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MANAGEMENT OF A SEWERAGE NETWORK BY COUPLING GIS AND HYDRAULIC MODELING: A CASE STUDY OF THE NETWORK OF THE NEW UNIVERSITY IN TLEMCEN, ALGERIA

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ABSTRACT

The objective of this work is to ensure the management of the sewerage network of the new university in Tlemcen using a MapInfo GIS and hydraulic modeling. Mapbasic subroutines are developed for the simulation of the network behaviour for different return periods, based on the model of Caquot (surface method). This model will generate strategies for managing rainwater flux taking into account the weather conditions, topography and land use. The simulations done helped to highlight the influence of rainfall events on the network. This methodology can help managers for decision-making by addressing the shortcomings identified and may therefore provide a performance level of the optimal network operation.

Keywords: Sewerage network- GIS - Database - Network Modeling - Caquot Model - Management - Rainwater.

RESUME

L’objectif de ce travail est d’assurer la getsion du réseau d’assainissement du nouveau pôle universitaire de Mansourah en utilisant le système d’information géographique (SIG) MapInfo et la modélisation hydraulique. Des sous programmes en langage Mapbasic sont développés pour la simulation du comportement du réseau pour différentes périodes de retour, en se basant sur le modèle de Caquot (méthode superficielle). Ce modèle permettra de générer des stratégies de gestion des flux d'eaux pluviales en tenant compte des conditions météorologiques, topographiques et occupation du sol. Les simulations effectuées ont permis de mettre en évidence les influences des événements pluviométriques sur le réseau. Cette démarche permet d'assister les gestionnaires dans la prise de décision pour remédier aux défaillances éventuellement décelées et de garantir en conséquence, un niveau de rendement du fonctionnement du réseau optimal.

Mots clés : Réseau d'assainissement - SIG - Base de données - Modélisation du réseau – Modèle de Caquot – Eaux pluviales

INTRODUCTION

People concentration in cities is increasing, thus the effort required in the management of sewerage networks are becoming a priority task. The complexity of this need make conventional management of sewerage networks difficult, hence the need methods to the use of computers (Abdelbaki and Zerouali, 2012). Geographical information systems (GIS) are powerful tools for handling spatial data, performing spatial analysis and manipulating spatial outputs. A GIS also provides a consistent visualization environment for displaying the input data and results of a model. This ability of GIS is very useful in a decision- making process (Vairavamoorthy et al., 2007). Development of a GIS model and production of the required information in water utilities are very time consuming and expensive. It has been clear in recent years that application of GIS in water and wastewater networks without any link with hydraulic simulation models can not support all required management targets (Tabesh and Delavar, 2003). The integration of GIS and models enables the utilisation of the advantages of both (Argent, 2004 ; Vairavamoorthy et al., 2007 ; Abdelbaki and Touaibia, 2014 and Abdelbaki et al., 2016). Therefore, many upgrades and extensions have been developed for the toolkit and presented in various research papers (Guidolin et al., 2010). In this paper we present the modeling methodology of sewerage network of the new university in Tlemcen using MapInfo GIS and Map basic programming language. The development of this coupling is to quantify storm water and check the discharge capacity of the sewerage network for different return periods. The surface method or Caquot model (Selmi and al., 2010) was programmed under Map basic language (Barbier, 2002) and subroutines are developed to take advantage of a powerful modeling environment in GIS.

PRESENTATION OF THE STUDY CASE

The new university center is located in the Northwest of the town of Tlemcen (Figure 1), at a distance of 3 km from the capital of the municipality of Mansourah. It covers an area of 1,2 km^2. It has a capacity of 24000 students and 12000 beds. It is limited geographically by the urban group Kiffane North, the urban group Bouhannak South, the urban group of Imama in the East and the habitat agglomeration of El Koudia West.

