



FACULTY OF ENGINEERING AND TECHNOLOGY

DEPARTMENT OF WATER RESOURCES ENGINEERING

FINAL YEAR PROJECT REPORT

DESIGN AND IMPLEMENTATION OF A REAL-TIME NOTIFICATION SYSTEM FOR WATER
NETWORKS

BY

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ABSTRACT

Characterizing the water network, involved a thorough analysis of the network's components. The process began with field surveys to gather data on the physical condition and spatial distribution of the network. Material identification was conducted to determine the types of materials used in different sections of the network. Pipeline diameter measurements were taken to understand their capacity and flow rates, while pipeline depth measurements were recorded to assess vulnerability to external damage. The network was mapped using handheld GPS devices to record the coordinates of key features such as valves, junctions, and storage tanks. The data collected from the field surveys was then digitized and imported into Quantum Geographic Information Systems (QGIS) for spatial analysis. QGIS was used to create a detailed map of the water network, overlaying pipeline data with other spatial elements such as building footprints and road centrelines'. Additionally, EPANET was employed to model the hydraulic performance of the network, simulating flow rates, pressure losses, and potential failure points. The results of this objective revealed a complex system with main lines adequately sized for high water volumes, but some distribution lines showed signs of aging and reduced capacity. Field surveys confirmed the presence of both modern and outdated materials, with galvanized steel being prone to corrosion. Pipeline depth measurements highlighted areas where pipelines were at risk of external damage due to shallow burial. QGIS analysis provided a visual representation of the network, identifying spatial patterns and vulnerabilities, particularly in high-risk zones such as heavily trafficked roads. EPANET simulations revealed areas with low flow rates and high-pressure losses, primarily in older sections of the network, and highlighted the impact of non-operational valves on network performance. developing and integrating a web-based water pipe network management system with real-time notification capabilities, followed a three-tier architecture, consisting of the data layer, application layer (backend), and presentation layer (frontend). The system was built using open-source technologies, including QGIS for spatial data management, PostgreSQL for database management, and Django for web application development. The system was hosted on Amazon Web Services (AWS) using EC2 for hosting the Django application and RDS for database management. The development process began with the environment setup, which involved the installation of XAMPP for local development, configuration of Apache and MySQL, and creation of the utility_network_db database using phpMyAdmin. The database setup included the creation of tables to store data related to building footprints, distribution pipelines, main pipelines, road centreline's, study areas, and valves. The utility network database was integrated with Python using PyCharm Community Edition, and required libraries such as Django, psycopg2, and pygdal were installed to facilitate database connectivity and geospatial data processing. The Django admin interface was used to create an admin panel for database management, allowing administrators to perform CRUD operations on database tables. The user interface was developed using HTML templates and Bootstrap to create a responsive and user-friendly frontend, with Django views handling user requests and displaying data from the database. The system was deployed on AWS, ensuring high availability and scalability.

The results of this objective included the successful creation and population of the `utility_network_db` database with data related to the water network, including pipelines, valves, and building footprints. The Django admin interface provided a user-friendly platform for administrators to manage the database efficiently, with features such as search, filters, and data import/export. The frontend offered an intuitive and responsive interface for users to visualize and interact with the water network data, enabling effective decision-making and analysis. Integration with QGIS and Open Layers enabled dynamic map visualization, allowing users to explore the network spatially. Hosting the system on AWS ensured high availability and scalability, providing a reliable platform for future growth. Testing and validating the developed system for performance and accuracy, involved a series of system testing, system integration testing, and validation of functional requirements. Testing was conducted in both small-scale networks to evaluate the system's performance under different conditions. System testing focused on individual modules of the application, such as the geospatial data visualization interface, real-time notification system, and database management tools, which were tested independently. In the small-scale network, each module performed as expected, but minor inconsistencies emerged in the larger network, such as lag in rendering extensive pipeline datasets and delays in the notification system during peak data ingestion periods. System integration testing verified that all modules functioned cohesively as a unified system. In the small-scale network, the integration was seamless, but in the larger network, communication bottlenecks between the backend and the PostgreSQL database were identified, leading to temporary discrepancies between displayed map data and database records. Validation of functional requirements ensured the system met its core functional requirements, particularly in proximity functionality and location accuracy. In the small-scale network, the system's geospatial accuracy was validated using ground-truth GPS measurements of pipeline nodes and valves, with an error margin of less than 1 meter. In the larger network, the error margin increased to 2.5 meters due to challenges in integrating heterogeneous data sources, but this was reduced to less than 1.5 meters after implementing a data normalization workflow to standardize coordinate references. The system successfully detected pipeline leaks, updated the database with event details, and triggered notifications to administrators via the user interface. Integration testing revealed communication bottlenecks in the larger network, which were resolved by implementing asynchronous task processing and optimizing API endpoints.

DECLARATION

I, MODI BOSCO WILSON, a student of Busitema University with a registration number of BU/X/2021/2652, declare that this report is a true work of my hands and has never been presented by any person or institution for an academic award.

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APPROVAL

This final year proposal report has been submitted to the Department of Water Resources Engineering under my supervision.

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DEDICATION

I dedicate this proposal report to my parents, Hedwig Nyawere my girlfriend, siblings, and myself.

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I would like to thank the almighty God for this guidance, protection and knowledge. I would like to thank my parents for their continuous support both spiritually and financially. My sincere gratitude goes to my final year project Supervisor ENG MOHAMMED BADAZA and Co-Supervisor OLOGE HECTOR DANIEL for his guidance, fellow students and the Water Resources Department who have equipped me with the necessary knowledge that has enabled me to excel in academics.

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LIST OF ACRONYMS/ABBREVIATIONS

EMI-Electromagnetic Induction

NWSC-National Water Sewerage Cooperation

2D- Two Dimensional

QGIS- Quantum Geographic Information Service

GPS- Global Positioning Service

GPR- Ground Penetrating Radar

TC- Terrian Conductivity

RFID- Radio Frequency Identification

RF- Radio Frequency

SCADA- Supervisory Control and Data Acquisition

CSV- Command Separated Values

API- Application Programming Interface

PVC- Polyvinyl Chloride

HDPE- High-Density Polyethylene

HTML- Hypertexts Markup Language

RAM- Random Access Memory

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Figure 2. picture showing the control valve

Figure 3. picture showing the general layout of network

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