GEOTEX ENVIRONMENTAL SOLUTIONS

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Analysis of Wasterwater Spills In the Edwards Aquifer Recharge Zone

A GeoTex Environmental Solutions Project

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1. INTRODUCTION

1.1 BACKGROUND

The Edwards Aquifer, located within 12 counties in Central Texas, is a natural karst aquifer that has provided life to South Central Texas for over 12,000 years and currently serves approximately 1.7 million Texans. The Aquifer is composed of four different zones: the contributing zone, the recharge zone, the transition zone, and the artesian zone. The focus of this project will be looking at the recharge zone which spans 1,250 miles and allows large quantities of water to flow into the aquifer due to the fractured and fragmented limestone geology.

1.2 PROBLEM STATEMENT

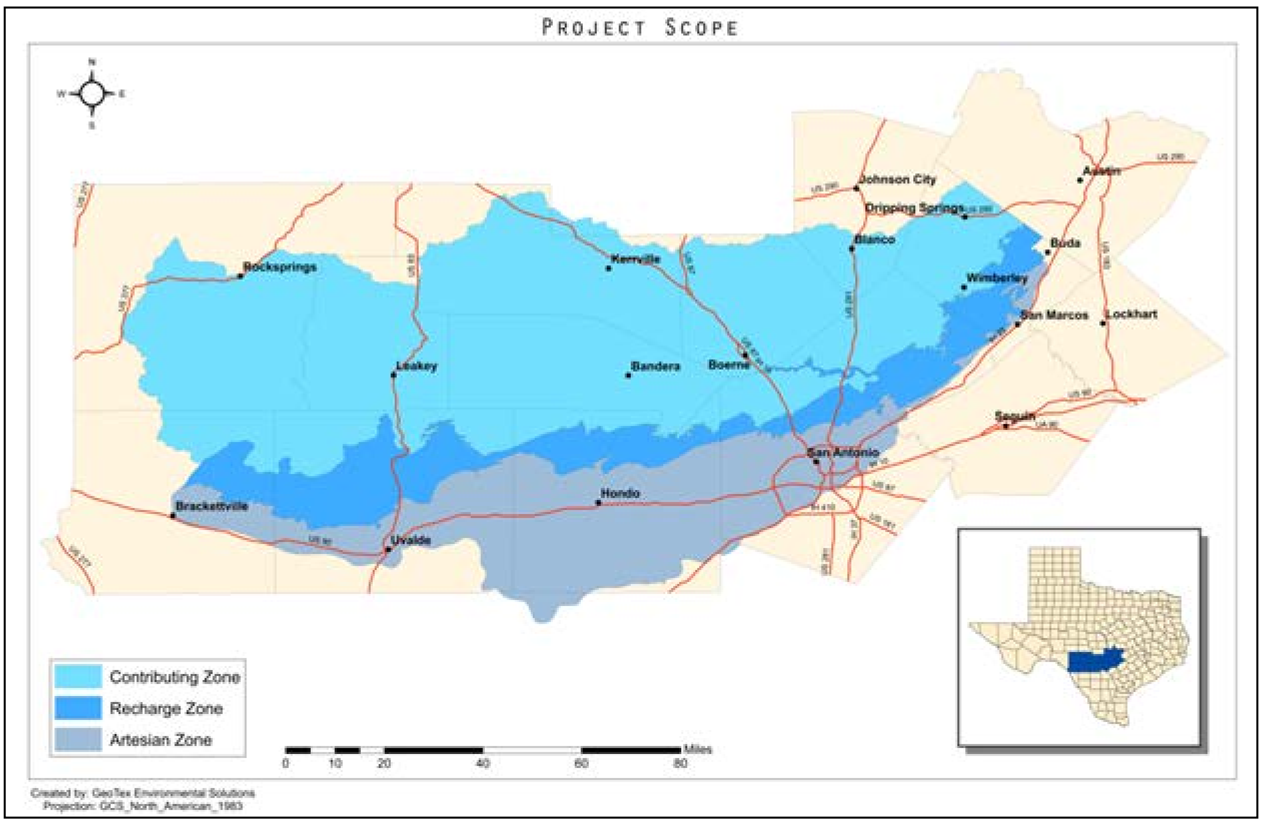
Although the Edwards Aquifer hasn't changed in the last several thousand years, the environment around the aquifer has been altered and developed to fit the needs of the people of South Central Texas, including adding man-made structures, such as wastewater pipelines. If the pipelines leak, the groundwater can become polluted which contaminates the community's drinking supply, but also is dangerous to the environmentally sensitive ecosystem that surrounds it.

The recharge zone is characterized by its unique limestone surface which is cracked and split, allowing surface runoff to easily enter the ground and recharge the aquifer. However, the geology of the recharge zone also makes it very vulnerable to pollution and contamination by wastewater.

1.3 SCOPE

The extent of the study area which focuses on the Edwards Aquifer, located in the Edwards Plateau region of Texas. More specifically, the project focuses on the recharge zone of the Edwards Aquifer because of its important role in groundwater recharge and its vulnerability to pollution. The recharge zone spans over 7 Central Texas counties (Travis, Hays, Comal, Bexar, Medina, Uvalde, and Kinney) and has an area of 1,250 square miles.

The project will focus on sewage spills that have happened within the past eight years (2004-present) over the recharge zone. A map of the scope is shown below as Map 1.



Map 1. Project Scope

1.4 LITERATURE REVIEW

A project was released by the California State Water Resource Control Board which plots sewage discharge from sewer systems as reported by local California agencies to the online California Integrated Water Quality System. The project shows the location of the spill as well as the amount spilled, source of the spill, and the name of the responsible or reporting agency. The map containing all the information was also made available for online viewing by its local community. A screenshot of the California State Water Resource Control Board's map is shown below as Image 1.

