Norfolk UST Risk Assessment

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ABSTRACT

Leaking underground storage tanks (USTs) pose a significant environmental hazard in Norfolk, Virginia, where factors such as weather, casing materials, and varying ground conditions contribute to potential leaks over time. Corrosion, exacerbated by Norfolk's coastal location and harsh soil conditions, is a primary cause of these leaks. Geographic Information System (GIS) tools can be utilized to develop a predictive model for identifying at-risk UST locations by integrating data from multiple sources, including UST records from the state of Virginia and other relevant datasets. This model would employ various spatial analysis techniques to generate maps and web applications, enabling field teams to validate its accuracy and support the City of Norfolk in mitigating risks associated with leaking USTs. The goal of this research is to produce valuable insights that help safeguard the health of Norfolk's residents and protect the delicate surrounding ecosystem, including the Atlantic Ocean, marshes, rivers, and Chesapeake Bay.

BACKGROUND

· The City of Norfolk is located in Virginia, USA (Fig. 1). According to the Environmental Protection Agency, Norfolk may contain a large amount of abandoned Underground Storage Tanks (USTs) often used for storing petroleum at gas stations or for fuel oils for homes/businesses (Norfolk Environmental Commission, 2018). This is a hazard to the city and its immediate environment. Norfolk Environmental Commission feels records of locations, installations, and/or removal of new/abandoned USTs as the tanks, recording process is inaccurate and in need of automation (Norfolk Environmental Commission, 2018). Norfolk is surrounded by several waterbody outlets that are used for domestic consumption, industrial processes, and energy production. These local waterbodies are shown to have brackish water types. Norfolk is known to be susceptible to flooding leading to seal level rise due to high amounts of storm surges from its coastal location. Flood waters lead to disastrous situations presenting a threat to the local ecosystem.

OBJECTIVES

- The purpose of this assessment is to evaluate areas that USTs pose potential harm that may lead to contamination:
  - Identify USTs status based on location from the EPA data
  - Use GIS software to assess population areas at high risk to leaks
  - Determine areas where leaks may pose an environmental threat to surroundings neighborhoods in proximity to wetlands effected by storm surges

REFERENCE/AKNOWLEDGMENT

- I would like to acknowledge the EPA and City of Norfolk for the use of several shapefiles and datasets in my assessment and Dr. Gebremichael for the help and guidance on the project.
- Hall, Jake. "City of Norfolk Underground Storage Tank Analysis" (2019), Poster, Old Dominion University GIS Day. https://digitalcommons.odu.edu/gisposters/1
- https://www.norfolk.gov/2378/Norfolk-Environmental-Commission
- ArcGIS Pro

