International Journal of Scientific & Engineering Research, Volume 6, Issue 10, October-2015 1622
ISSN 2229-5518

Application of Very Low Frequency Method and Ground Penetration Radar in Underground Utility Investigation, Onshore Eastern Niger Delta

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Abstract— Ground penetration radar and very low frequency methods were used as novel approach to identify the presence of the increasing installation and application of underground oil and gas industry related utilities in part of the onshore eastern Niger Delta. The dominant underground utilities in the study area are pipelines and electrical cables, mostly buried at depths of less than two meters from the ground surface. It is therefore, necessary to investigate the presence, position and nature of these underground utilities for proper designing and safety of new construction and engineering projects. Failure to carryout subsurface utility checks prior to inception of new and potentially subsurface infrastructure- impacting projects may result in utility damage and serious accidents. The results of the study indicate that the applied geophysical methods prove to be accurate, effective and feasible, and are recommended for underground utility investigations in the onshore Niger Delta.

Index Terms— Uttilities, Very low frequency, electromagenetism, ground penetration radar, radagram, transmitter, receiver.

1 Introduction

Utility location is the process of identifying and labelling public utilities which are mainly underground. These utilities include lines for telephones, electricity distribution, natural gas, cable television, fibre optics, traffic lights, street lights, storm drains and water pipes. In the Niger Delta underground utilities are dominantly oil and gas pipelines, water pipelines, Underground storage tanks and communication line. In early times, the presence of underground utilities was determined only through excavation but with improvement in geophysics, relatively portable very low frequency (VLF) and ground penetration radar (GPR) devices has made identification easier and excavation is dominantly a confirmatory tool.

The VLF method initially uses very low frequency electromagnetic signals propagating from external sources, such as from military radio stations located internationally and government-sponsored stations propagate signal with high power (up to 1000 Watts) and frequencies varying between 15 to 30 KHz. These signals propagate well along water-filled or mineralized fractures that are oriented in strike with these transmitting base stations. Modern potable tools based on the VLF principle are now made available to give flexibility to choose orientation and position of VLF source. This tool contain both transmitter and receiver component. A secondary field will be generated where the primary field passes through a subsurface conductor, such as a buried cable. These two vector fields will add to produce a resultant signal, which will differ in amplitude and direction to that generated by the transmitter. The receiver coil emits an audio response indicating the strength of the resultant field detected. The hand-held receiver unit is carried across the survey area, and the position of the maximum audio signal is noted. This will correspond to the surface position directly above the buried cable.

Ground-penetration radar (GPR) uses radar pulses within the microwave band of radio spectrum to image the subsurface [1]. GPR uses transmitting and receiving antennas or only one containing both functions. The transmitting antenna radiates short pulses of the high-frequency (usually polarized) radio waves into the ground. When the wave hits a buried object or boundary with difference in dielectric constants, the receiving antenna records the variation in reflected return signal. This principle is similar to reflection seismology, except that electromagnetic energy is used instead of acoustic energy, and reflections appear at boundaries with different dielectric constants instead of acoustic impedances. Various bulk dielectric constants for common earth materials are documented in [2], [3]. The depth range of GPR is limited by the electrical conductivity of the ground, the transmitted centre frequency and the radiated power. Ground-penetrating radar antennas may be in contact with the ground to achieve the strongest signal strength; however GPR air launched antennas can be used above the ground. GPR can be applied in utilities, mining, hazardous waste, ordnance, archaeology, road, railway and environmental investigations related to geotechnics, engineering and transportation [2], [4] . The most significant limitation of this method is in high conductive materials such as clays and salt contaminated soils. In addition, expertise is also required for design, conduct and interpretation of results (Radargram) in GPR survey.

The aim of this study is to demonstrate how electromagnetic locators are used together in underground utility investigation. The objective is to illustrate the principles and approach used in identifying underground utilities in the study area.

