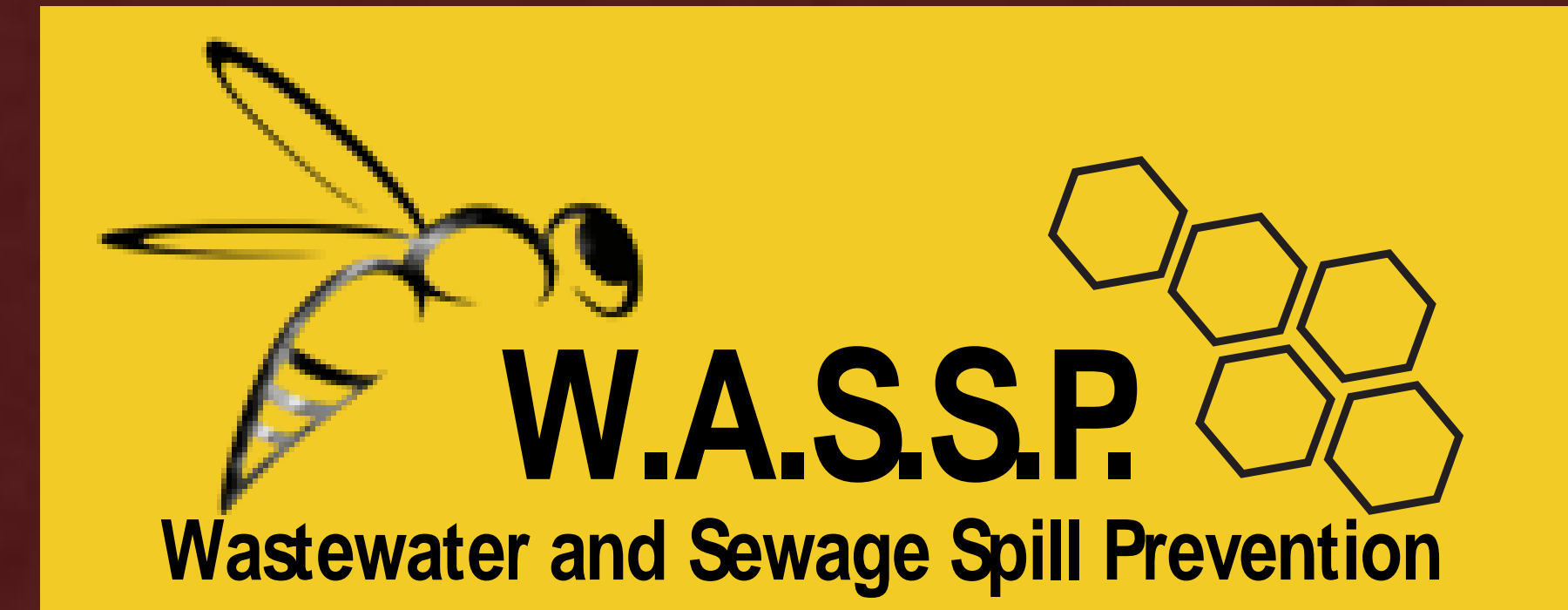


Vulnerability Analysis and Visualization of Sewage Spills

on Edwards Aquifer TCEQ Regions 11 and 13 from 2012 – 2017

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Background

Previously, a Texas State GIS Design and Implementation project had been conducted on the visualization of raw sewage spills in TCEQ Regions 11 and 13 for years 2006 through 2012. Our first goal was to update the existing interactive map with spill location and attributes they made, including years from 2012 through 2017. Our second goal was to conduct a vulnerability analysis, visualizing areas of the Edwards Aquifer that are sensitive to pollution from sewage spills. Our final goal was to make recommendations for future data collection and updating these maps.

Purpose

The Edwards Aquifer provides drinking water for approximately 2 million people and significantly contributes to the Texas economy by means of irrigation and agriculture. The aquifer is naturally relatively clean and requires little maintenance other than mild treatment, unless contaminated. Sewage spills that occur on the surface and from underground sewage lines could make their way into the stream and springs that feed into the aquifer. Contamination of the Edwards Aquifer would pose health risks the local community, affect endangered species, harm crops and livestock, and raise the cost of water maintenance that directly affects consumers.