The study area has a complex rainfall influenced by a Mediterranean climate with hot dry season in summer, and another rainy and cold in winter. The distribution of annual precipitation shows a rainy period, which runs from October to April with a peak in January. Annual precipitation fluctuates between 500 and 800 mm (Bensaoula et al., 2007). The calculated average rainfall is 560 mm / year, average temperatures range between 5 ° C in January and 34 ° C in August (ONM, 2011)

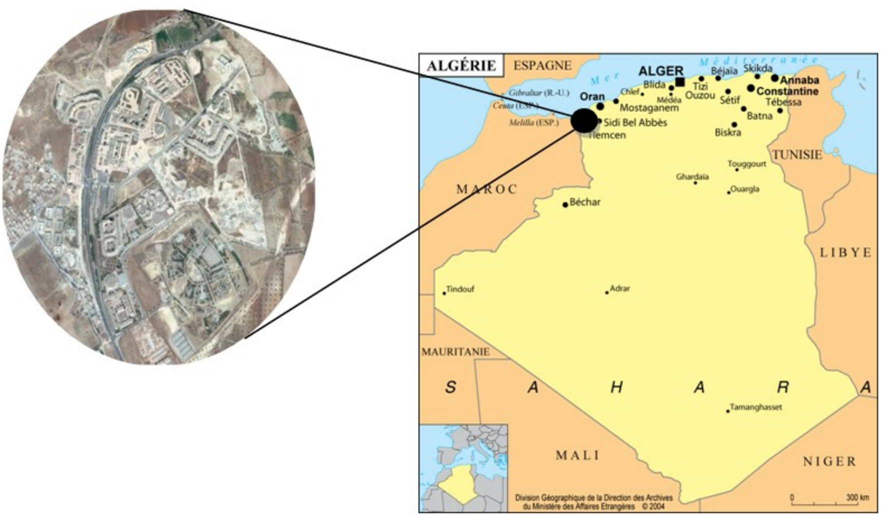


Figure 1 : Presentation of the study area

The sewerage network of the new university center of Tlemcen is unitary, with a length of 15,21 km. The slopes vary from 20 to 35%. The diameters of the collectors vary from 300 to 1250 mm. The number of manholes is 327 (ONA, 2012). The discharge pattern of the network of the new pole of Tlemcen University depends on various parameters: the topography, the geographical distribution of buildings, the installation of pipes in buildings, the conditions of the release, the economic aspect, the possibilities connections and the impact caused on the environment. Dividing sub basins reflects the following characteristics: soil type, level curves, roads and existing roads and slopes.

METHODOLOGY

The approach adopted is to analyze and to understand the operation of the sewerage network of the new pole University of Tlemcen, then exploiting data to perform a diagnostic study of the network, because the current operation of the latter has several problems. The application developed in this paper is intended to simulate the operation of the network of the new pole University of Tlemcen under GIS (MapInfo) using the Caquot model (surface method), for rainfall events of different return periods, to test the ability of the network to evacuate the flow of rainwater and thus provide the means of protection of the new university of Tlemcen pole against flooding. The approach is shown in figure 2.