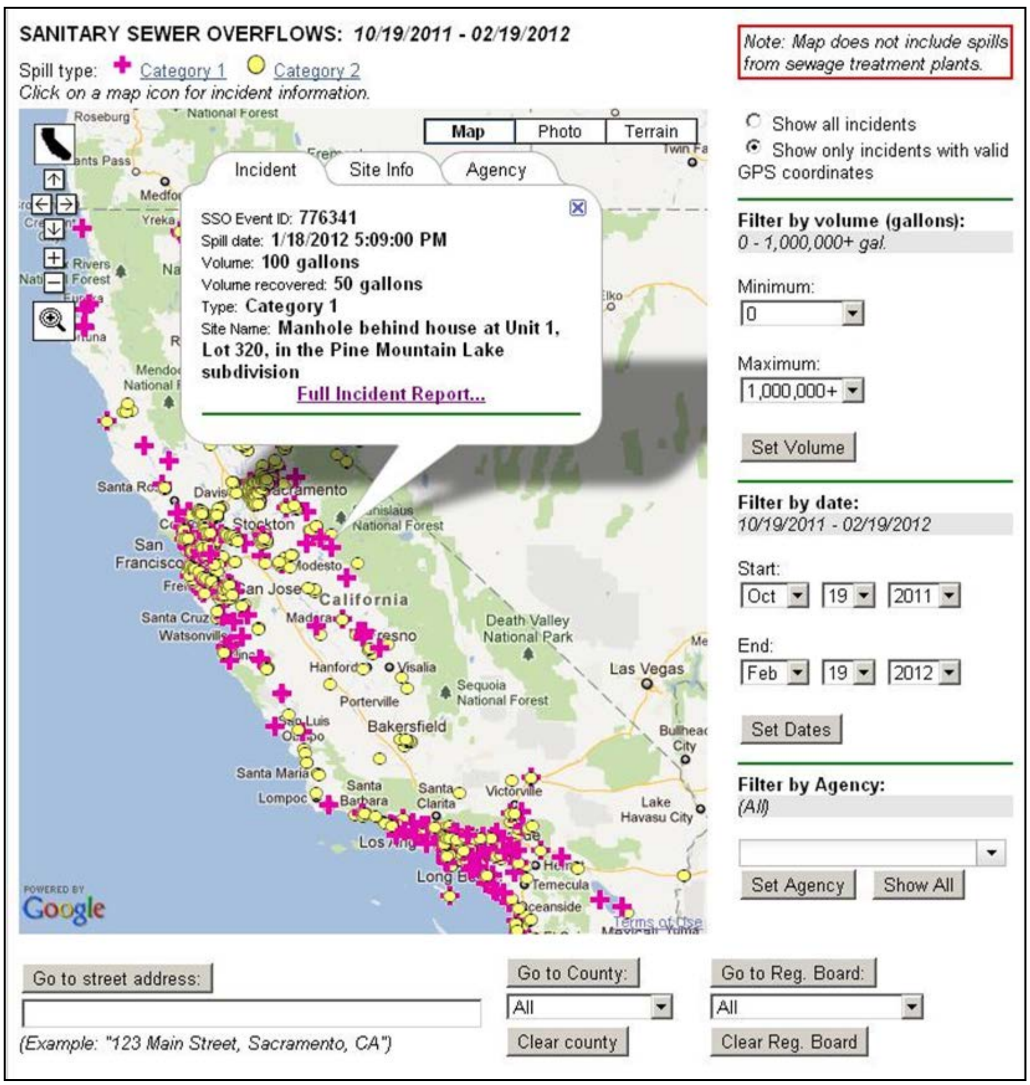


Figure 1. Screenshot of the California State Water Resource Control Board's Interactive Map

The state of California's project shows that mapping wastewater spills on a map creates a map that illustrates the abundance of wastewater spills in a given area. The map can be easily viewed by the public, which will educate them on the severity of wastewater spills in their community.

2. DATA

2.1 DATA COLLECTION

Data collection was a large component of this project for GEAA. GeoTex Environmental Solutions had received contact information for Wastewater Treatment Plants (WWTPs) and Multiple Utility Districts (MUDs) which had been collected by the group who had been previously working on a similar project for Greater Edwards Aquifer Alliance. Contacting these entities by phone and email did not yield a surplus of results. However, GeoTex then began researching and contacting other entities with a more extensive jurisdiction, which the team hoped would produce more extensive results.

The second group of entities that GeoTex contacted included San Antonio Water Systems (SAWS), San Antonio River Authority (SARA), Edwards Aquifer Authority (EAA), and the Texas Commission of Environmental Quality (TCEQ). A "Request for Data" was universally submitted to all and a "Nondisclosure Agreement" had to be signed, scanned, and sent to SARA and SAWS in order to receive their information.

The time it took for GeoTex to receive back data varied greatly between the entities. The process of receiving data took anywhere between a month and two and a half months. SARA scanned and emailed 7 wastewater spill reports. The EAA emailed a .pdf file of 46 wastewater spills, which included the EAA file number. the latitude and longitude of each spill, the type of discharge (raw sewage), the date of discharge, and the spill quantity. The entity who provided the data last and who provided the most data was TCEQ. They sent a Microsoft Excel file with 1,700 wastewater spills that were located in the TCEQ Region 13 area, which covers Medina, Bexar, Karnes, Wilson, Atascosa, Guadalupe, Comal, Kendall, Gillespie, Kerr, Bandera, Uvalde, Frio, Real, and Edwards counties. A map of the TCEQ regions is provided below as Image 2.