Study Area

This project focused on raw sewage spills that have occurred in the Texas Commission on Environmental Quality (TCEQ) Regions 11 and 13 on the Edwards Aquifer. The counties included were Bexar, Travis, Hays, Comal, Medina, Uvalde (shown in the inset map in Figure 1)

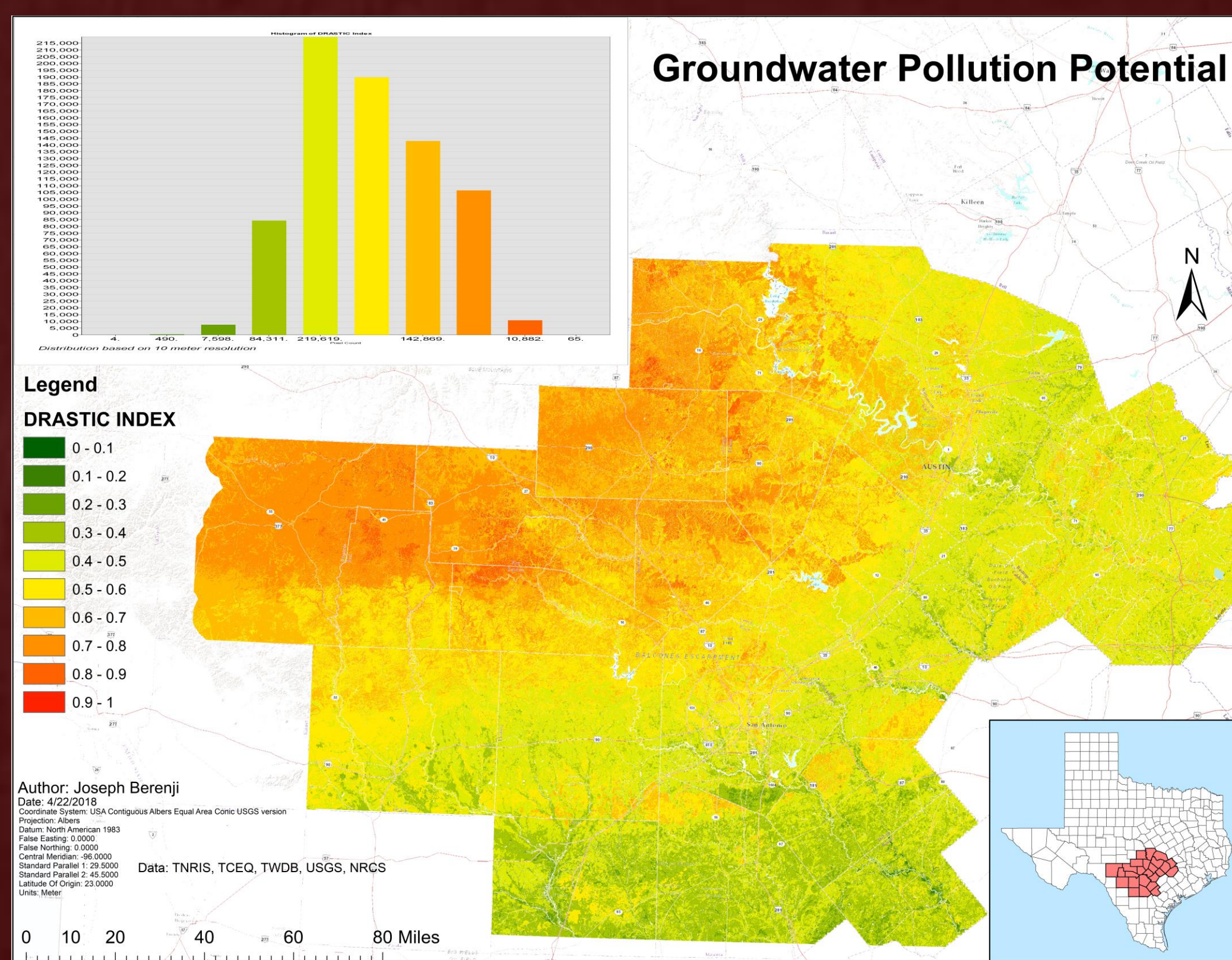


Figure 1: Results of Vulnerability Analysis using The DRASTIC Method

Methods

Spill Sites

The excel document received from TCEQ consisted of 3,094 spill incidents. There were major inconsistencies in data entry between employees. For example, addresses were entered in different fields, there was no formatting standard so some spills causes and remediation were very detailed and others were explained in one word. Due to these inconsistencies, the data underwent several stages of sorting, cleaning, and batch geocoding before it could be projected:

- Records were sorted by years and assigned to group members
- Created a new address column and separated out addresses or relative locations
- Doogal Batch Geocoder to acquire latitude and longitude
- Created and filled in cause, remediation, and description fields
- Displayed in ArcMap and ArcGIS Online's Interactive Story Map

Interactive Story Map

- Projected from the latitude and longitude coordinates through ArcMap's "display xy" function
- Exported displayed spill sites as a shapefile
- Uploaded shapefile into The ArcGIS Online Story Map Platform
- Displayed gallons spilled with graduated symbols
- ArcGIS Online generated a heat map of spill sites

Vulnerability to Pollution Analysis

The DRASTIC Method was developed by the EPA and models the vulnerability to pollution of groundwater resources based on hydrogeologic parameters, evaluating an area using open source data without the need for extensive field investigation. These parameters are in a raster file format, which are ranked and weighted, and inputted into raster calculator. Weights involve the impact of the hydrogeologic features with respect to one another, and ranks classified into ratings, comparing like features with one another. This is chiefly a tool for comparative assessment, calculating DRASTIC index locates areas that present a greater risk for groundwater contamination relative to all other locations in a study area. Data preparation for the DRASTIC analysis is detailed in Table 1.

DRASTIC = DwDr + RwRr + AwAr + SrSw + Irlw + CrCw
Where:

- D: Depth to Groundwater
- R: Net Recharge
- A: Aquifer Media
- S: Soil Media
- T: General Topography or Slope
- I: Vadose Zone