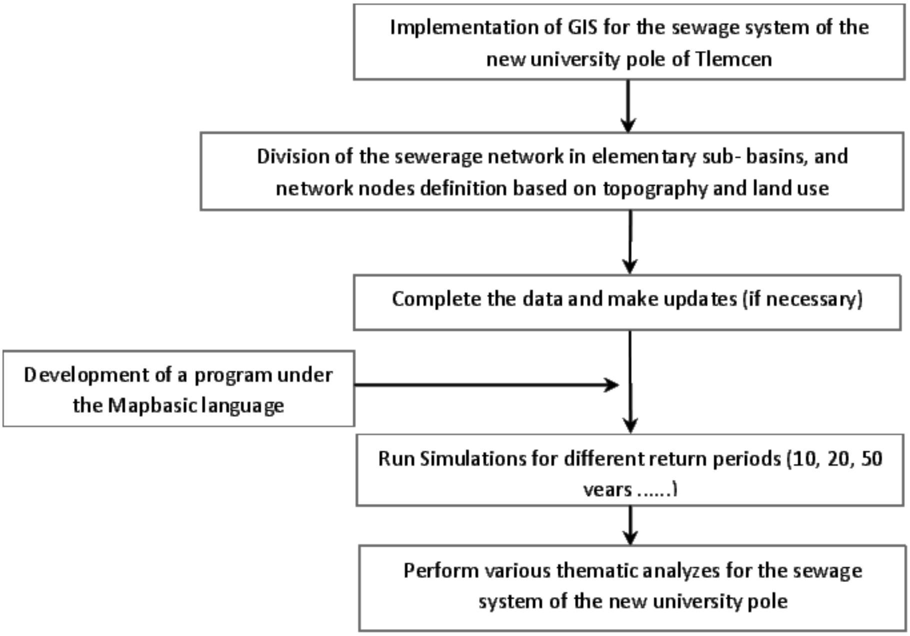


Figure 2 : Methodology Flowchart

Implementation of GIS for the sewerage network of the new university

The various features including GIS enable them to acquire the network plans and their associated characteristics (Cheng-I Ho et al., 2010, Abdelbaki and Touaibia 2014). Then associated with each "layer" or level displayed a theme to a different scale. Can be assigned to each object on the network, the alphanumeric information associated (Blindu, 2004). These systems are therefore particularly well suited to the representation of sewerage networks (Abdelbaki and Zerouali, 2012). The GIS of the sewerage network of the new university pole of Tlemcen lies in the facility to allow spatial analysis by crossing the layers of information stored in the database (Abdelbaki and Touaibia, 2014).

Sewerage network modeling

The surface method called Caquot model (Selmi, et al., 2010) is well adapted to calculate storm water flows, as surface formulas for sanitation of cities, are commonly used to urbanized watersheds. The collectors of the storm sewerage network are designed to prevent flooding from the rain and for protection.

A Map Basic language program (Barbier, 2002) was developed based on the model of Caquot, allowing one hand, the background map display of sewerage data and the other display sewerage with its geometric and hydraulic characteristics based on the simulation of it for different return periods. The general architecture of the application is given in figure 3.

The objective is to facilitate access to data of different databases, ensure communication between the software and the user in the various tasks to accomplish: data loading, calculating, displaying results...

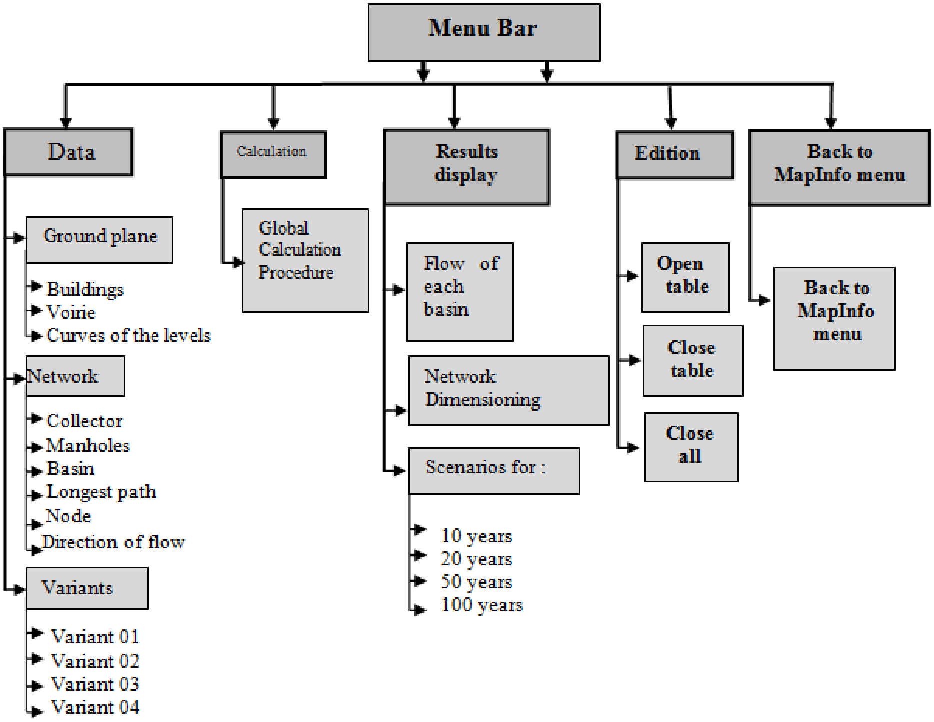
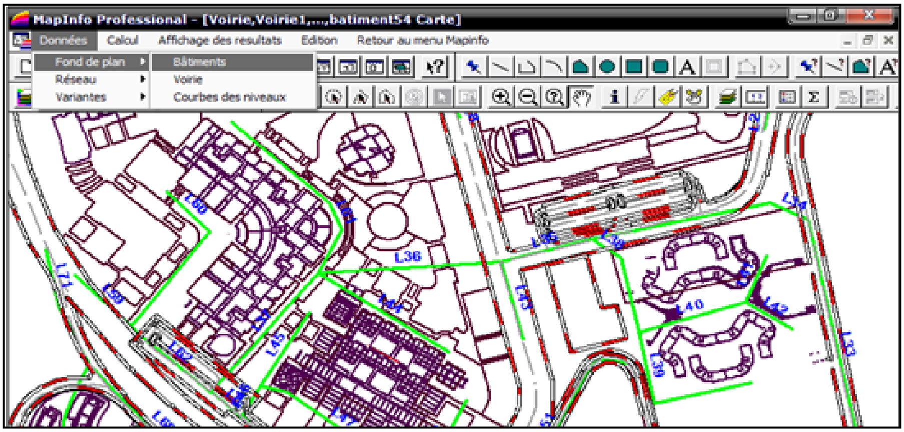