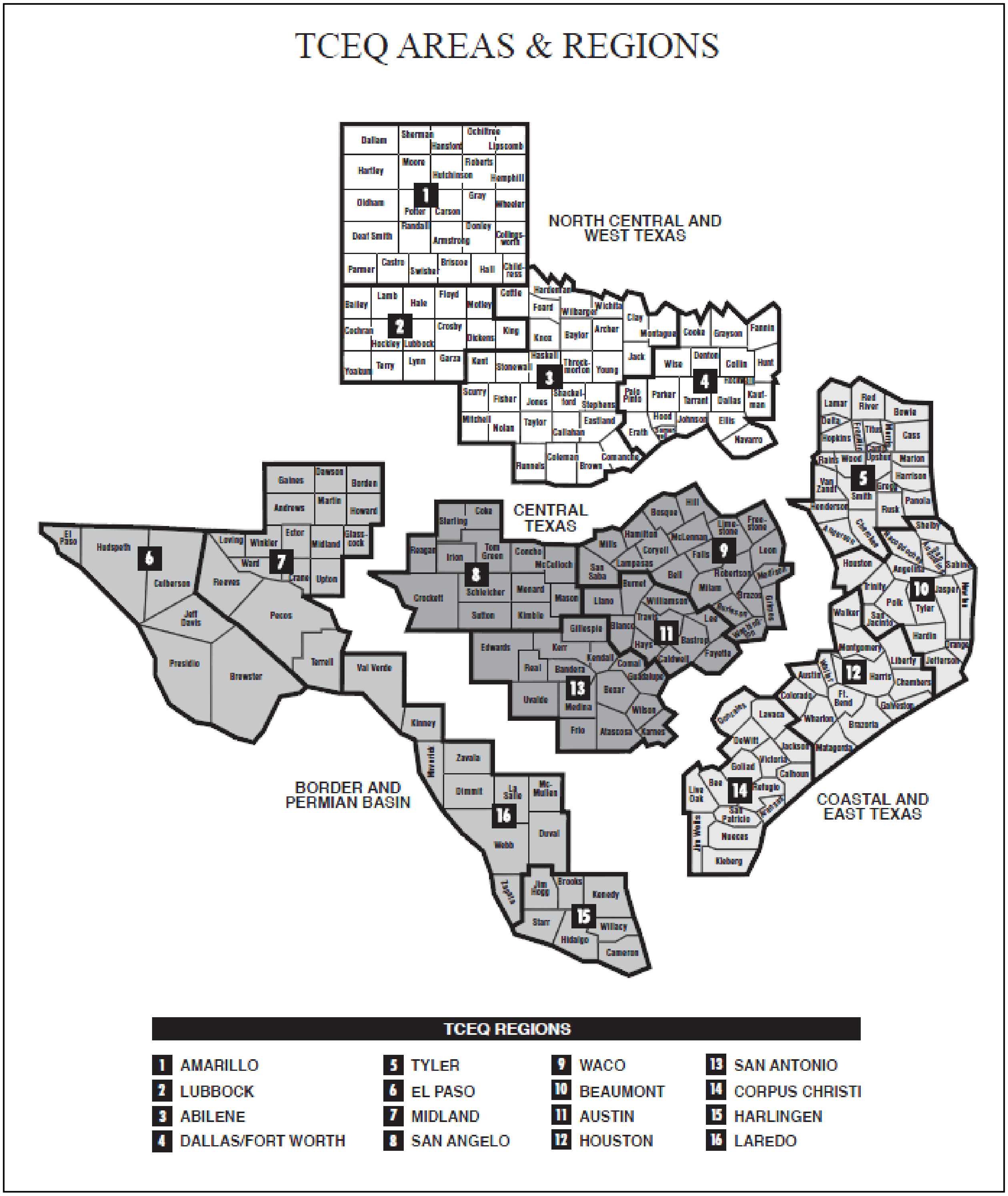


Figure 2. TCEQ Areas and Regions

GeoTex attempted to get wastewater spill data from TECQ region 11, (Hays, Blanco, Caldwell, Bastrop, Fayette, Bastrop, Travis, Llano, Burnet, Williamson, Lee counties) which contains some of the counties in the study area. Unfortunately, GeoTex was not able to obtain this data before the assigned "end date" for the project. Therefore, the results and maps the team has made only show wastewater spills that have occurred within TECQ Region 13. Despite this, GeoTex believes that enough wastewater spill data was received to call the project a success.

2.2 METHODOLOGY

The wastewater data records were received in three different formats: EAA sent a .pdf file, TCEQ sent a Microsoft Excel file, SAWS sent hand-written records which were scanned and then emailed. These different formats were then standardized into one universal format on Microsoft Excel to create a wastewater spills database.

The majority of the data came from TCEQ Region 13. The location of each spill was described by street address and county. To obtain latitude and longitude coordinates, the address locator was used within ArcGIS, which connects directly to ESRI servers to locate each address. This process is called geocoding.

The TCEQ field for each address often contained inaccurate or vague records. This required us to 'clean' the individual address records before geocoding. Significant time was spent preprocessing the data. An example of the raw data (data before it was cleaned) is shown below as Figure 3.

1	Description/Location
115	In the alley of Cedar Street and Brown Street, a sewer backup due to a collapsed line caused approximately 200 gallons to be discharged into residential area , 1901 Brown Street
116	1815 N Foster Rd sewer spilled on ground at the rear of the property
117	14331 O'Connor Rd discharged into a nearby drainage ditch.
118	
119	3838 Medical Dr in the rear entered the drainage channel
120	10102 Kings Grant in rear of address spilled into drainage
121	3400 Blk of Magic Dr in the rear entered a drainage easement
122	103 Rhinestone manhole overflowed into alley located between Twilight and Rhinestone into an open field.
123	6200 Wenzel Rd manhole overflowed and ran into drainage
124	5704 Glacier Sun in front overflowed and entered drainage
125	6623 Babcock Rd on the west side of the apartment complex by drainage ditch
126	5908 Elm Valley entered the dry Indian Creek
127	13131 Nacogdoches Rd. in front of address manhole overflowed into storm drain
128	100 Lyric manhole overflowed into storm drainage
129	8500 Blk of Floyd Curl at Huebner Creek valve stem broke causing recycled water to flow into Huebner Creek
130	145 Vista Del Ray
131	Manhole outside lift station in the center of the road at 9600 Autumn Ln

Figure 3. Example of raw data

Initial automatic geocoding was approximately 60-70% accurate. Matched records were checked to ensure the point placed on the map was within the study area. Unmatched records were individually searched, checked, or cross-referenced with Google Maps' address locators. After cleaning, checking, and rematching each address individually GeoTex was able to match at least 90% of all the records to a latitude-longitude position. The 10% which were not matched were left unmatched for different reasons. Some of the records had insufficient descriptions of locations, such as "Mrs. Gillson property", or the address reported by TCEQ did not exist in the ArcGIS address locator, or spelling mistakes made by TECQ which could not be solved and therefore not corrected by a GeoTex team member. When an address cannot be matched, it is still left in the attribute table, but there is no point on the map for the record.

The result of the geocoded records is a shapefile of wastewater spill points. Those points contain an attribute table that includes fields with location (latitude and longitude), date, and volume information about each spill. There are also a variety of other attributes associated with each spill, including:

- Address
- Lat/Long
- Entity responsible for spill
- Permit number (assigned by TCEQ)
- EAA file number
- County
- Start date of spill
- End date of spill
- Date TCEQ was verbally notified of spill
- Date TCEQ received a written report of spill
- Description of spill location
- Quantity of spill in gallons
- Duration of spill hours or days
- Cause of spill
- Any danger associated with the spill
- Actions taken to clean up or prevent further spills

To present this data, various reference layers were also retrieved. This includes:

- Edwards Aquifer layer (including contributing, recharge, and artesian zones)
- Streams layer
- Counties layers
- Roads layer
- Cities layer

The Edwards Aquifer layer was retrieved from the EAA. The streams layer was from the Texas Natural Resource Information System (TNRIS), and was clipped to the study area. The counties layer, also from TNRIS, provides a background that outlines the counties in the study region, the unclipped file was also used as an inset map to serve as a location reference. The roads layer was also retrieved from TNRIS, and clipped to the study area. Cities were also obtained from TNRIS.