- C: Hydraulic Conductivity of the Aquifer
- w: assigned weights
- r: assigned ranks

Results

Web Map

The improved and updated story map allows communities dependent upon the Edwards Aquifer to have direct access to a detailed assessment of wastewater infrastructure. Additionally, we have created a heat map visualizing the concentration of spill sites (Figure X) Comparison of the up to date web map can also give valuable insight on any improvements or exacerbation from the previous project in 2012.

Vulnerability Analysis

The results of the DRASTIC Method (shown in Figure 1) show that 1.07% of the study area has a low pollution potential, 64.73% has a moderate pollution potential, 34.18% has a high pollution potential, and 0.02% has a very high pollution potential. The results of this study can be used in managing groundwater resources, and can be used as a screening tool prior to applying more in-depth analysis. For future spills events, the locations could be plotted on this vulnerability map to assess the severity in terms of potential pollution.

Data	Source	Preparation
Sewage Spill	TCEQ through an open records request	Received in an excel spreadsheet, geocoded and cleaned up attributes.
Depth to Groundwater	Water elevation data from Texas Water Development Board's Groundwater Database	Water well data and the Geostatistical Analyst Toolset were used to interpolate by means of Empirical Bayesian Kriging (EBK).
Net Recharge	Precipitation: National Oceanic and Atmospheric Administration, Land Use/Cover: National Land Cover Database, Soil: Natural Resources Conservation Service	$Q = (P - 0.2S) / (P + 0.8S)$ S= 1000/CN Q: Depth of runoff (in) P: Depth of rainfall (in) S: Maximum potential retention (in) CN: Curve number (dimensionless)
Aquifer Media	Texas Geologic Database	Ratings were applied to rock unit data based on the porosity and permeability.
Soil Media	Natural Resources Conservation Service	Percent sand, silt, and clay used to classify soil textures.
Topography	The National Map from The United States Geological Survey	Topography raster was generated by altering DEMs to visualize percent change in elevation for a given distance (10 m).
Impact of Vadose Zone	TCEQ	Classified similar to soil media by texture. Thickness of horizon was integrated in the development of vadose zone to account for distance to water table.
Hydraulic Conductivity	Natural Resources Conservation Service	Hydraulic conductivity in this study represents the ease at which water can reach the aquifer by using ksat rates (a soil's ability to transmit water).

