MAPPING WATER DISTRIBUTION IN FEDERAL POLYTECHNIC, ILARO

(Using SRTM data and GIS Technology)

BY

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ABSTRACT

The location of pipe borne water lines is germain to the distribution of portable pipe borne water. This is attributable to the increasing population, the demand for portable water and the activities of the people that affects the pipe line network. This paper aim at providing and managing a sustainable water distribution system for the Federal polytechnic Ilaro. A digital map of the institution showing all spatial details within the campus was obtained from the archives of Geoinformatics department of the Institution. The map was updated with location data of wells and boreholes using handheld GPS. The attribute data about these water utilities were collected from the works department of the school and through social surveys and stored in ArcGIS database. Shuttle Radar Topographic Mission (SRTM 90m resolution) data was used in Surfer 10 and ArcScene to delineate the topographic configuration of the school. A number of analysis such as Shortest Route Analysis, best location of overhead water tanks, query and location of existing deep wells and bore holes etc. was carried out to suggest suitable ways of ensuring efficient water delivery in the institution. The shortest route for the water distribution was determined using ESRI's ArcMap Network analysis. The longitudinal profile along the shortest route was carried out using Level equipment in order to design a free-flow water system from the source. This profile was plotted with Autodesk's AutoCAD Civil 3D 2016 software. The paper proposes three favorable locations within the school for overhead tanks, two deep wells and the shortest route for the distribution of water to the overhead tanks viz: Gbokoto staff quarters, West and East Campus. It was ascertained from the outcome of the analysis that SRTM data and surface modelling software with the analytical tools of GIS are competent and effective cut edge tools for the water distribution.

Keywords: SRTM, GIS, Surfer 10, Topography, database, data, Shortest route, Utilities, attributes, query, water delivery,

1.0 INTRODUCTION

A utility is a facility composed of equipment connected to or part of a structure and designed to provide a service such as heat, electricity, water or sewage disposal e.t.c. The use of utilities is often regulated by the government. The network of water distribution co-exists with human society for about two million years. They serve people's daily water consumption quietly after being laid underground. They are laid underground in such a way that they cannot be easily disturbed by human activities. Pindiga A.M. and San M.J., 2015. Opines that people notice the inconvenience when this network is under unhealthy conditions

The change in climate and pollution has adversely affected the availability of potable raw water. To curb the challenges caused by water crisis Anwuri et al, 2015 observed that this scenerio has led to an emerging interest in small-scale water projects at the household, (provision of personal water boreholes).

Furthermore for effective planning, monitoring and maintenance of the existing underground utilities. It is pertinent to have accurate information about their location and attributes. Jamil et al, 2012 observed that lack of information on this may result in fatality and catastrophic damages of existing underground utilities and disruption to utility services

In addition for effective and optimum location of water distribution pipelines A topographical map of the area showing the positions of roads, streets, lanes, residential areas, commercial locality, industrial areas, sewer lines electric and telephone lines and existing water supply lines and also to obtain the levels for fixing up the alignment of the rising main. This main will carry treated water to the distribution reservoir(s) located in the distribution area. (Pindiga A.M. and San M.J., 2015).

1.2 RESEARCH PROBLEMS

Major turnarounds need to be made in the institution's water supply lines. There have been outcries from different blocks in the school over the inefficient water supply. This is largely due to the dearth of information about how the water distribution is being managed. Often the geographic locations are more than often not recorded and the status and conditions of this utilities are not documented at all. The present location of boreholes and deep wells within the institution is scattered or not fit and is un-esthetic. Some are under-utilized or condemned out-rightly and unmanageable as a result being too copious. Effective supply, environmental protection and efficiency of operations, however, require good basic information system. Excavation damage can be largely avoided when reliable information regarding location and description of underground utility lines such as water pipes, cable lines etc. are available. Repair and replacement of underground water pipelines can be carried out in the optimal manner when based on an efficient GIS/utility mapping system.

