Quantifying the Extent and Growth of Austin, Texas on the Edwards Aquifer Recharge Zone: From the Years 1990 to 2010

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Problem

Urbanization poses a threat to our groundwater supply. Urban development inhibits groundwater recharge by increasing the amount of impervious cover. Impervious cover is essentially nonporous and does not allow for precipitation to penetrate the surface. Urbanization also increases the amount of surface runoff pollution and soil contamination which have a negative effect on groundwater quality. Therefore, it is essential that urban areas not be built over zones of recharge. This, however, is not always the case. In this project, we will examine the growth of Austin, a major urban city in Texas, over a two decade period.

Goal

This project aims to quantify the extent and growth of the city of Austin on the Edwards Aquifer recharge zone in Travis, Williamson, and Hays counties from the years 1990 to 1910 using online public data and ArcGIS software.

Furthermore, an attempt will be made to project the city's growth into the future to assess the amount of recharge coverage for future years and to estimate the year of 100 percent coverage in Travis, Williamson, and Hays counties.

A final map is presented representing a timeline of the extent of Austin, Texas on the Edwards Aquifer recharge zone.

Data Collection

Data used in this project came from the following sources:

- City of Austin GIS datasets: ftp://ftp.ci.austin.tx.us/GIS-Data/Regional/coa_gis.html
    - Recharge zone in Travis, Williamson, and Hays Counties: recharge.shp
    - Austin jurisdiction: jurisdiction_history.shp
- Capital Area Council of Governments dataset: http://www.capcog.org/data-maps-and-reports/geospatial-data/#city-limits
    - Texas aquifers: aquifers_mjr.shp
- Lab 1: Building Network Basics and Introduction to ArcGIS: Texas data folder
    - Texas county boundary: texas_counties_shape.shp
- ArcGIS Basemap Images: Bing maps hybrid basemap

Data Preprocessing

The chosen coordinate system for this project was NAD_1983_StatePlane_Texas_Central_FIPS_4203_Feet. Data collected from the CoA GIS dataset was downloaded with the following pre-projected coordinate system: NAD_1983_StatePlane_Texas_Central_FIPS_4203_Feet, and thus, did not require preprocessing. The aquifer shapefile downloaded from the CACoG dataset contained the following coordinate system: GCS_North_American_1983 , and was projected in ArcCatalog to NAD_1983_StatePlane_Texas_Central_FIPS_4203_Feet (See Figure 1). The Texas county boundary shapefile and Bing basemap were also pre-defined, but did not need to be projected. Instead, these files were projected on the fly when added into ArcMap document.
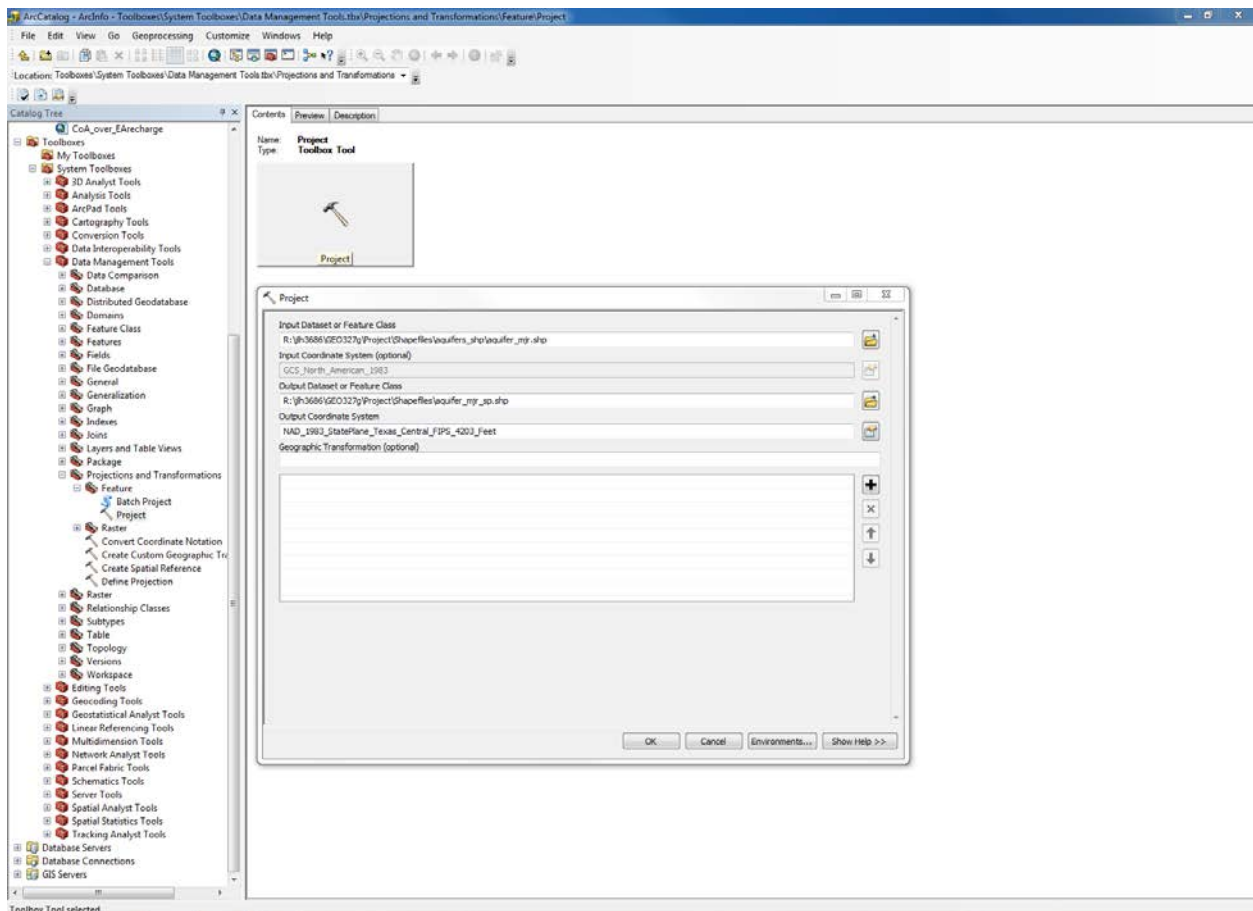