ISSN 2229-5518

2 Study Area

The study area was a right-of-way in Emouha Local Government Area, Rivers State (Figure 1). It is generally, a lowland area with elevation of 4m to 7m above sea level. Its vegetation comprises of thick bushes and plantations with a topography that is undulating. The low gradient found within the study area, affects run-off and drainage having a profound influence on the moisture regime of the soil. The soils present show variation in sand, silt and clay composition. The area is mostly describes as a seasonal swamplands. They are numerous industrial activities going on in the study area which are evident in the increasing number of engineering and construction projects. They were evidences of interference sources present in the study area such as a slightly buried wire mesh and a distant telecommunication network mask, which could affect the efficiency of the geophysical tool utilized for studies.

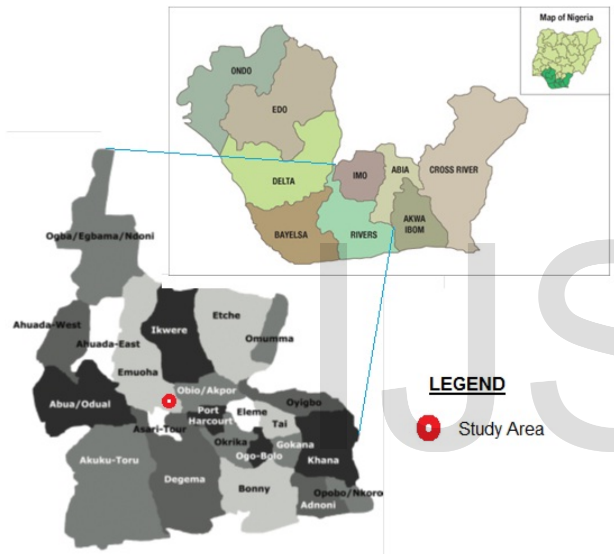

Fig. 1: Map of Niger Delta Showing the Study Area in Rivers State.

3 Methodology

A reconnaissance survey of study area was carried out to determine the environmental condition. The various tools were checked for quality assurance and control. The VLF device was utilized in an inductive mode which requires both transmitter and receiver held independently by operators that are separated by 20 paces. Subsequent sweep and inductive search will be carried out to determine the orientation of the utility.

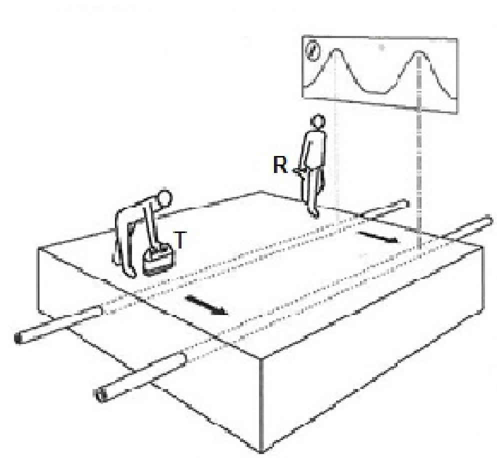

Fig. 2: Sweep and Inductive Search using a VLF device. (*T=Transmitter, R=Receiver*).

In every transient path traced, points indicative of utility presence were pegged or marked with pink coloured paints (Table 1) because their nature was yet to be identified on excavation.

TABLE 1
Uniform Colour Codes for Utilities

Applications	Colour
Power lines	Red
Water	Blue
Sanitary	Green
Telephone	Orange
Flammable material	Yellow
Cable TV	Orange/Black
Unknown utilities	Pink
Proposed excavation limit	White
Reclaimed water and slurry lines	Violet

The VLF method is prone to high interference which could probably be generated by the presence of a nearby communication network mask, overhead metallic tank, earthening wire, electrical cable and transformers that are not of interest to the research. One limitation of the VLF device used is that it is an electromagnetic locator that lacks a printable display. To achieve a display of results in the form of a utility map, the VLF device, needs to be complemented with a geo-referencing tool for which a Total Station is more highly recommended [5] in tropical environments but this was not accessible during this search.

