LOUISIANA TRANSPORTATION RESEARCH CENTER
LTRC

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Corrosion Map for Metal Pipes in Coastal Louisiana

INTRODUCTION

Transportation agencies often allow metal pipes as an option for cross drains under/along roads and highways. Metal culverts can corrode over time at various rates based on their environmental conditions. The corrosive nature of coastal waters and the soil around New Orleans was creating a maintenance problem with metal culverts. The Department of Transportation and Development (DOTD) District 02, a mostly coastal region including New Orleans, recently set a policy of prohibiting the use of metal pipes for new drainage installations to avert this problem. Other southern DOTD districts have similar environmental conditions and needed guidance on where to set boundaries regarding the use of metal culverts.

Concrete pipes are less susceptible to corrosion, but the initial capital investment is more than corrugated metal pipes. Metal pipes require a lower initial capital investment; however, in corrosive soil conditions they corrode faster, and will not retain their mechanical properties needed to serve the design purpose. Thus, they will need to be changed often. This results in an increased overall cost in long-term.

Detailed on-site soil investigations are one way to determine the best material for the pipes to be used for culverts. These investigations, usually, are done during the implementation phase. More often, this kind of investigation and analysis is overlooked. The corrosive nature of environmental conditions generally tends to decrease as one moves deeper in-land and away from coasts. The delineation of such areas where corrosive soil effect is not strong enough will allow these agencies to permit the use of metal pipes and reduce overall cost. A corrosion map will provide a combined corrosive effect of some of the main soil characteristics and will be an essential tool to have access to during planning phase and will also ensure the better selection of durable materials for drain pipes based on environmental conditions.

OBJECTIVE

The objective of this project was to create a guidance document with maps that delineates zones where metal pipe is prone to increased corrosion due to environmental conditions. Results from this project will provide a logical rationale to support DOTD restricting the use of the metal drainage pipe in certain areas.

METHODOLOGY

This project utilized Geographic Information System (GIS) to understand and predict the spatial distribution of corrosive environments based on soil characteristics (pH and resistivity). This project utilized ArcGIS toolbox, Geostatistical Analyst, and two of its interpolation toolsets (Inverse Distance Weighted and Kriging) to combine and interpolate spatial data from the United States Department of Agriculture (USDA) and DOTD field surveys. DOTD provided PDF copies of field surveys, which is ideal for creating a predictive GIS surface. Some of the field survey reports didn't have location information. The field surveys comprised (only) just over a hundred locations, which identified both pH and resistivity readings. This quantity and quality of data would suit many GIS researchers since many soil studies are on localized regions for agricultural or soil science purposes. However, the size of the study area for this project is

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approximately 21,877 square miles. The field survey did not have enough locations to accurately predict the chemical nature of the over such a large area.

The Web Soil Survey datasets, made available by the Natural Resources Conservation Services (NRCS), which falls under the USDA, were used to assist with the DOTD dataset. The shapefiles provide the spatial location and pull the attribute data from the tabular dataset which is connected to an Access database. The connection between the shapefile and tabular dataset is established by Soil Data Viewer. Once downloaded, the application was added into ArcMap and enabled as a Toolset. The datasets used for this study were Soil Electrical Conductivity and pH polygon files that were displayed at the parish level. There was no information regarding the quantity and locations of the field surveys within those polygons. The four techniques of interpolation that were used on the three separate chemical properties were Universal Kriging (UK), Ordinary Kriging (OK), Inverse Distance Weighted (IDW), and Spline. The method was geostatistical as opposed to spatial. The techniques were conducted using all their parameters that were available at the time of the study. After running the interpolations, a cross validation was performed on each of the predicted surfaces. The mean error and standard deviation were used to rank the methods. The resulting cross validations showed that UK had the lowest mean error and standard deviation amongst the methods used. The UK interpolator often times proves to have greater accuracies with the predictive surfaces they produce.

Corrosion Zone (expected service life of a metal pipe)	Total Area (Mile^2)	Percentage Area
Extremely Corrosive (0-20 yrs.)	9,259.06	42.5%
Highly Corrosive (20-40 yrs.)	8,177.88	37.5%
Corrosive (40-60 yrs.)	3,339.57	15.3%
Mildly Corrosive (60-80 yrs.)	1,004.15	4.6%

Table 1
Corrosion data

CONCLUSIONS

The corrosion map presented here is based on combined values of spatial soil pH and spatial soil resistivity. The corrosive zones, divided into four categories based on expected service life of metal pipes along with their corresponding area in the study zone is provided here in the table. The results indicated that the most of the soil environment is corrosive in nature to metal culverts in coastal Louisiana. However, there are exceptions: the greater Baton Rouge area and the Atchafalaya River Basin. The data shows that the corrosive nature of about 80% area of the coastal region is not ideal for metal pipes, as the expected service life is less than 40 years. There is about 15% of the area, as shown in corrosion map, where metal pipes are expected to have service life between 40 to 60 years. There is an even smaller percentage (less than 5%) of area where expected life of metal culverts is between 60 to 80 years.

RECOMMENDATIONS

The results of this project should be used as a general tool for project planning and culvert material selection in the coastal region of Louisiana. The author recommends that DOTD should specify standard guidelines for field soil investigations that are specific to number of soil samples to be collected and their respective depths for pH and resistivity values and their spatial locations to be recorded. It has become a lot easier to record a geo-location using a smartphone. It is recommended that the corrosion maps be utilized in the design process to maximize the life cycle cost analysis with DOTD as over 80% of the study area is either highly corrosive or extremely corrosive.

The pH and resistivity data obtained from various sources were valid for a few points, and suitable interpolation techniques were used to create data for points that did not have any data originally. Soil properties at a given point vary with the depth of the soil. The soil samples used in this study were not collected at the same depth. Therefore, the pH and resistivity were weighted at a certain depth and these weighted values were used for further spatial interpolation. It is recommended that, for higher accuracy, site specific soil investigations should be used. The accuracy of this map can be increased in the future if pH and resistivity from more field investigations are incorporated. It is recommended that this data be frequently updated and re-calibrated often (every 4-5 years) for it to be even more useful and accurate.

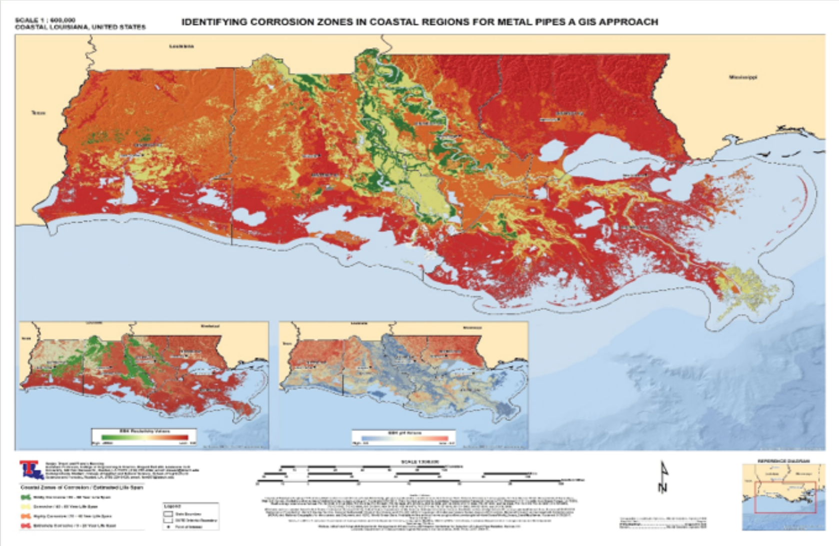

Figure 1
Corrosion map