1.3 DESCRIPTION OF STUDY AREA

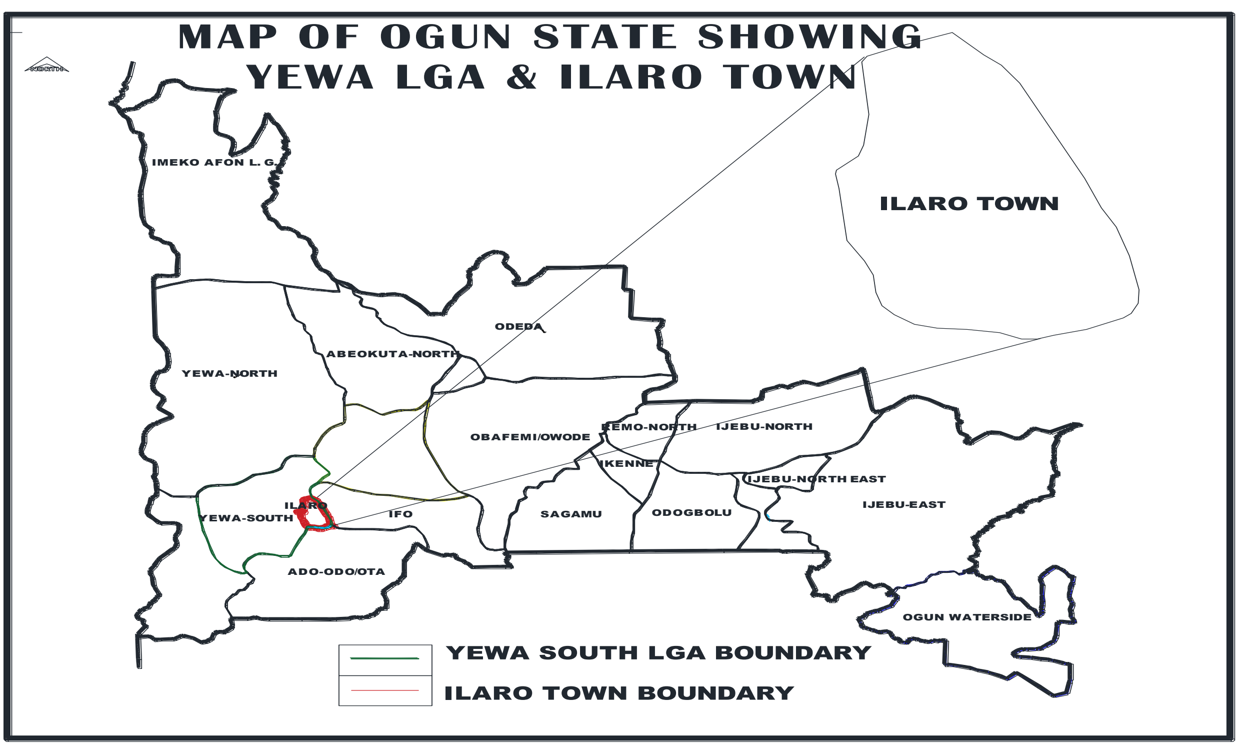


Figure 1: Map of Ogun State showing Ilaro

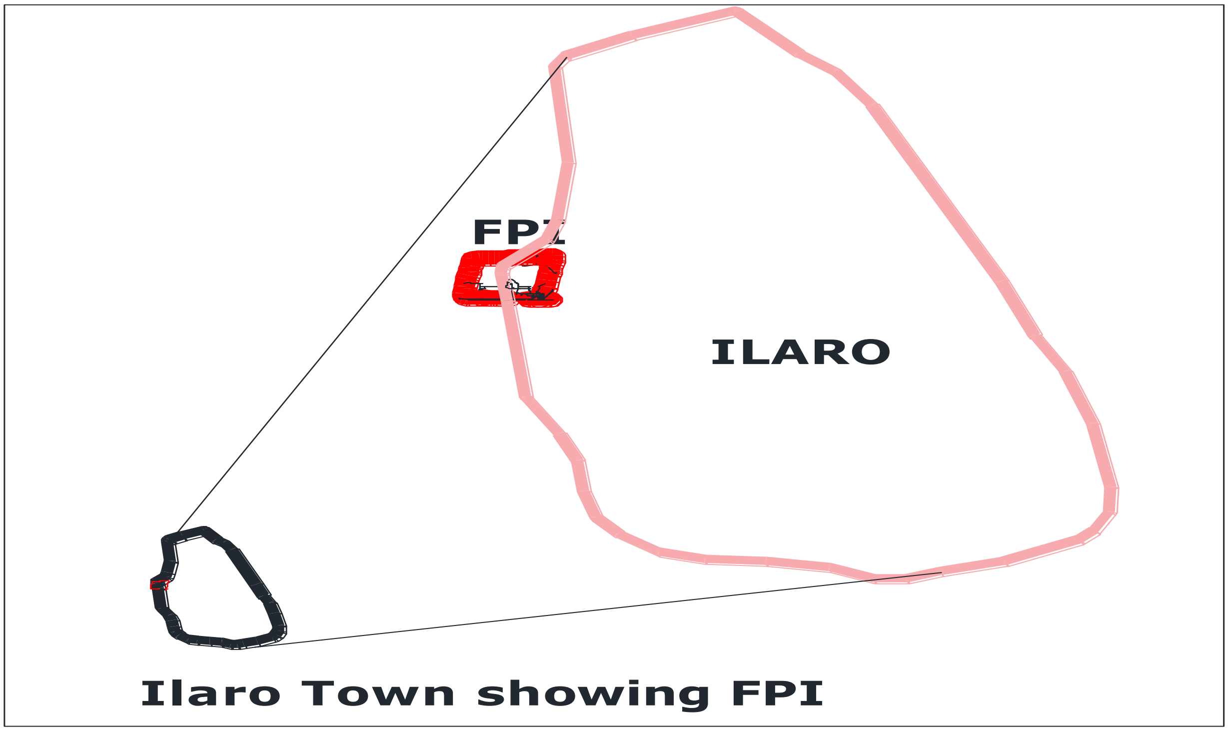
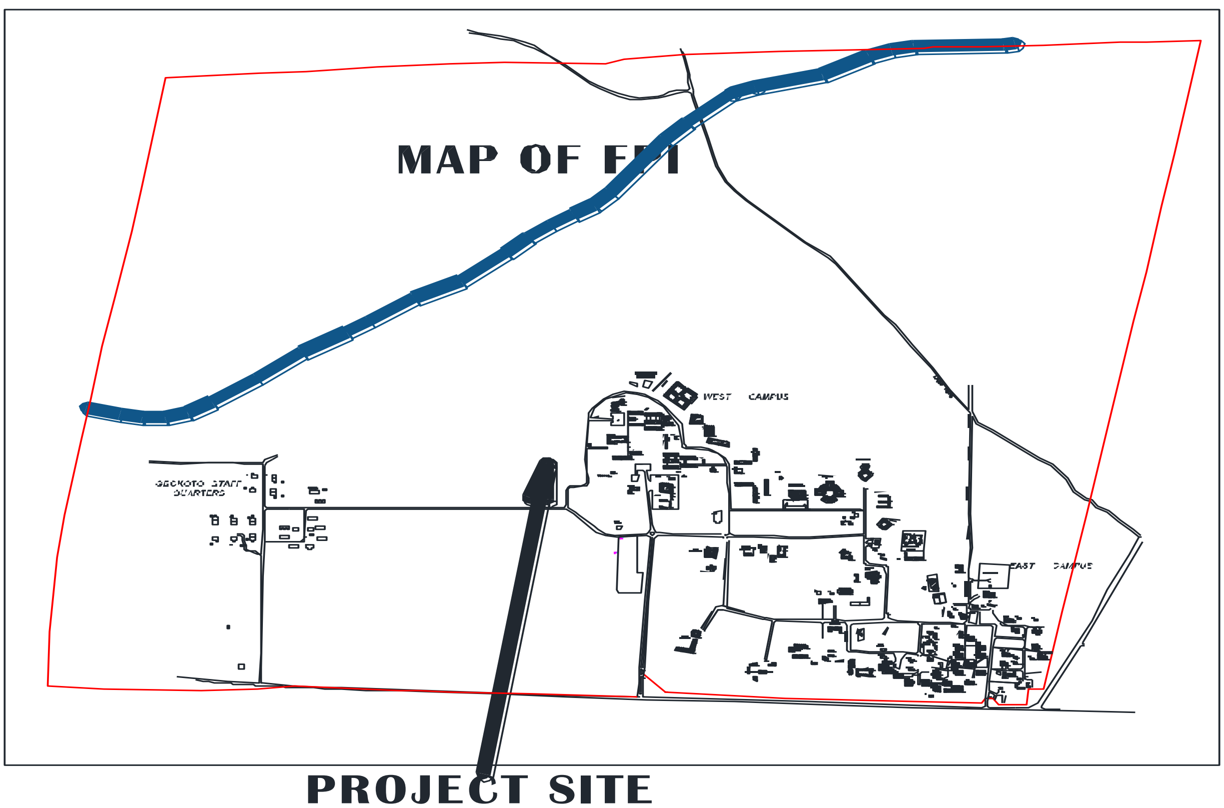