Table 1: Results of Vulnerability Analysis using The DRASTIC Method

Recommendations

It was requested we make recommendations on improving data quality from a geographer's perspective.

- Complete map of sewage pipelines within every service area, with depths and sizes of pipes as attributes.
- Use GPS units on site to record exact locations of spills, and create waypoints to update the map easily.
- Utilize our list of standardized spill causes. This step would be beneficial in mapping or statistical analysis on the causes of spills.
- Utilization of our Standard Spill Event Category Ranking System. This will clear up any reporting inconsistencies amongst Environmental Investigators.

Conclusion and Discussion

This project was successful in mapping sewage spills from 2012-2017, and in making this data publicly available through an online interactive map. We would like to see this project evolving into a live, publicly available sewage spill webpage. The DRASTIC Method was successful in visualizing the potential for pollution across our study area.

Acknowledgements

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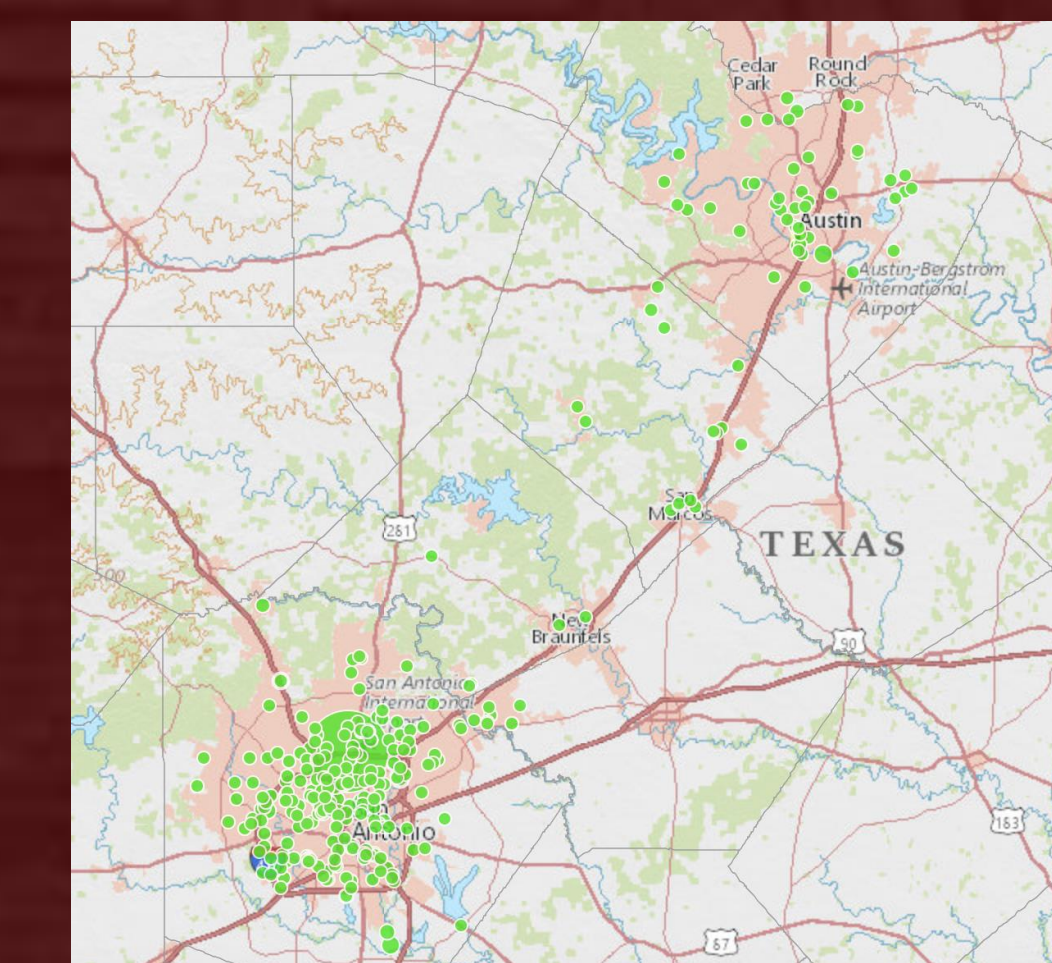