Figure 1

ArcGIS Processing

The following steps outline the general procedure taken in ArcGIS to complete the map portion of the project:

1. Create new Austin jurisdiction shapefiles for the years, 1990, 1995, 2000, 2005, and 2010: select by attribute table field
2. Create new shapefile for the Edwards Aquifer: select by attribute

3. Create new Austin jurisdiction shapefiles that cover the Edwards aquifer recharge zone for the years, 1990, 1995, 2000, 2005, and 2010: clip (analysis) tool
4. Calculate the area of the Edwards Aquifer recharge zone in meters^2: statistics tool
5. Calculate the area of the Austin jurisdiction shapefiles that cover the recharge zone for the years, 1990, 1995, 2000, 2005, and 2010: statistics tool
6. Final touches to map

1. Creating Austin jurisdiction shapefiles

a) Open a blank ArcMap document
b) Connect to project folder
c) Add data: jurisdiction_history.shp. Note: coordinate system for the data frame has been set to match first file added, NAD_1983_StatePlane_Texas_Central_FIPS_4203_Feet
d) Open attribute table of jurisdiction_history
e) Select by field "EFFECTIVE_DATE" to select all records through the year 1990
f) Create a new shapefile from the selected data: Data-> export selected data ; name new file "Juris_1990" (See Figure 2)
g) Repeat these steps d-f for the years 1995, 2000, 2005, and 2010 ; the new shapefiles are "Juris_1995" "Juris_2000" Juris_2005" "Juris_2010"
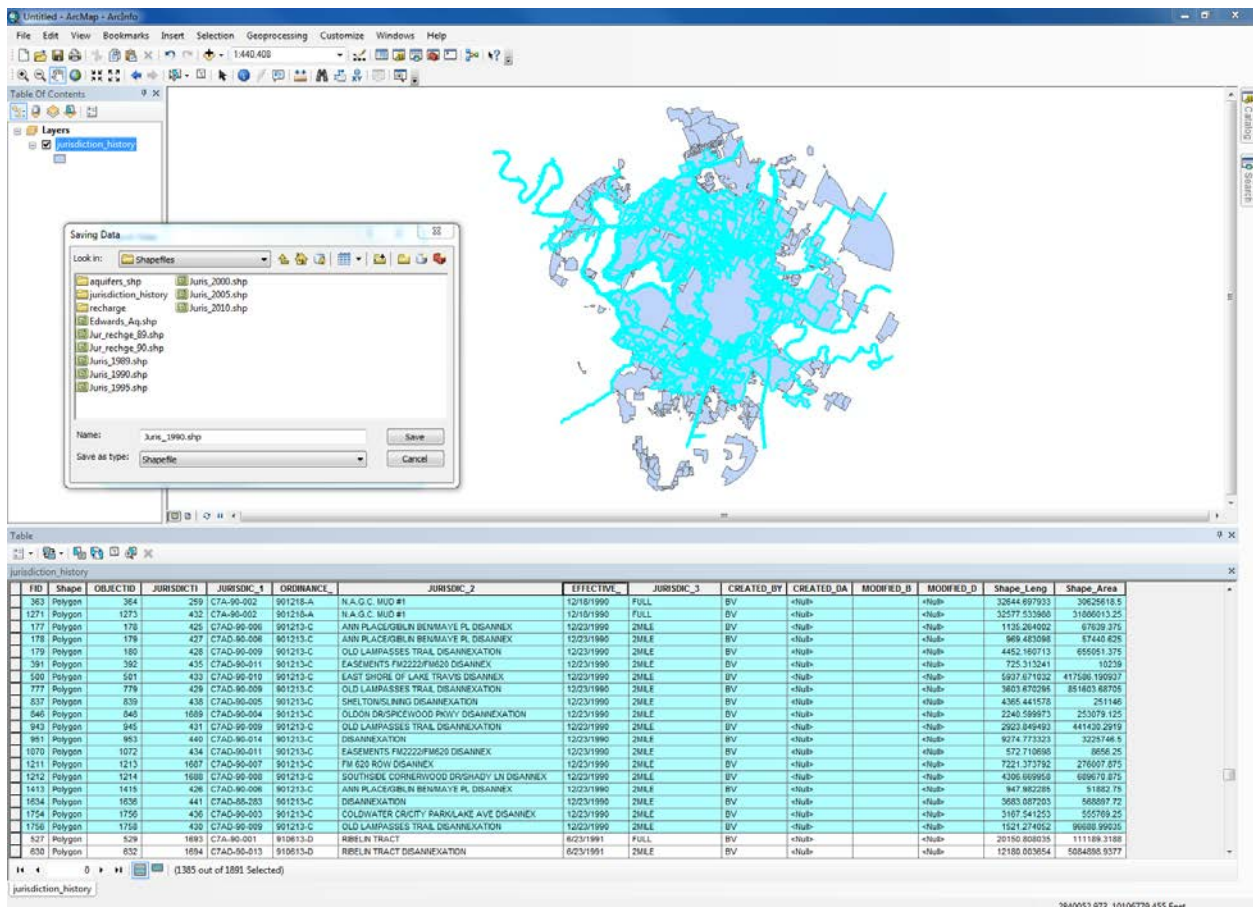