Figure 2: Map of Ilaro showing FPI



1.4 AIM

The work aimed at management and provision of a sustainable water distribution system in the Federal polytechnic, Ilaro in Ogun State using SRTM data and the cut edge tools of Surfer, CADD and GIS for solving the geospatial problems of water distribution in the institution.

1.5 OBJECTIVES

- Planning
- Data collection and verification
- Database creation and linking attribute table to geometric data.
- Spatial and non spatial data analysis

1.6 EQUIPMENT USED

The equipment used are categorized into hardware and software;

1.6.1 HARDWARE

- Handheld GPS equipment
- Total station equipment
- Laptop Computer
- A0 Printer

1.6.2 SOFTWARE

- Autodesk's Civil 3D 2016
- Microsoft Suit 2016
- ArcGIS 10.2
- Surfer 10

2.0 METHODOLOGY

A GIS database was developed for the acquired dataset about the water utilities. Spatial and non-spatial analysis was performed on the acquired data sets and ways for efficient water delivery was proffered. The procedure is itemized below:

- Acquisition of locational and attribute data of the utilities
- Creating data base for the collected datasets and identifying the spatial distribution of existing water utilities
- Identifying the status of existing utilities and performing spatial and non-spatial analysis on the utilities from the acquired data sets
- Surface representation of the campus terrain from SRTM data using surfer 10 and ArcGIS's ArcScene
- Identify shortest route for the water distribution network using ArcGIS Network Analysis
- Carry out longitudinal profiling along the shortest route using Level instrument and plotting the profile using Autodesk's Civil 3D 2016 software

2.1 DATA NEEDS

TABLE 2.1 – DATA NEEDS

Data Needed	Data Type	Data Source	Data Format
Map of Federal Polytechnic Ilaro	Spatial/map	Department of Surveying & Geoinformatics, FPI. (2016)	Digital
Inventories of existing water utilities	Attributes	Department of works, Social surveys and Field observations. (2016)	Analogue, text files.
Shuttle Radar Topographic Mission (SRTM) height data and profile height	Spatial/Non spatial	USGS and Level Instrument downloads (2012)	Raster/Text
Additional location detail	Spatial	Handheld GPS (2016)	Text

However, the above identified data have been obtained from reliable sources and field observations as indicated.

2.2 DATA MANIPULATION

The three modules of the ArcGIS software namely ArcMap, ArcCatalogue and ArcToolbox were used accordingly in developing the database and in carrying out required analysis. The ArcCatalogue was used to create necessary GIS files (both spatial and attribute), the ArcMap was used to capture all relevant spatial and attribute details while ArcToolbox was used to carry out various analysis and queries such as the number of non-functional wells, closest deep well to each faculty as well as where and how many bore holes and or wells are needed to supply water to new facilities and route network analysis e.t.c. SRTM image was used to obtain height information about the school terrain while surfer 10 and ArcScene were used to generate the different surface representations of the school's terrain such as Contour, Aspect map, slope map etc.

2.3 WATER DISTRIBUTION ROUTE (SHORTEST ROUTE ALGORITHM)

A well planned and adequately mapped water distribution network plays an immense role in the provision of potable water supply. A good water distribution system is fundamental to environmentally sustainable development in any country and is also important in the control of water borne diseases (Audu and Ehiorobo, 2015). A good location of water will be incomplete without a strategic route to distribute the water. The methodology in this work used an Algorithm to determine the best route to link up the water pipeline from the overhead water tank in the Senior Staff Quarters of the school to overhead water tank in the East Campus of the school.