DATA

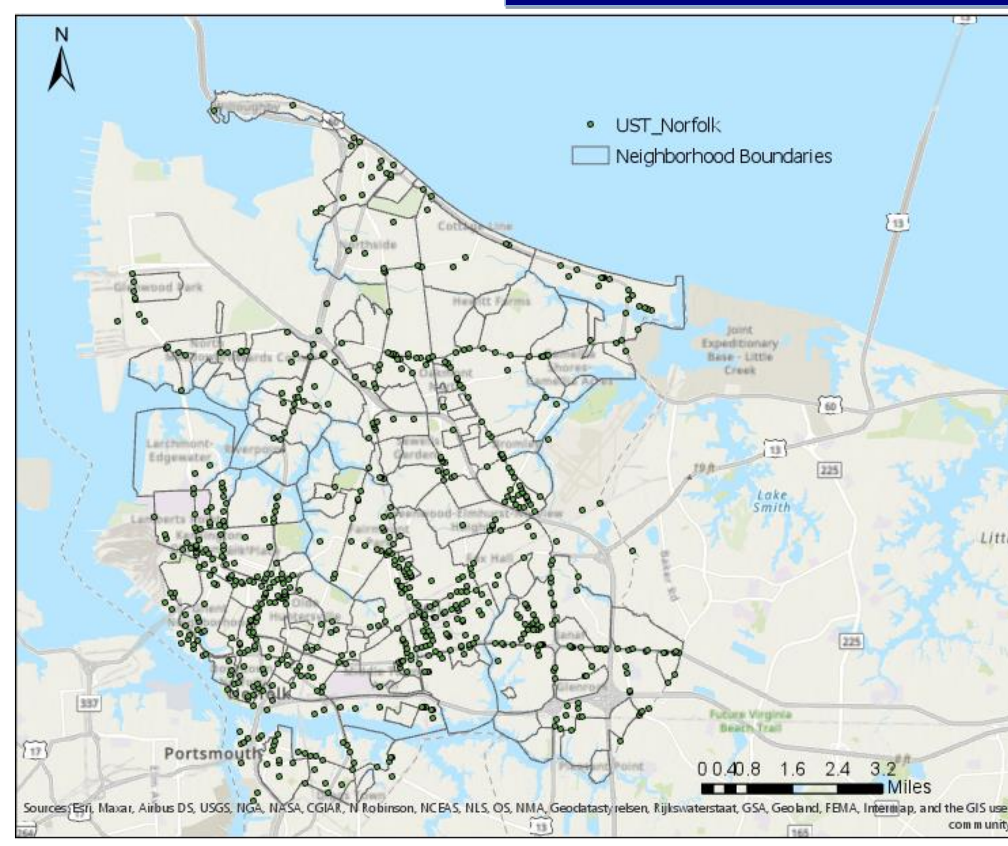

Figure 1: Norfolk USTs and Neighborhood boundary

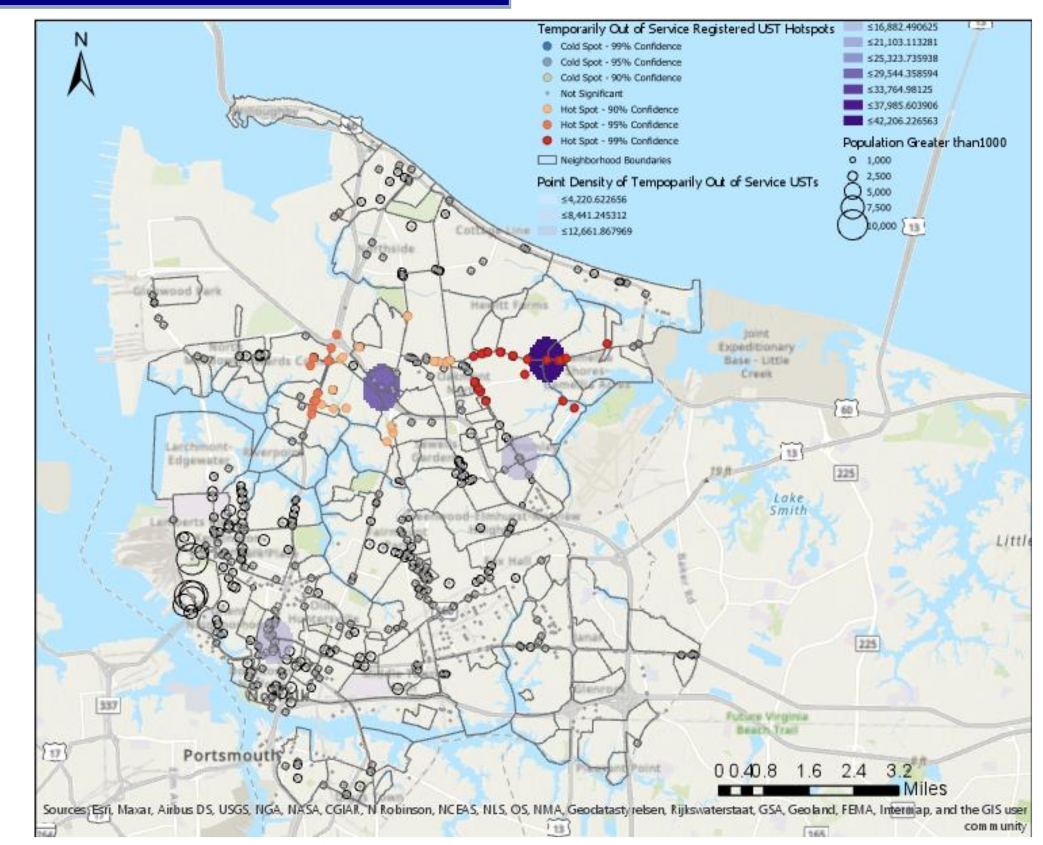

Figure 2: Temporarily Out of Service USTs Hotspots and Point Density Analysis

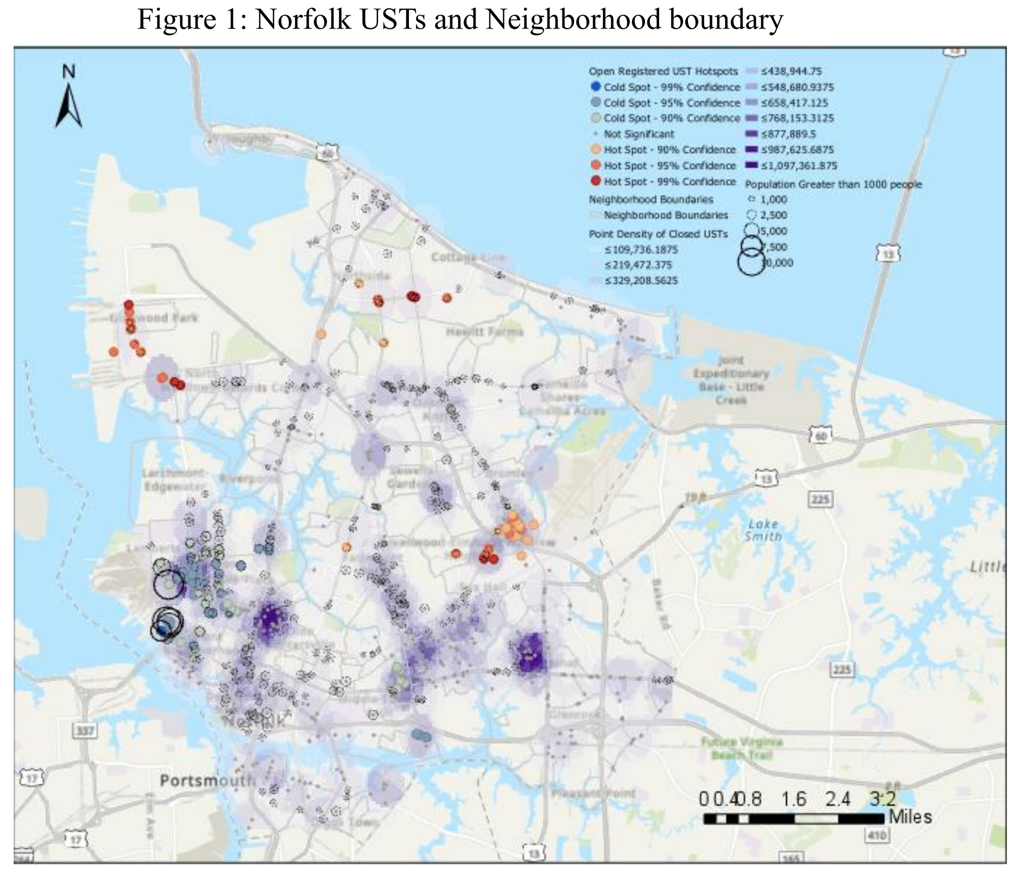

Figure 3: Open USTs Hotspots and Point Density Analysis

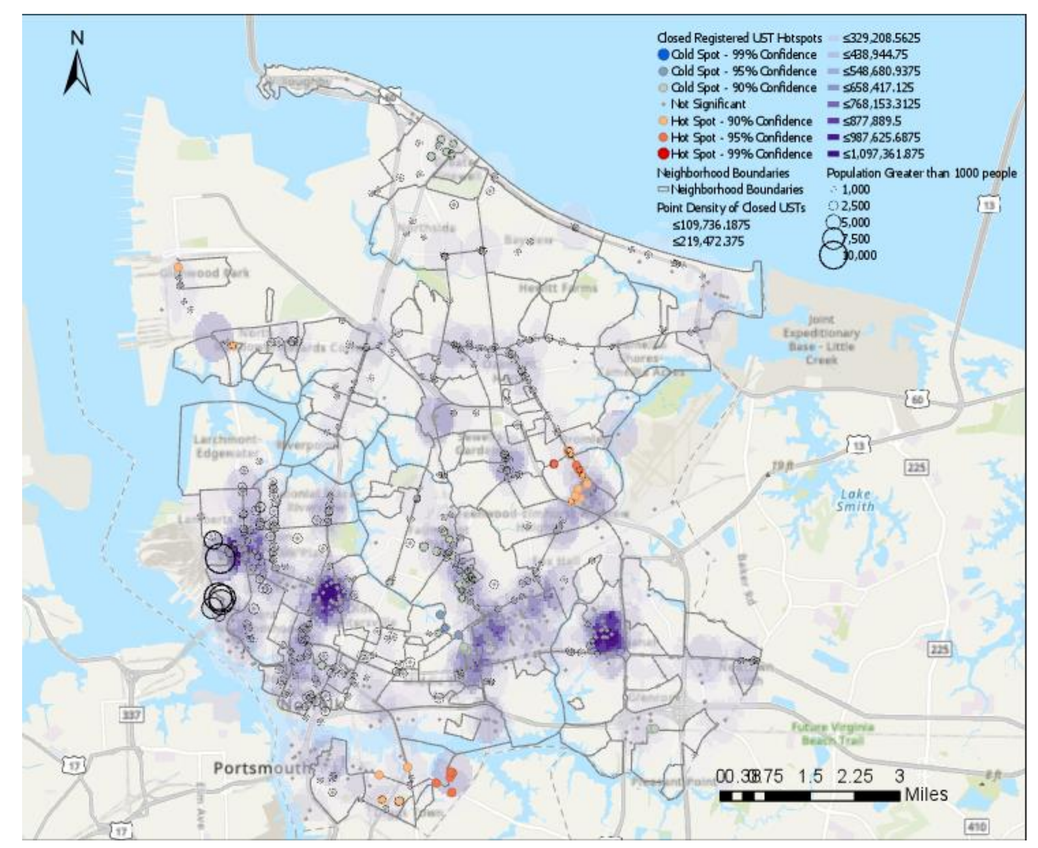

Figure 4: Closed USTs Hotspots and Point Density Analysis

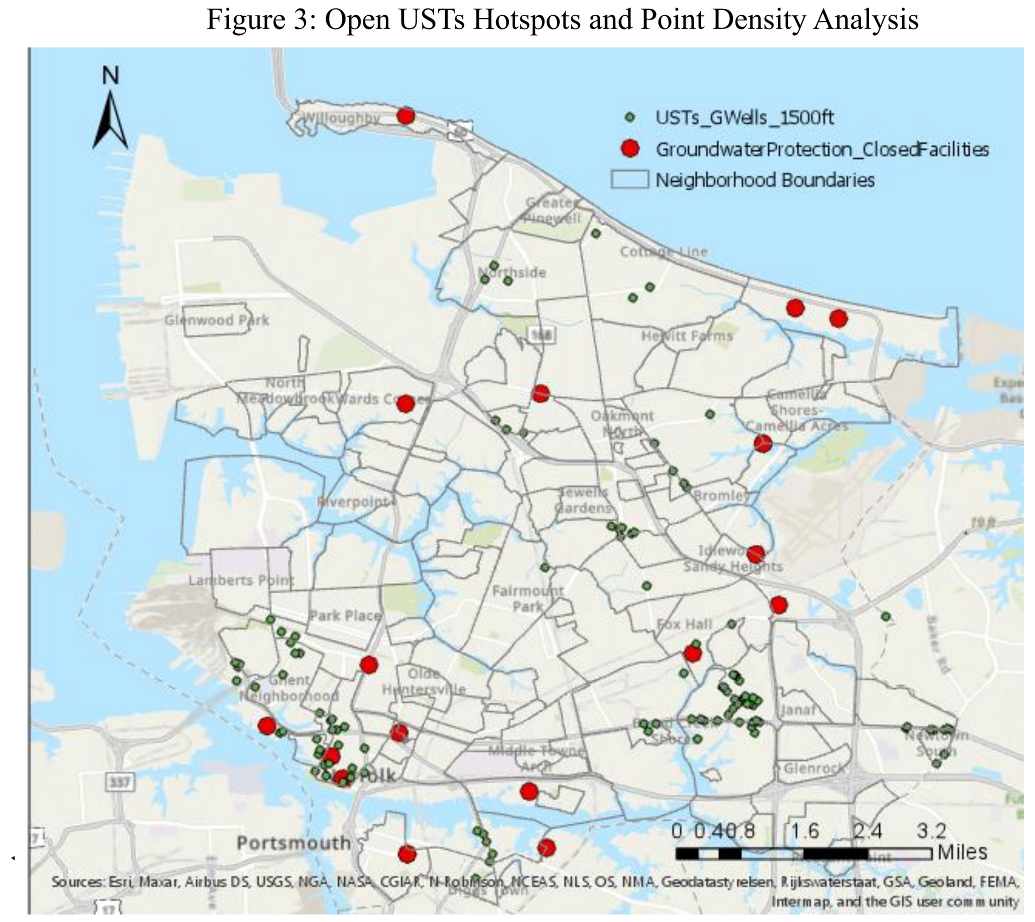

Figure 5: USTs within 1500ft of private wells and Groundwater Protection Areas

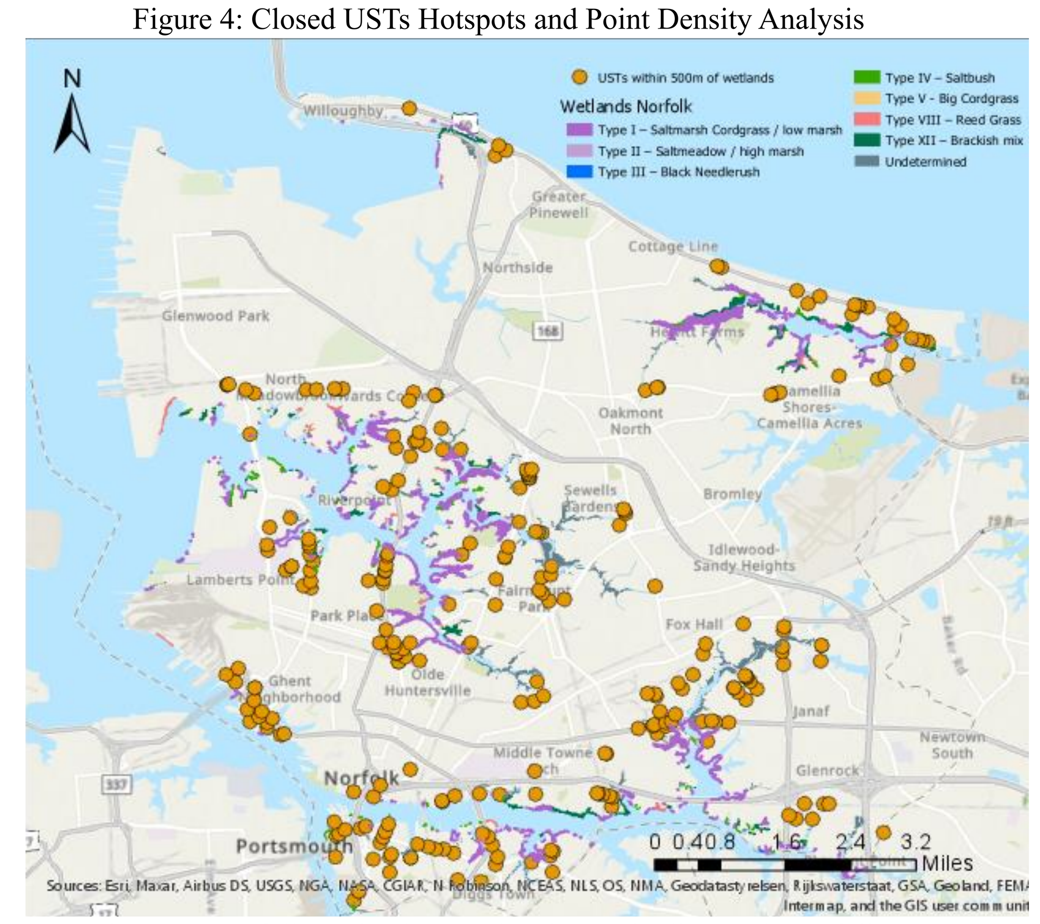