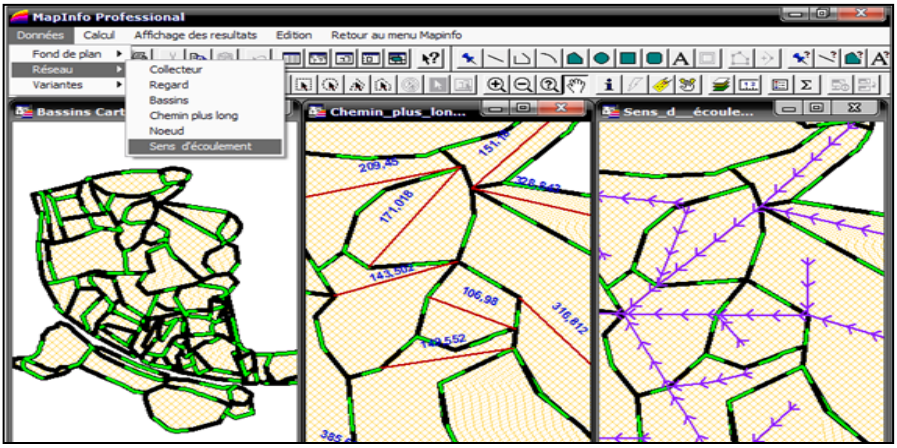
Figure 3 : Organization menu of the application

Application presentation

The developed application is organized by a set of menus and routines: A custom menu is created, it has to appeal to the tasks in data loading menus, calculation and display of data, figures (4a, 4b, 4c) loading data for the developed application (Data Menu).



a) Displaying the background map



b) Display the sewerage network

Figure 4 : Presentation of the developed application (data loading).

Menu "Calcul" consists of a single command" Procédure Globale de Calcul (Global Procedure of Calculation)" shown in Figure 5. This procedure computes all parameters of the sewerage network of the new university pole based on the model of Caquot, starting with the calculation of the peak flow in each basin, then passing to calculate the mass flow rates and groups in parallel and check the conditions of self curage.

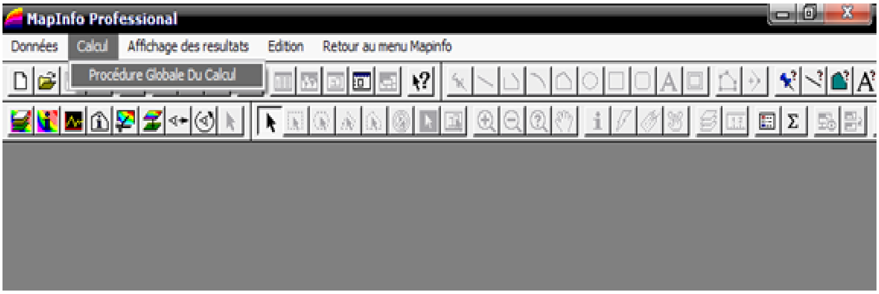


Figure 5 : Menu Overview The "Calcul"

Menu "Affichage des résultats (Display Results)" has three sub menus: Flow of each basin, sewerage design and simulation results for different return periods. Figure 6 shows the display calculation results of each sub-basin, after sizing.

