water resources engineering”, India, pp. 2-6.

Forkuo E., Quaye-Ballard J., 2013. GIS based fire emergency response system, International Journal of remote Sensing and GIS, Volume 2, Issue 1, Ghana, pp. 32-40.

Lates I., Luca M., 2017. The management of water supply system using GIS application. RevCAD, Journal of Geodesy and Cadastre, no. 22, „1 Decembrie” University of Alba Iulia, Aeternitas Publishing House Alba Iulia, pp. 123-130, ISSN 1583-2279.

Lates I., Luca M., Ilie G., Iurist N., 2016. Studies on the implementation of GIS model in water supply systems, PESD, Vol. 10, No. 2, pp. 153-160.

Lates I., 2017. Monitoring special urban installations with the GIS model, Buletinul Institutului Politehnic, Universitatea Tehnica „Gheorghe Asachi” din Iasi, Vol. 63 (67), Nr.3-4, Iasi, pp. 63-70.

Luca M., Alexandrescu S.A., 2010. Modern techniques for measuring the flow rate through water conveyance pipes, Buletinul Institutului Politehnic din Iasi, Tom LVI (LX), Fasc.4, Sectia Hidrotehnica, Politehnium Publishing House, Iasi, pp. .63-69.

Marian R.A., Haidu I., Craciun A.I., Vaduva B., 2012. GIS utility for hydrological impact evaluation caused by damages of water supply network in rural areas. applications in Baia Mare depression, Geographia Napocensis Anul VI, Nr. 2, Cluj-Napoca, pp. 103-109.

Montasir M., Abrar A.C., Rifat M., Mahommad S.R., 2015. Water Distribution System Modelling By Using EPA-NET Software, International Conference on Recent Innovation in Civil Engineering for Sustainable Development, Gazipur, Bangladesh, pp. 960-964.

Nisanci R., 2010. GIS based fire analysis and production of fire-risk maps: The Trabzon experience, scientific research and Essays, Vol. 5 (9), Turkey, pp. 970-977.

Ramesh H., Santhosh L., Jagadeesh C.J., 2012. Simulation of Hydraulic Parameters in Water Distribution Network Using EPANET and GIS, International Conference on Ecological, Environmental and Biological Sciences, Dubai, pp. 350-353.

* * * NP 133/2013-1 Normative regarding the design, construction and operation of the water supply and sewerage systems of the localities, MatrixRom Publishing House, Bucharest.

* * * P118/2-2013 Norms on fire safety of buildings.