Figure 2

2. Creating Edwards Aquifer shapefile
   a) Add data: recharge.shp and aquifers.mjr
   b) Selection-> Select by attribute: the layer is "aquifers" ; the method is "create a new selection" ; enter the SQL query "AQ_NAME=EDWARDS"
   c) Create a new shapefile from selected data: Data-> export selected data ; name new file "Edwards_Aq" (see Figure 3)
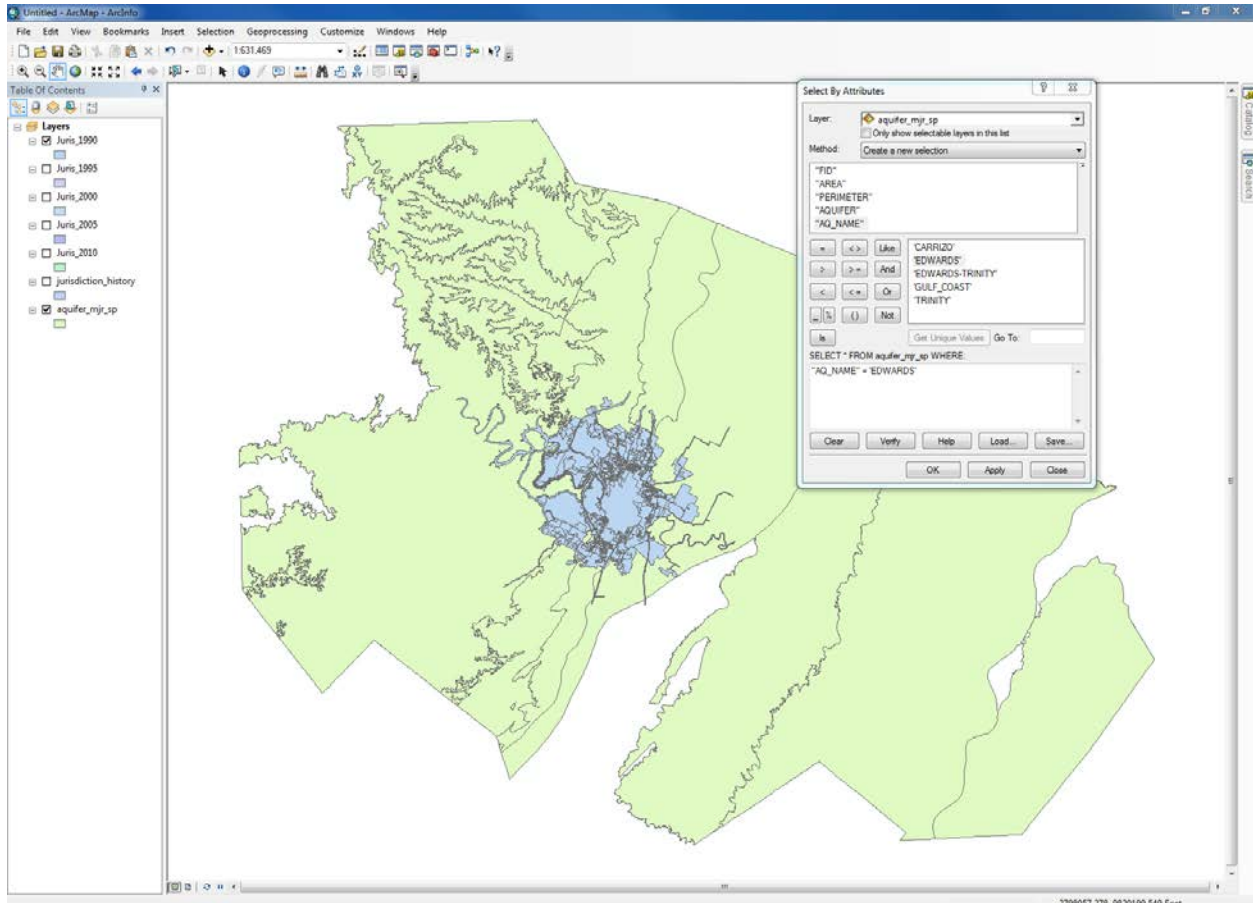