This algorithm assisted in deciding the shortest route to run water pipelines to connect to end users (consuming units) (Figure 6). On a weighted graph this algorithm solves single source and shortest route problem. To find a shortest route from a starting point P_1 through P_2 to a destination point P_3, the algorithm maintains a set of junctions (point feature), Overhead tanks $O_{1,}$ $O_{2,}$ and O_3 whose final shortest route from O_1 has been computed. The algorithm repeatedly finds a junction in the set of junctions that has the least short route, adds it to the set of junctions at $O_{1,}$ O_2 and O_3 and updates the shortest route estimates of all neighbors of this junction that are not in $O_{1,}$ O_2 and O_3. The algorithm continues till the destination junction is added to $O_{1,}$ O_2 and $O_{3.}$

2.4 RESULTS

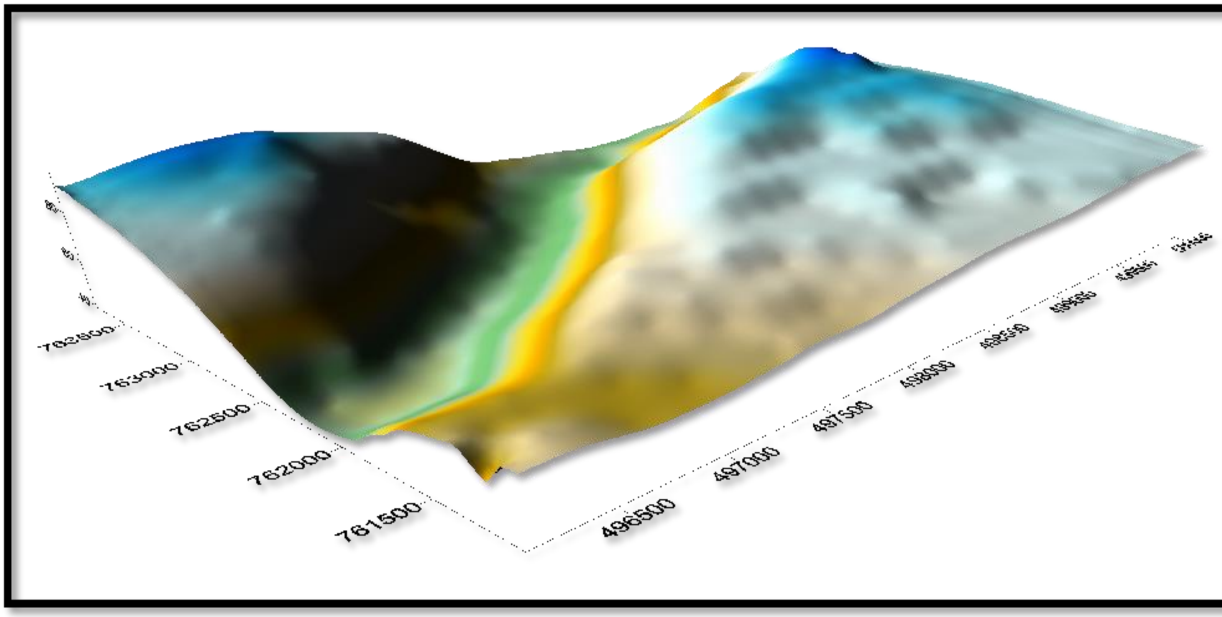


Figure 3: 3D Surface Model of the School

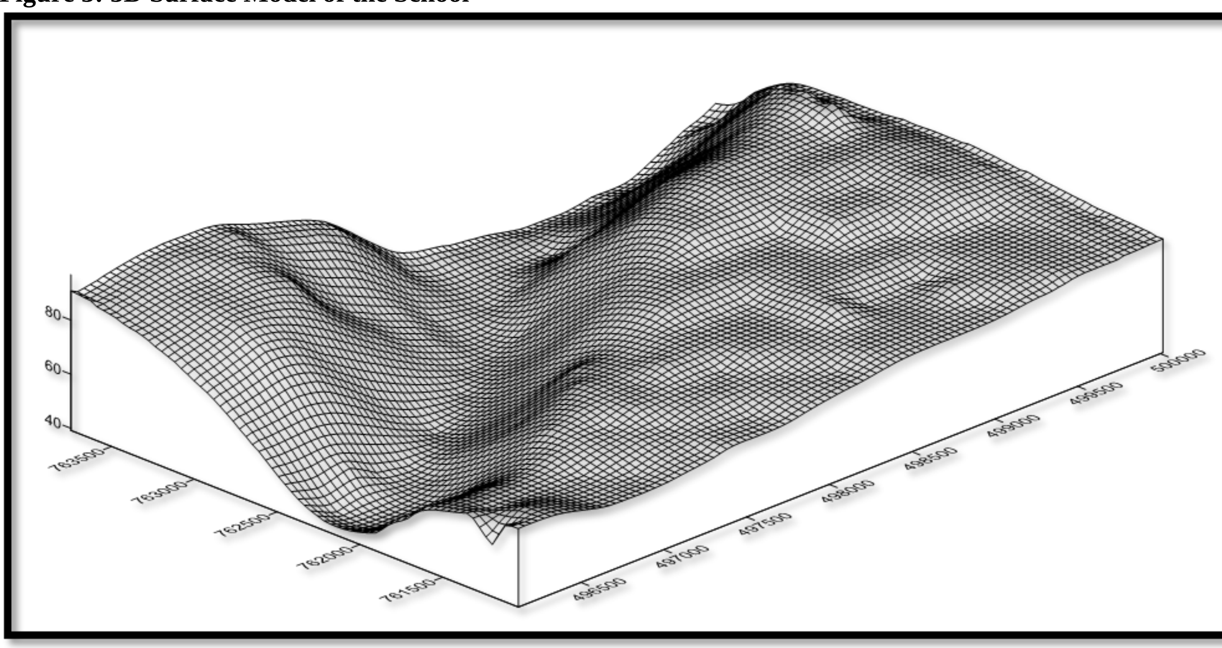