Figure 2: Screenshot of web map, 2015 Sewage Spills

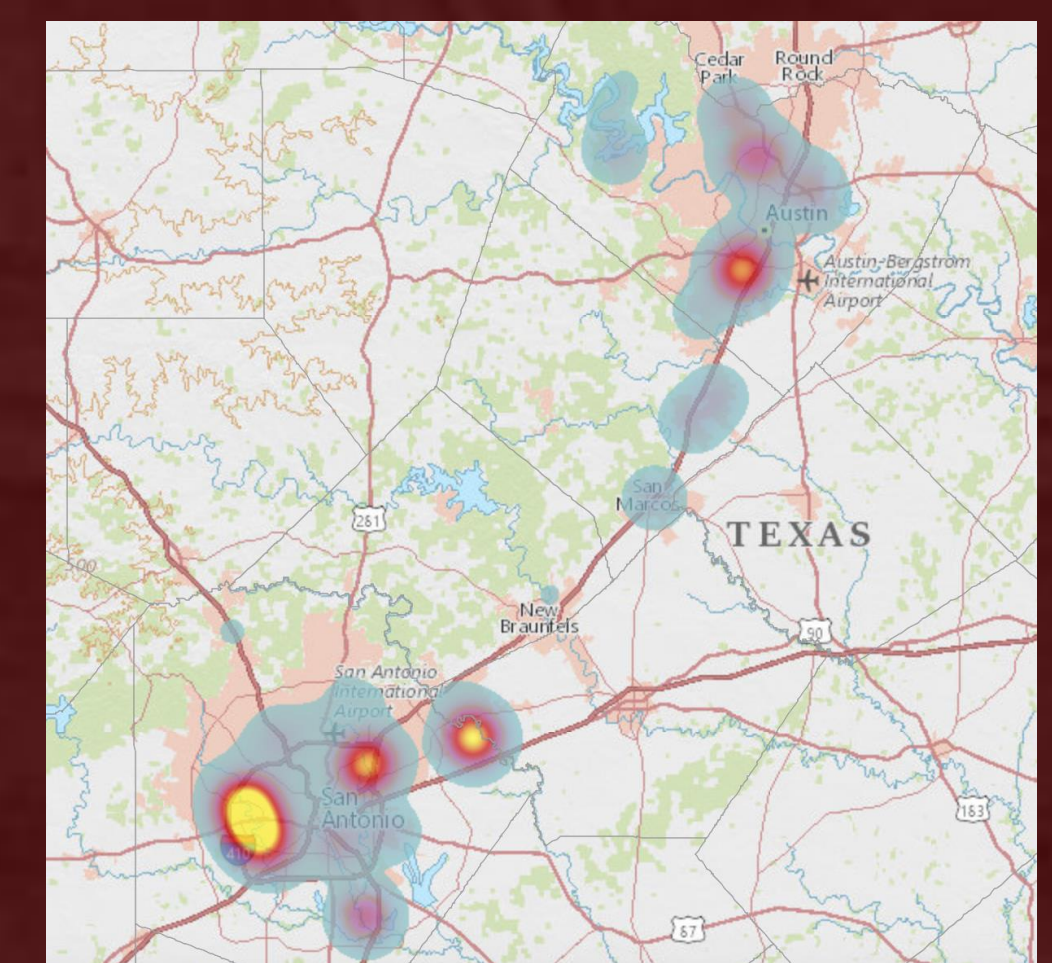


Figure 3: Screenshot of web map, 2017 Heat Map

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