3. INTERACTIVE MAP

3.1 OVERVIEW

A primary objective of this project was to make the findings available to the public in order to heighten awareness of the frequency, quantity, and location of wastewater spills in the Edwards Aquifer. To achieve this, GeoTex Environmental Solutions has created an interactive map, which will be placed on the Greater Edwards Aquifer Alliance's website for public access. The layers used in the interactive map include:

- Edwards Aquifer layer (including contributing, recharge, and artesian zones)
- Streams
- Counties
- Wastewater Spill Points
- Roads
- Cities

3.2 CHALLENGES

GeoTex initially developed two interactive map prototypes which display the results, one through GoogleMaps, and another through Manifold, a GIS software package with interactive mapping capabilities. There were advantages and disadvantages to each system.

As more complex datasets were added to the GoogleMaps interface, its limitations became apparent. Each individual layer can only have a certain amount of complexity, which limited how well the streams and aquifer layers appeared on the map. As additional spill records were added to the interface, only 100-200 records would display; anymore and the file would not load. Due to a limited storage capacity, the GoogleMaps system was not able to provide the amount of storage space needed to show the entire project.

3.3 MANIFOLD

As a result, the interactive map has been delivered in Manifold. Manifold allowed for the storage capacity needed to display all of the data. The Manifold map will show all of the spills recorded over the counties within the study area. The map will also display the three zones of the aquifer, the streams that intersect it, as well as a major roads and cities layer for location reference. The layers can be manipulated to fit the wants of the user because the layers can be turned “on” or “off” with the click of a button. This interactive map includes clickable points, which when clicked will show the volume of spill, date of spill, address of spill, as well as all the other attributes associated with the records (listed above under data processing). A screenshot of the interactive Manifold map is shown as Figure 4.

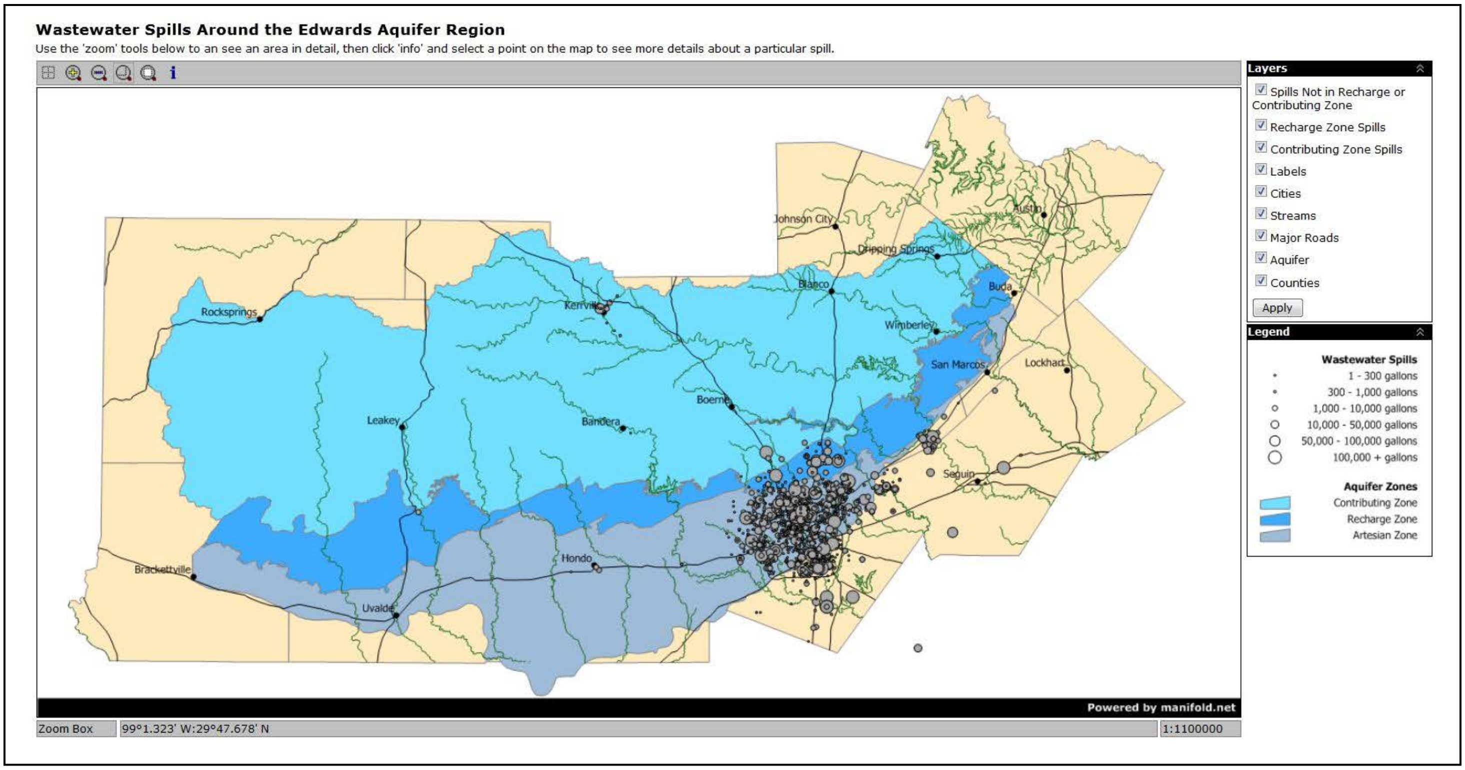


Figure 4. Interactive Manifold map

The Manifold map will be hosted directly on the University web servers. Within two weeks of this final presentation, Texas State Geography IT department will launch all of the final deliverables, including the final website and interactive Manifold map, to a website that will be available to the general public. At this point, the Manifold map will have a direct link, which GEAA can link to directly from their website.

ArcMap was used to input, create, modify, geocode, organize and manage the data. Once the layers were completed using ArcMap they were exported into Manifold to create the interactive map.