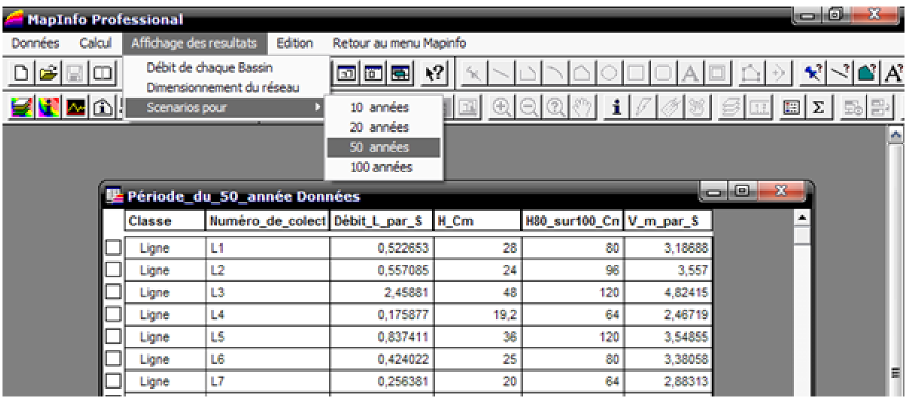


Figure 6 : Displaying flow rates for each sub-basin

Menu "Retour au menu MapInfo (Back to MapInfo menu)" (Figure 7) returns to the standard menu of MapInfo.

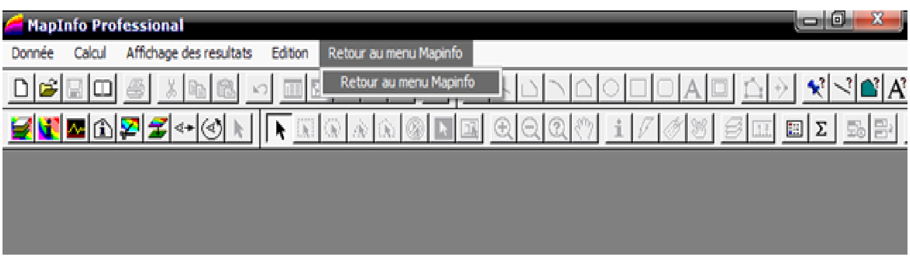
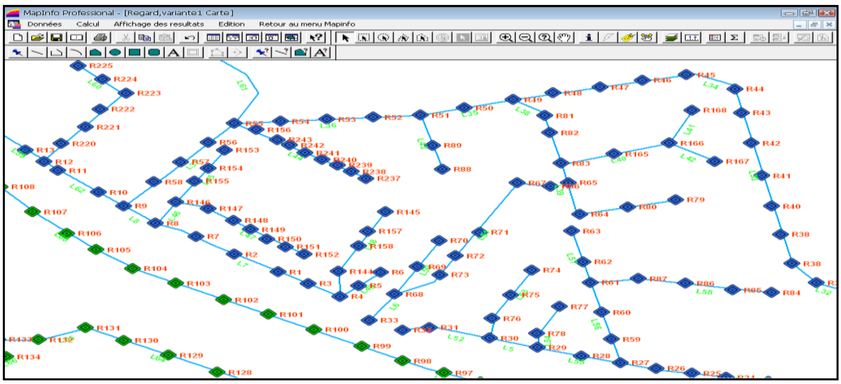


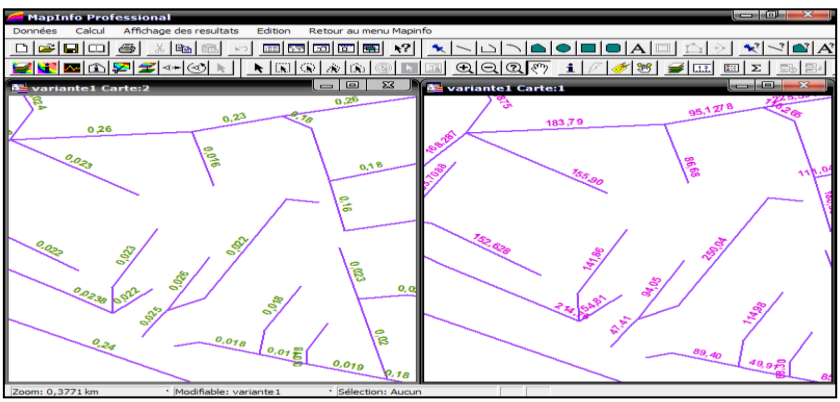
Figure 7 : Menu Overview The "Retour au menu Mapinfo (Back to MapInfo menu)"