Figure 6: Norfolk wetland types, local waterbodies, and Norfolk USTs

METHODOLOGY

- Used small sample of the UST records maintained by the EPA.
- The XY Tools in ArcGIS Pro was used to create a shapefile for tank locations, neighborhood zones, storm surges areas, & water bodies. Data was gained from the City of Norfolk's Open Data GIS website.
- Criteria used for assessment (Open, Closed, Temporarily Out of Service):
  - I. Hotspots cluster (Getis-Ord Gi*)
  - II. Point Density
  - III. Land use/land cover impact assessment

The Getis-Ord local statistic is given as:

$$G_i^* = \frac{\sum_{j=1}^{n} w_{i,j} x_j - \bar{X} \sum_{j=1}^{n} w_{i,j}}{S \sqrt{\frac{\left[n \sum_{j=1}^{n} w_{i,j}^2 - \left(\sum_{j=1}^{n} w_{i,j} \right)^2 \right]}{n-1}}} \quad (1)$$

where x_j is the attribute value for feature j, $w_{i,j}$ is the spatial weight between feature i and j, n is equal to the total number of features and:

$$\bar{X} = \frac{\sum_{j=1}^{n} x_j}{n} \quad (2)$$

$$S = \sqrt{\frac{\sum_{j=1}^{n} x_j^2}{n} - (\bar{X})^2} \quad (3)$$

The G_i^* statistic is a z-score so no further calculations are required.

Figure 7: Hot Spot Analysis (Getis-Ord Gi*) formula

RESULTS/CONCLUSION

- The majority of the statistically significant (>90% confidence) hotspot clusters occur along coastal land development with Open and Closed facilities shown in the southeast portion of Figures 2, 3, & 4 close to Portsmouth (Figs. 2, 3,& 4).
- Density analysis also demonstrates the distribution is widespread over the city of Norfolk, with the pattern mimicking the hotspot analysis result (Figs. 2, 3,& 4). Most USTs in Norfolk are closed and are spatially clustered around the southern and western coastal parts of the city (Fig. 4).
- Based on population data analysis, 812,454 people live within 1,500 feet of these facilities out of which 79% are Closed facilities meaning 643,786 people living close to them.
- 22 facilities fall within the Groundwater Protection Area and 19(86%) of them are Closed (Fig. 5). Based on this analysis, we can infer that shallow aquifers are potentially susceptible to leaks from these facilities (Fig. 6).
- 365 Facilities within about 1500 feet of wetlands, of which 59% are Closed (214 facilities).
- Most USTs are proximal to saltmarshes-type wetlands that can harm these ecosystems which are the first line of defense during storm surges (Fig. 6).