4. RESULTS

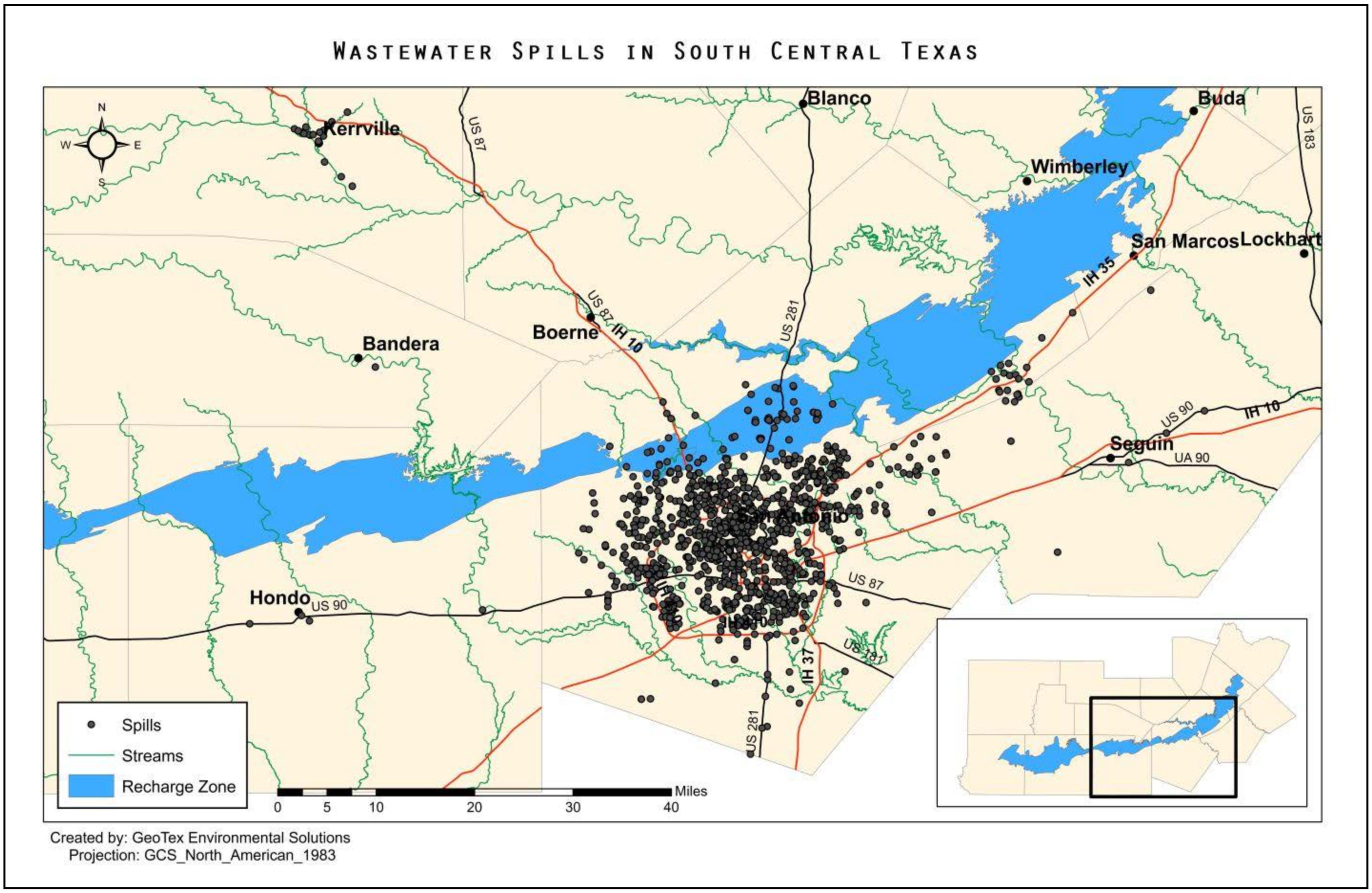
4.1 COMPREHENSIVE FINDINGS

Overall, GeoTex received 1,688 wastewater spill records. Volumes ranged from 1 to 4,216,000 gallons per spill, and totaled 25.69 million gallons. Total counts, total volumes, maximum spill, average spill, median spill, were calculated for each zone of the Edwards Aquifer. Relative percentages of the total count and total volume were also calculated for each zone. A table of this information is included below as Figure 5. As said previously, 10% of spills were not able to be mapped; however these spills are still included in the statistical information provided. Below as Map 2, is a map of all wastewater spills received by GeoTex.