Figure 4: 3D Wire Frame showing the topography of Surface of the School

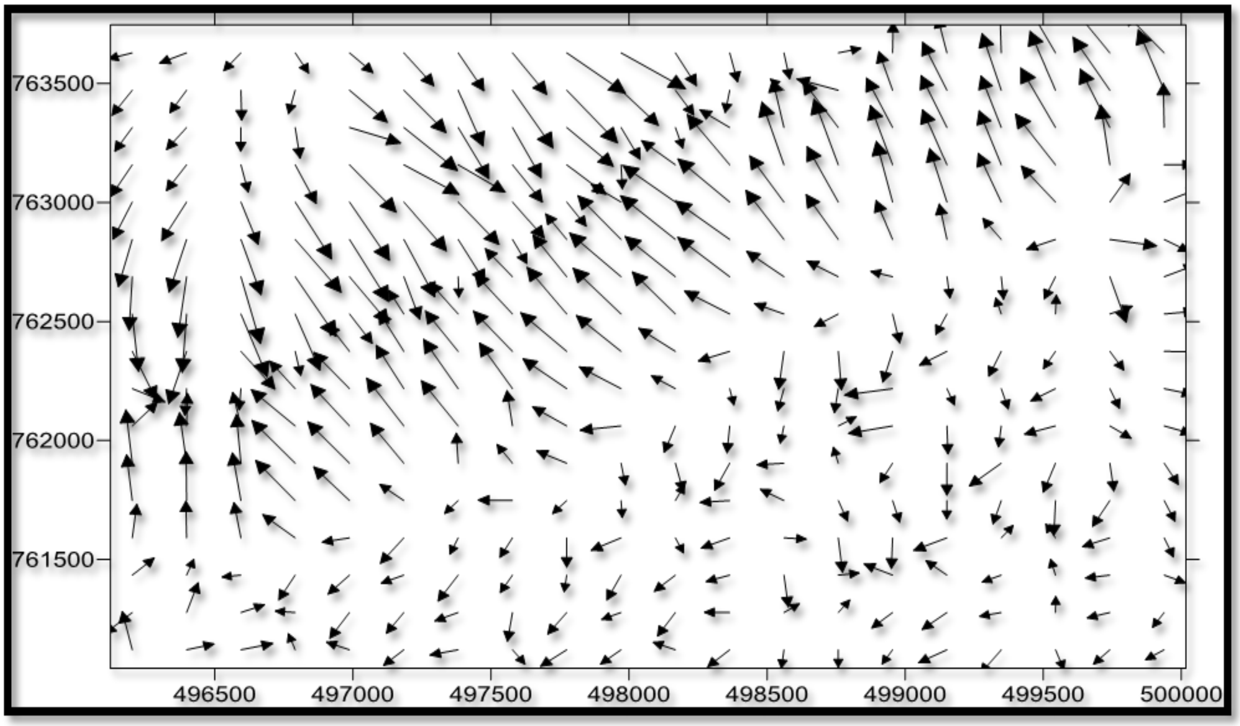


Figure 5: Grid Vector map showing runoff water direction in the School

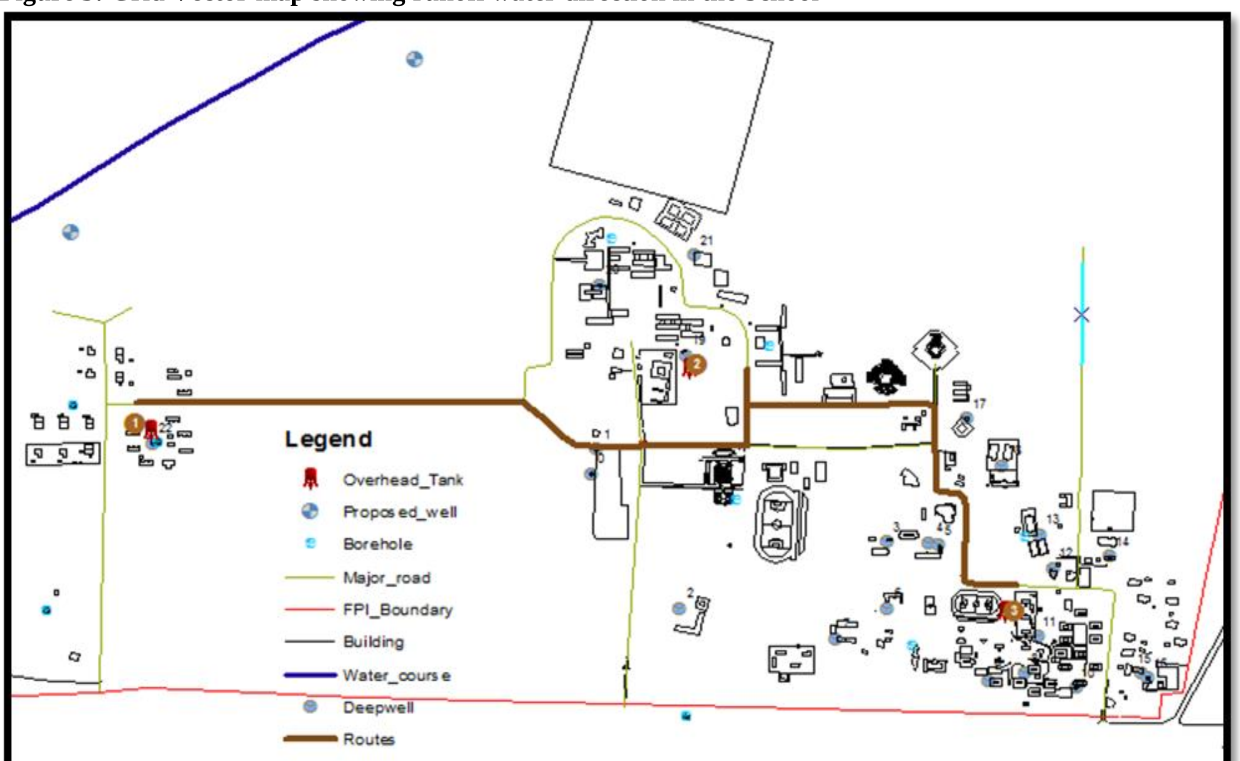


Figure 6: Map showing shortest route for distributing water from Senior Staff Quarters to East Campus of the school.

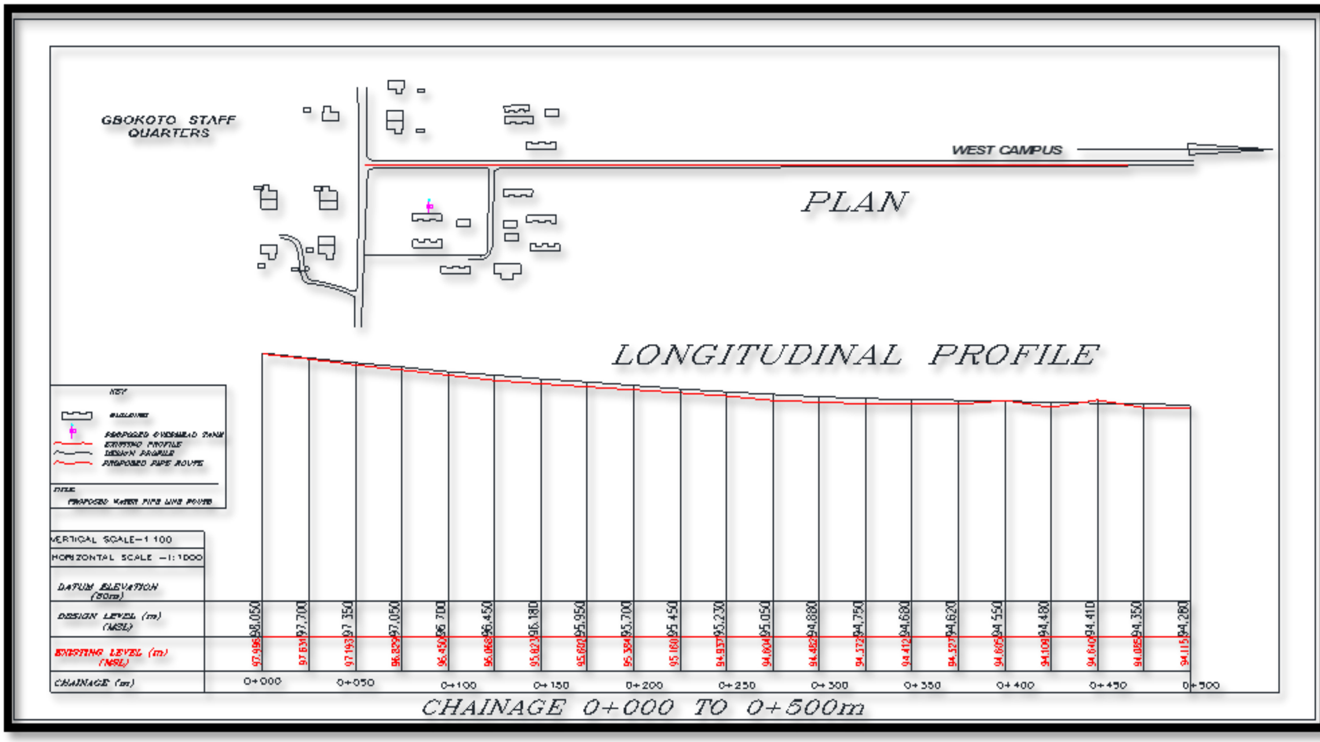


Figure 7: Map showing a part of the longitudinal profile of the proposed water distribution route