The GPR tool was also adjusted to suit environmental condi-

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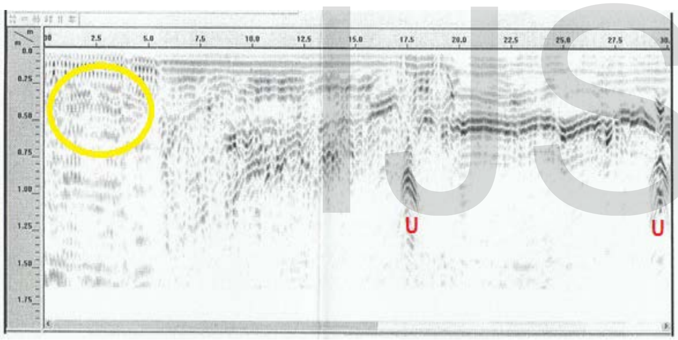
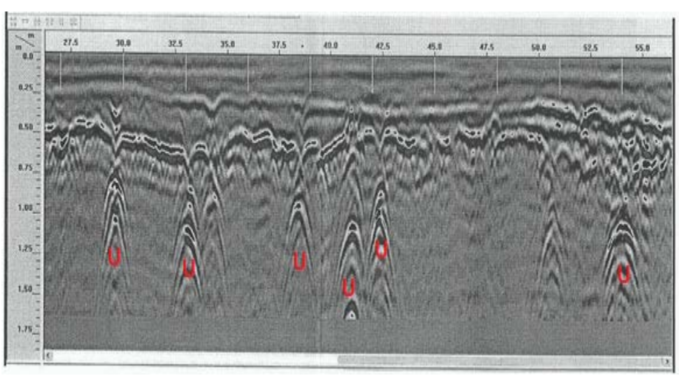
tions and to achieve better resolution during site investigation. Data acquired along a pre-defined transient path was adequately saved with a unique file number for easy reference, and processing. Excavation was eminent to evaluate the precision level of the VLF tool (RD4000) and 400MHz GPR antenna, in positioning and depth measurement. In addition, revealed the nature and determine actual number of the underground utilities present at each point.

5 RESULTS AND DISCUSSION

The ground penetration radar investigation along transient path show presence of utilities (marked "**U**") in study area as shown in Figure 3. Depths greater than 1.6m in the GPR section (Radargram), show high absorbing rate which is probably due to high soil moisture content. The area circled with a yellow line show high interference caused by a wire mesh. The buried utilities can be identified by high amplitude hyperbolic surface in the radargram. The result obtained was affected by environmental factors, which introduced noise and interferences. The closeness of this buried utilities in some areas caused interference that affected the resolution of the VLF device (RD4000) utilised which indicated the presence of one utility that was found to be more on excavation.



(a)



(b)

Fig. 3: Radargram along a surveyed transient path in study area. (**U** = Utility position; Yellow circular line = High interference zone).

These discrepancies in the actual number were further checked using the ground penetration radar. The main utilities established on excavation were dominantly pipelines and buried cables. They are found at depths that are less than two meters (<2m).

Fig. 2: An excavated point revealing utility (pipeline) nature on identification.

The actual size of the pipelines was not relevant to this research because it was limited to ascertaining presence, nature and number of underground utilities on excavation after geophysical survey in the study area.The combination of these two geophysical electromagnetic locator techniques in underground utilities investigation in the study area proved to be very precise and proficient in determining the presence, position and depth from ground surface to buried utility.

4 CONCLUSION

Underground utilities within the study area are identified accurately using Very Low Frequency, ground penetration radar and excavation as a confirmatory tool for the position, type, nature and number of utilities. The dominant underground utilities are pipelines and electrical cables which are mostly buried at depths of less than two meters from the ground surface. This result serves as a safety check before inception of any potential subsurface impacting project within the study area.

ACKNOWLEDGMENT

The authors wish to thank Esa Odan for GPR training lessons.

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