RESULTS AND DISCUSSION

The implementation of GIS for the sewerage network of the new university of Tlemcen and its modeling was used to analyze it for different return periods. Several scenarios were studied to simulate its behavior. Figures (8a, 8b, 8c) show geometric and hydraulic characteristics of the collectors after the simulation.



a) Displaying of the numbers of collectors and manholes



b) Displaying of lengths and slopes of the collectors

c) Displaying simulation results of a collector

Figure 8 : Geometric and hydraulic characteristics of collectors

The results of the sewerage network simulation are summarized in the following sections:

Discharges

The collectors must be able to pass the highest instantaneous flow rates taking into account the peak flow (Selmi et al, 2010). Figure 9 shows the distribution of flow and diameters in the sewerage network for a return period of 10 years.

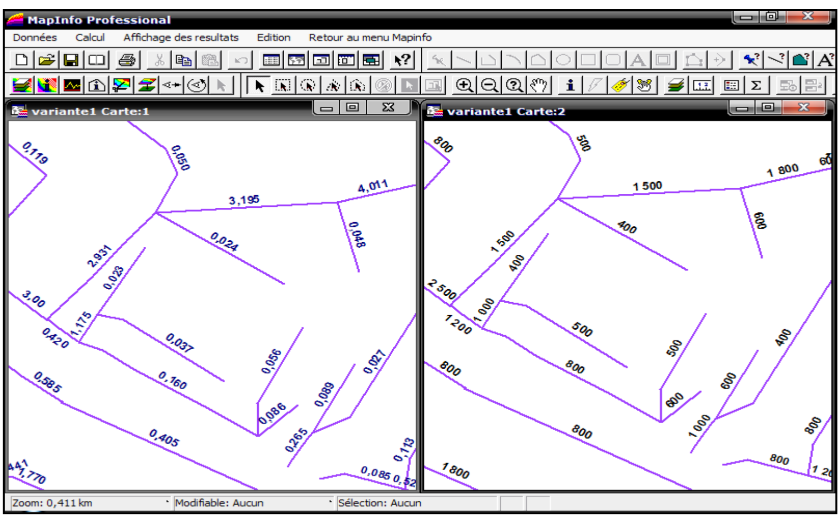


Figure 9 : Overview of flows and collectors diameters

Velocity

The water velocity in the pipes should be in the order of 0,6 to 4 m/s. Velocities in excess than 4 m/s, as well as those less than 0,6 m/s are to be avoided (Selmi et al., 2010). Low velocities favor the formation of deposits which are difficult to evacuate and those greater than 4 m/s possible to consider internal pipes erosion.

For a return period of 20 years, velocity varies between 1,17 and 5,23 m/s, self curage requirements are met for all collectors. The velocity in 24% of collectors exceeds the standards (V> 4 m / s), from where a possible charging.

For a return period of 50 years, velocity varies between 1,30 and 5,76 m/s, the conditions for self curage are met for all collectors. The velocity in 34% of collectors exceeds the standards (V> 4 m /), from where a large loading.

Based on the results for the sewerage network of the new University of Tlemcen, and to improve the characteristics of the latter, the geometry of the network is to review and rehabilitation operations are necessary to correct the geometric characteristics of the network. This is of great importance for satisfactory hydraulic characteristics for the velocity (risk of erosion of the internal collectors).

The analysis determined effective in the management of sewerage new university. The developed application is a decision support tool for the exploitation of the network. The input operations, storage and updating of data allow to store a history of operational problems (renewal, realignment ...) useful for forecasts of interventions on the network.

CONCLUSION

In this paper, we identified the hydraulic performance of the sewerage network of the new pole University of Tlemcen and this by developing a coupling between the GIS MapInfo and a model calculation developed based on the superficial method. This methodology provides network operators a management tool to:

- Know the network at any point;
- Analyze malfunction with an instant response to any incident that may occur there;
- Know the status of the selected particular point.

This is an operating methodology for the manager to make the diagnosis of its network, to explore solutions to problems and predict future situations.

It will be used to generate storm water flow management strategies taking into account the weather conditions to optimize the efficiency of the sewage network but also to reduce operating costs.

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