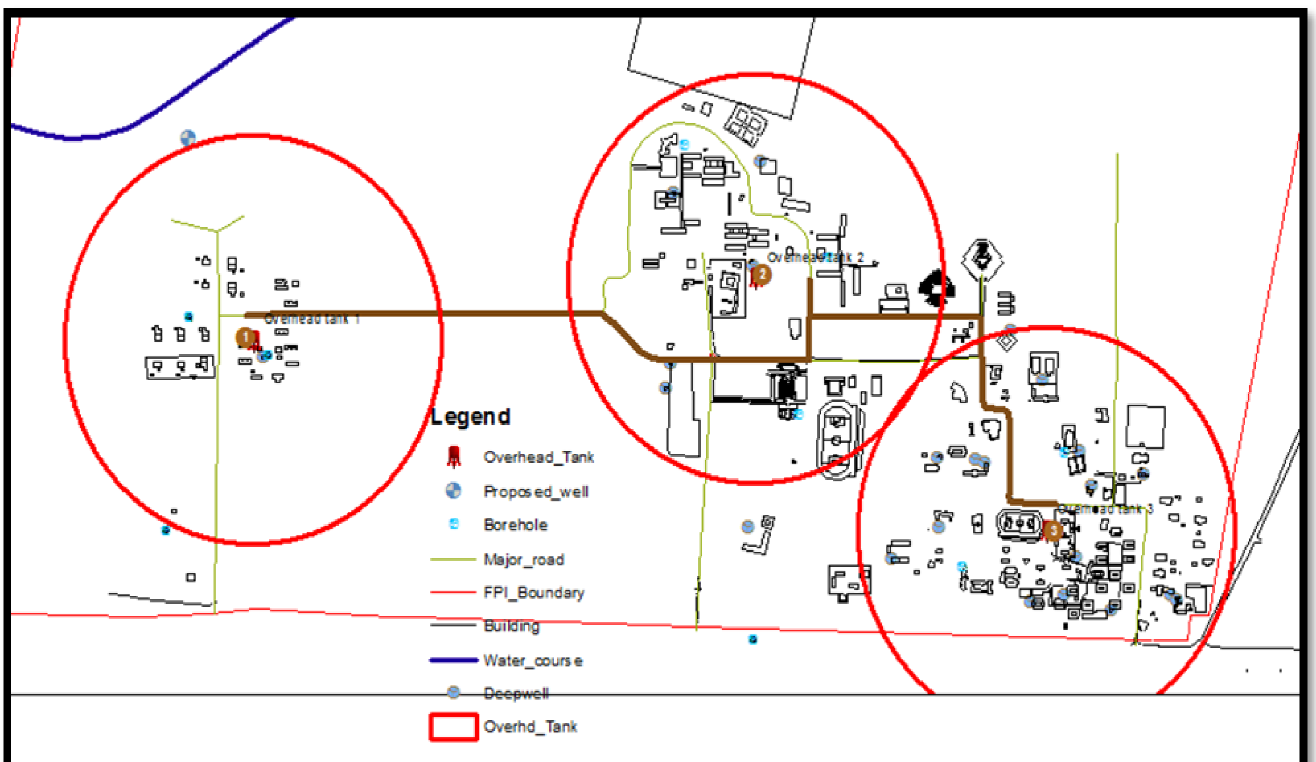


Figure 8: Map showing 500m radius buffer around each of the three proposed Overhead tanks

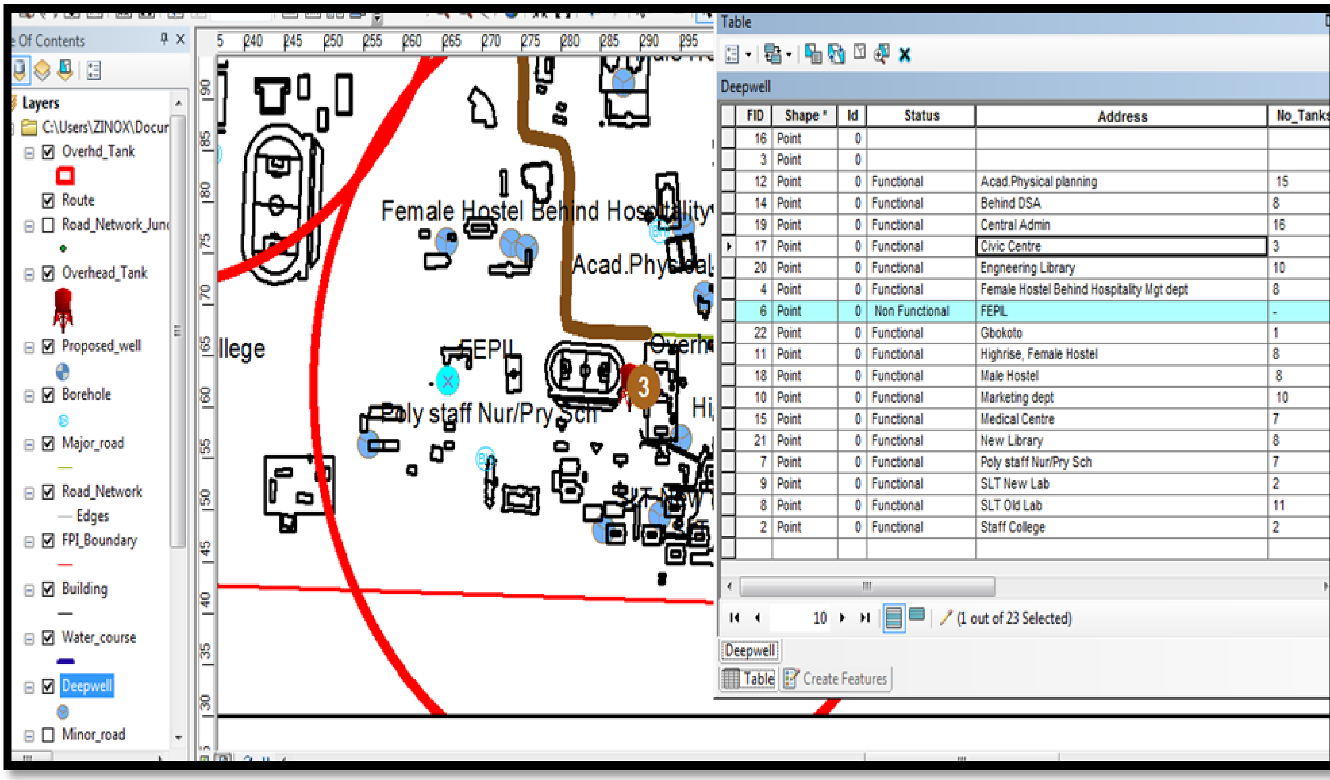


Figure 9: Spatial location of some non-functional deep wells and their attributes in ArcMap