WASTEWATER SPILL STATISTICS

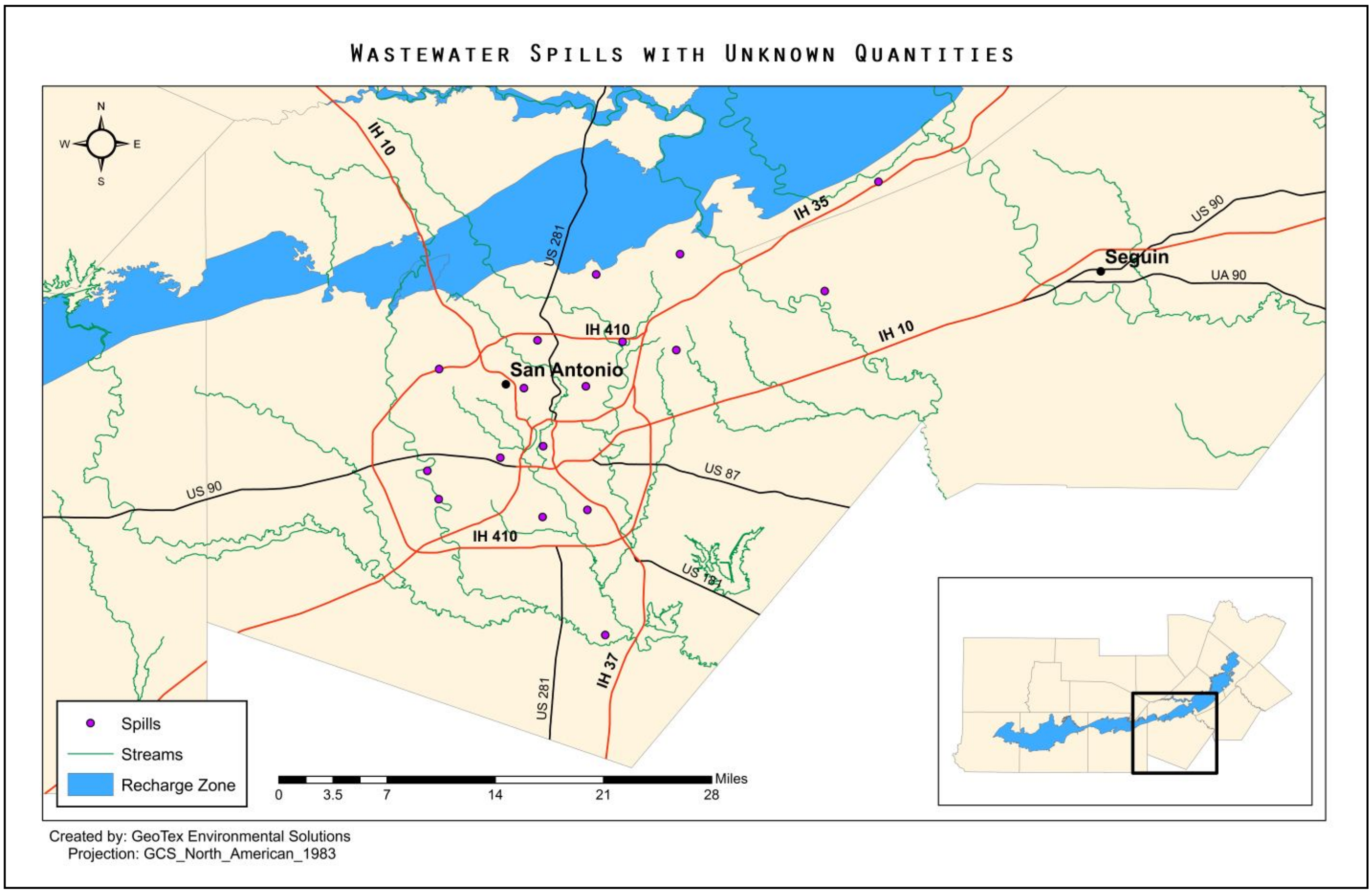
	Total Spills	Spills in Recharge Zone	Spills in Contributing Zone	Spills in Artesian Zone	Other
Total Spills (count)	1,688	81	25	1,219	363
Total Volume of Spills (gal)	25,690,000	809,000	480,000	11,000,000	13,401,000
Largest Spill (gal)	4,216,000	150,000	400,000	3,600,000	4,216,000
Average Spill (gal)	15,220	10,000	19,200	9,000	36,900
Median Spill (gal)	200	825	450	200	300
Percentage of Spills	100.00%	4.80%	1.48%	72.22%	21.50%
Percentage of Total Volume	100.00%	3.15%	1.87%	42.82%	52.16%

Figure 5. Wastewater spill statistics



Map 2. Wastewater Spills in South Central Texas

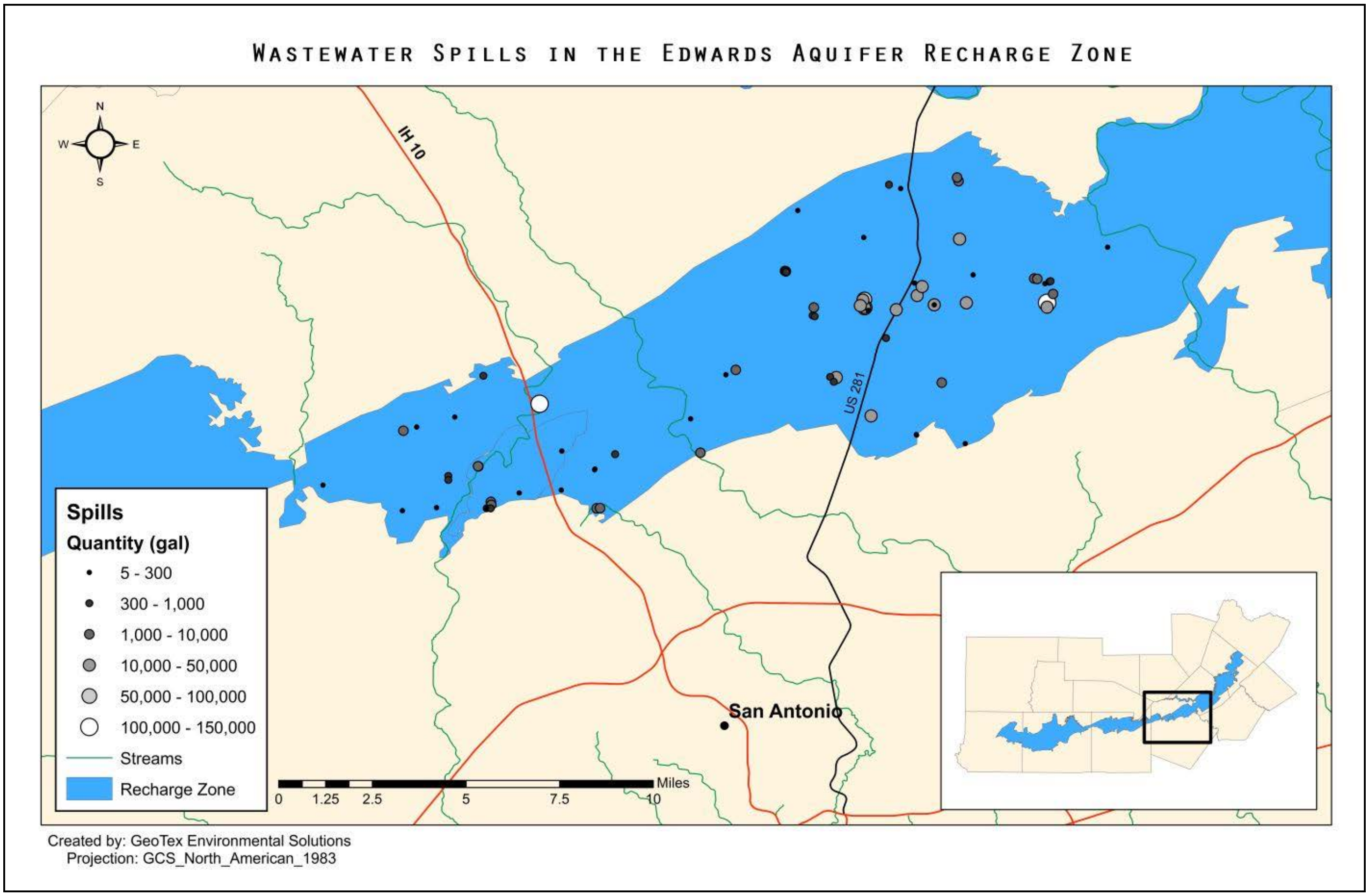
There were also seventeen spills which were labeled by TCEQ as having a spill quantity of “0 gallons”, however, the spills included locations and descriptions. The GeoTex team decided that because a spill was recorded, and included a location and description, the spill must have occurred; otherwise it would not have been reported to TCEQ. The GeoTex team created a separate map to include these points to distinguish the existence of the spills that occurred, but where the quantity was unknown. This map can be seen below as Map 3.



Map 3. Wastewater Spills with Unknown Quantities

4.2 FINDINGS - RECHARGE ZONE

After locating all spill points, GeoTex Environmental Solutions produced a variety of maps that show the amount and location of wastewater spills. The main area of interest is to map spills in the recharge zone, because they can impact the groundwater of the Edwards Aquifer more than in other zones. This map can be seen below as Map 4.

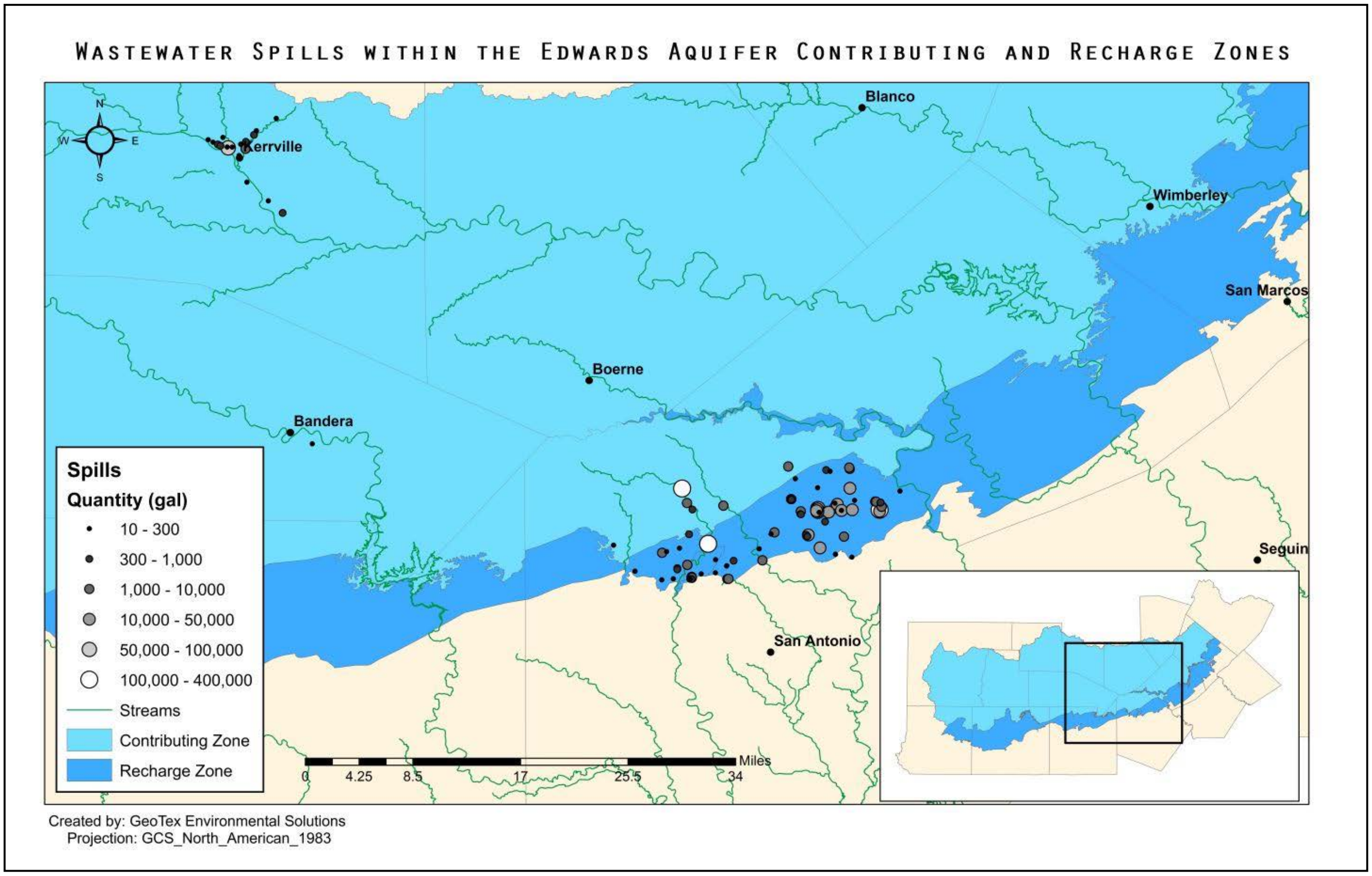


Map 4. Wastewater spills in the recharge zone

Within the recharge zone there were 83 spills ranging from 5 to 150,000 gallons per spill from 2004 to 2012. 81 of these spills occurred between 2008 and 2012. Approximately 5% of the spills recorded were within the boundary of the recharge zone, comprising 3% of the total volume of spills recorded across South Central Texas. Spills within the recharge zone totalled 809,000 gallons. The recharge zone contains the highest median spill volume, at 825 gallons. A summary of statistics is shown as Figure 5.