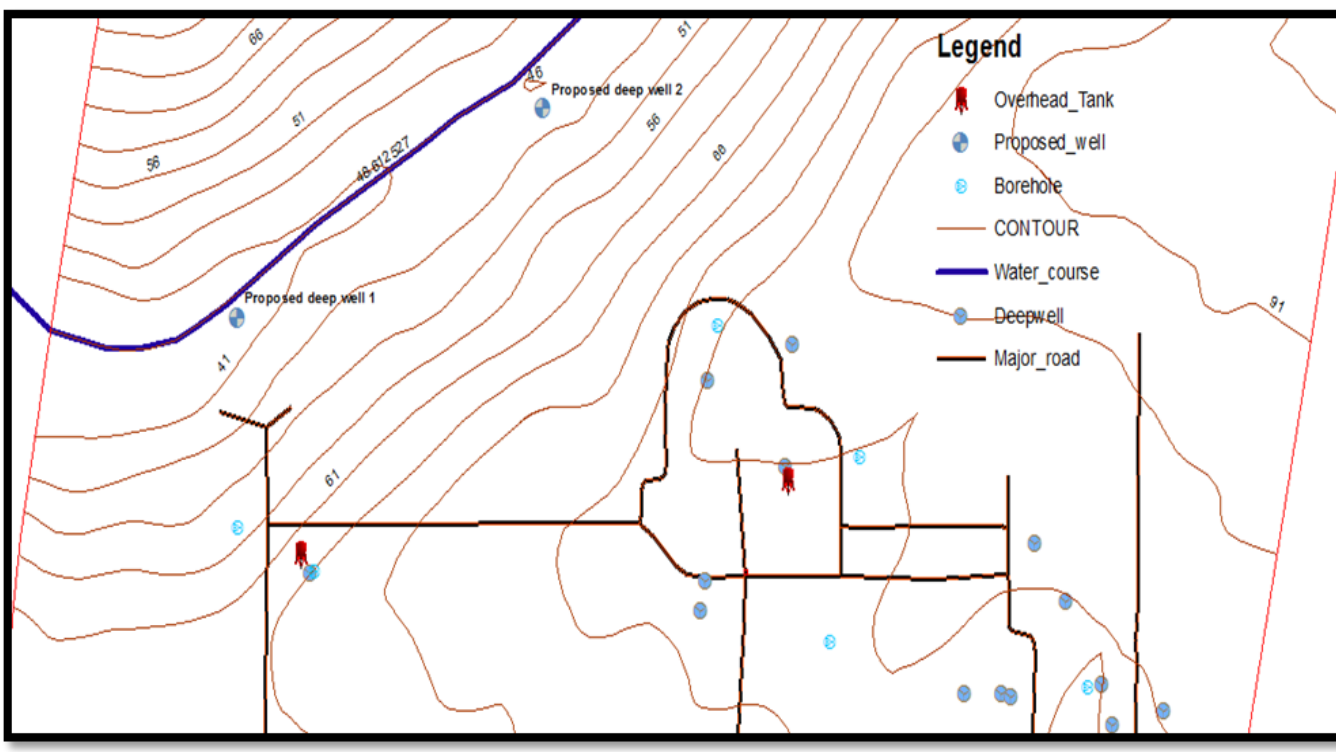


Figure 10: Map showing the location of the two proposed deep wells close to the stream

3.0 DISCUSSION OF RESULTS

Geographical information system result is the process whereby data in a database are integrated and manipulated in such a way that it would provide answer to generic questions of location, condition , trend, pattern etc. the spatial data acquired were also structured for intelligent use.

From the database query, out of 23 deep wells 16 are functional, 1 is not functional. It suffices to say here that the number of deep well is over sufficient for the entire school community. Where there are clusters of deep wells, an overhead tank that can contain more than ten times the volume of the existing deep wells can be used as replacement. Boreholes can be used instead. For instance in the east campus area of the school were clusters are most. From the database three deep wells are located in the west campus viz; Central administrative block, engineering's building and new library. These deep wells can be combined as one with an overhead tank for storage to supply different offices.

Based on the contour map and the 3D surface map, the topography of the northern part of the institution is high and gently slopes downwards towards the southern parts of the school. Surfer was used to depict the directions of flow water in the school (Figure 5). This would aid in deciding on the best area to locate over head water tanks for efficient distribution of water. Two deep wells and three overhead tank locations were proposed. These locations were subject to the study of the products of the SRTM data viz; contour map, wire frame, 3D model (Figures 3, 4 and 5), as well as proximity to developed areas such as staff quarters, administrative offices, hostels, class areas, libraries etc. The feeder deep well is located close to an existing stream that traverses across the north western part of the school to feed the overhead tank at Gbokoto staff quarters.

The proposed over-head tanks are strategically placed at nodal points on the shortest route to evenly distribute water within the entire campus using a buffer of 500m. The 500m buffer ensured that all buildings, office blocks and laboratories etc. fall within buffer zone (Figure 8).

4.0 CONCLUSION AND RECOMMENDATIONS

Water is vital for man's existence and without it, there would be no life on earth. As a resource to any nation, it should be well planned, developed, conserved, distributed and managed. Its infrastructure should be properly maintained to avoid future water problems (Audu and Ehiorobo, 2015). For this reason there is the need for up to date information about the current status and condition of the existing water infrastructure embedded in a functional digital map.

Up to date, digital map data on utility services are needed for proper planning, design and execution of any service project. They are very vital in developmental process, infrastructure maintenance, fault detection and rectification by any utility management scheme. The availability of digital maps of the utility supply network is very necessary for network extension and integration.

It is hereby recommended that the polytechnic should as a matter of top priority, implement a database system for prompt and optimum solutions to be applied to the problems affecting the efficient delivery of utilities in the campus.

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