4.3 FINDINGS – CONTRIBUTING ZONE

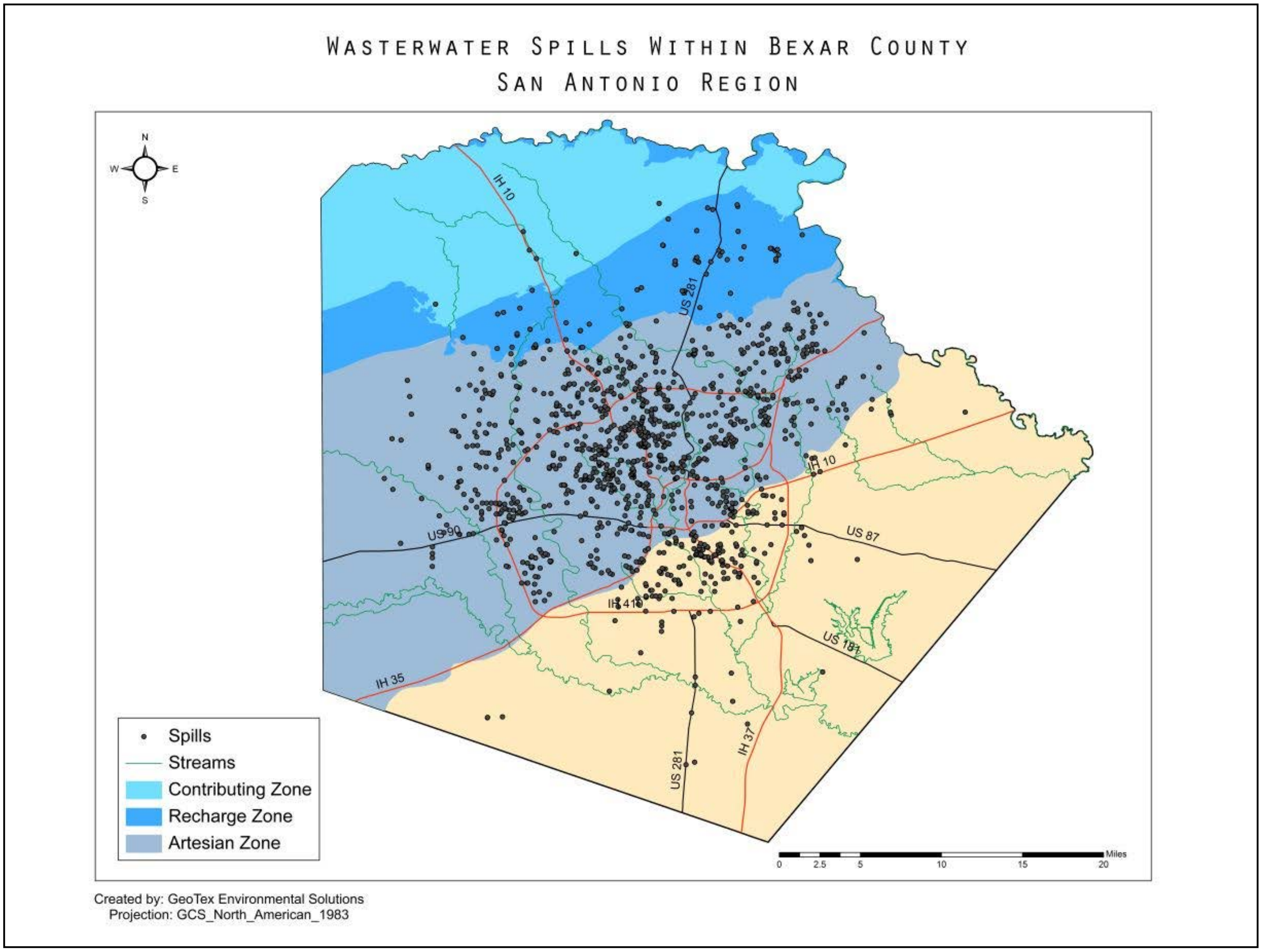
Maps that show both the recharge and contributing zones have also been created because the contributing zone has a secondary importance in groundwater quality. Contaminants in the contributing zone could eventually travel into the recharge zone. For example, spills have occurred adjacent to streams in the contributing zone, once the contaminants flow downstream into the recharge zone, the contaminants could be absorbed and enter the groundwater. Below is a map of spills that occurred in the recharge or contributing zone (Map 5.).



Map 5. Wastewater spills in the contributing and recharge zones

The area generally north-west of the recharge zone contributes runoff to the recharge zone of the aquifer. Within this contributing zone, 25 wastewater spills were recorded from 2009-2012. Volumes ranged from 10 to 400,000 gallons and totalled approximately 480,000 gallons. Many of these spills occurred in the city of Kerrville, as well as San Antonio. These statistics are also included in Figure 5.

The majority of our data was provided to us by Region 13 of the TCEQ. San Antonio, located in Bexar County, is the largest metropolitan area in this region and is where the majority of spills occurred. A total of 22.1 million gallons, comprising 86% of the total volume, were spilled within Bexar County. These spills account for 90% of the total number of spills mapped. Show below is a map of spills within Bexar County. A map of wastewater spills in Bexar County, Texas is shown below as Map 6.



Map 6. Wastewater spills in Bexar County, Texas

4.4 DISCUSSION

GeoTex Environmental Solutions would like to explore this project further for GEAA but due to time constraints of the class and a lack of cooperation by TCEQ Region 11, we were not able to acquire information needed to continue analysis. Region 13 of TCEQ which was the main focus of this project, does not span the entirety of the Edwards Aquifer. However the addition of Region 11 of TCEQ which covers Bastrop, Blanco, Burnet, Caldwell, Fayette, Hays, Lee, Llano, Travis, and Williamson counties would allow analysis of the entire recharge zone, completing the goal which was originally set out for the GeoTex team this semester.

Another avenue of analysis that GeoTex wished to explore was the relationship of wastewater spills to recharge features (such as caves) and streams. By analyzing the quantity and volume of wastewater spills in relation to the streams and recharge features over the Edwards Aquifer, a vulnerability analysis could be conducted to assess their sensitivity.

5. CONCLUSIONS

The data collected showed that there is no lack of wastewater spills in South Central Texas. This project has highlighted the fact that wastewater spills in Texas are not a small problem, but a large issue that deserves to be addressed. This project provides quantitative data that may cause reactions and initiative in the community to increase consciousness of the building of infrastructure over such a delicate ecosystem. The interactive web-based map produced for the GEAA website will easily display the collected wastewater spill information to the public.

After spending the semester collecting and analyzing this data, it is the hope of the GeoTex team that the Greater Edwards Aquifer Alliance will be able to use this information in their continued efforts to protect the Edwards Aquifer and the 1.7 million Texans that rely on the aquifer for their drinking water.

6. REFERENCES

California Environmental Protection Agency - State Water Resources Control Board. 2012. *Sanitary Sewer Overflow Incident Map*. http://www.waterboards.ca.gov/water_issues/programs/sso/sso_map/sso_pub.shtml (Last accessed 25 April 2012)

Texas Commission on Environmental Quality. 2012. *Area and Regional Offices Map.* Texas Commission on Environmental Quality: Austin, TX.