Figure 3

3. Creating Clipped Austin Jurisdiction Files
   a) Open the arc toolbox: Analysis tools-> Extract-> Clip (analysis)
   b) For input enter "Juris_1990" ; for clip feature enter "recharge" ; For the output, navigate to the project folder and save the new file as "Jur_rechge_90" (see Figure 4)
   c) Repeat steps a-b for "Juris_1995" "Juris_2000" Juris_2005" and "Juris_2010"
   d) Name new files: "Jur_rechge_95" "Jur_rechge_00" "Jur_rechge_05" "Jur_rechge_10"
   e) *Problem: I had to create a new folder "GIS_proj_clips" on the computer Desktop to contain Jur_rechge_90 through 2010 because an error was occurring when trying to save output in the project folder. The problem occurred because there was not enough space on the R Drive. Solution was to delete items off R Drive. I then created a new folder "clips" under the project folder where I saved all of the Jur_rechge_XX files.
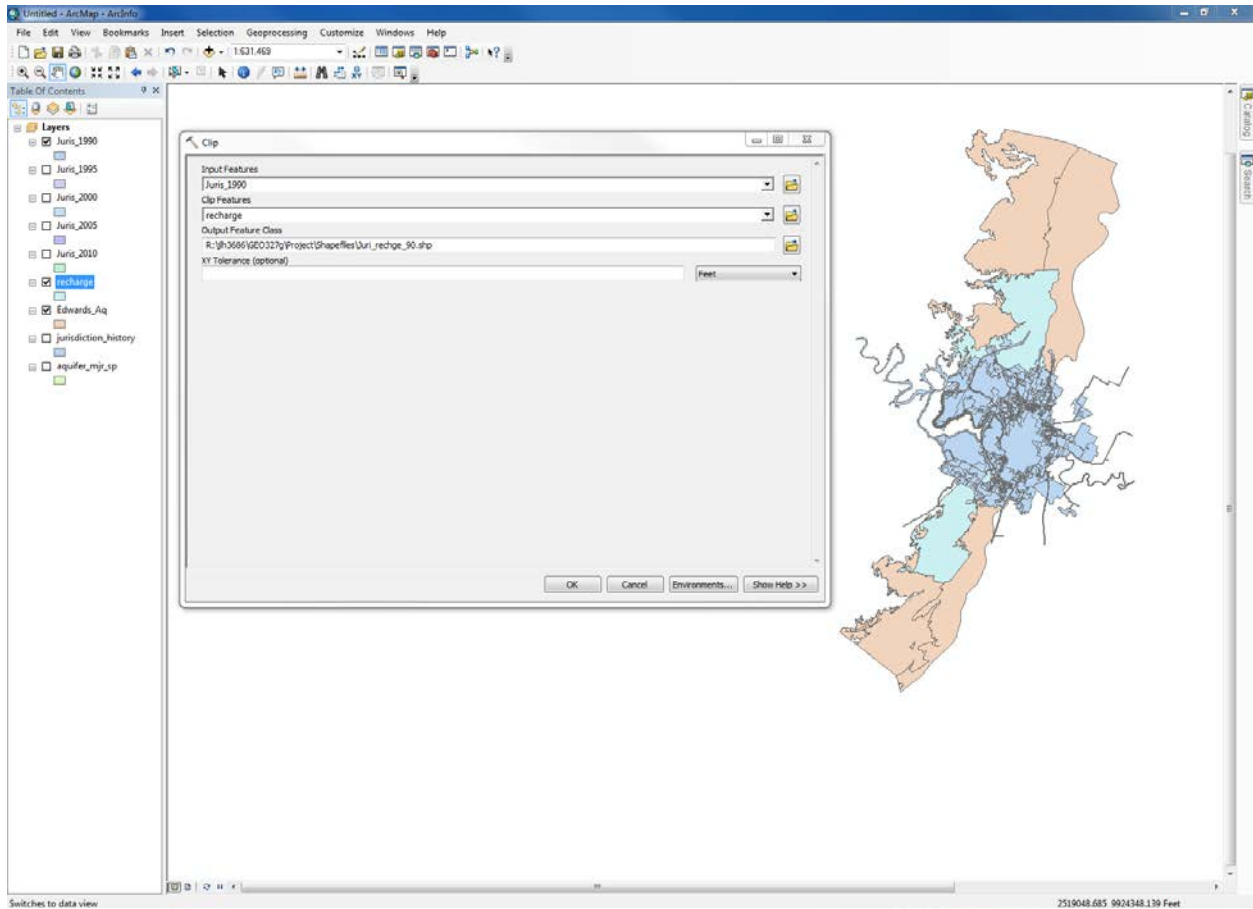
Figure 4

4. Calculating the Edwards Aquifer Recharge Zone Area
    a)   Open the attribute table for "recharge"
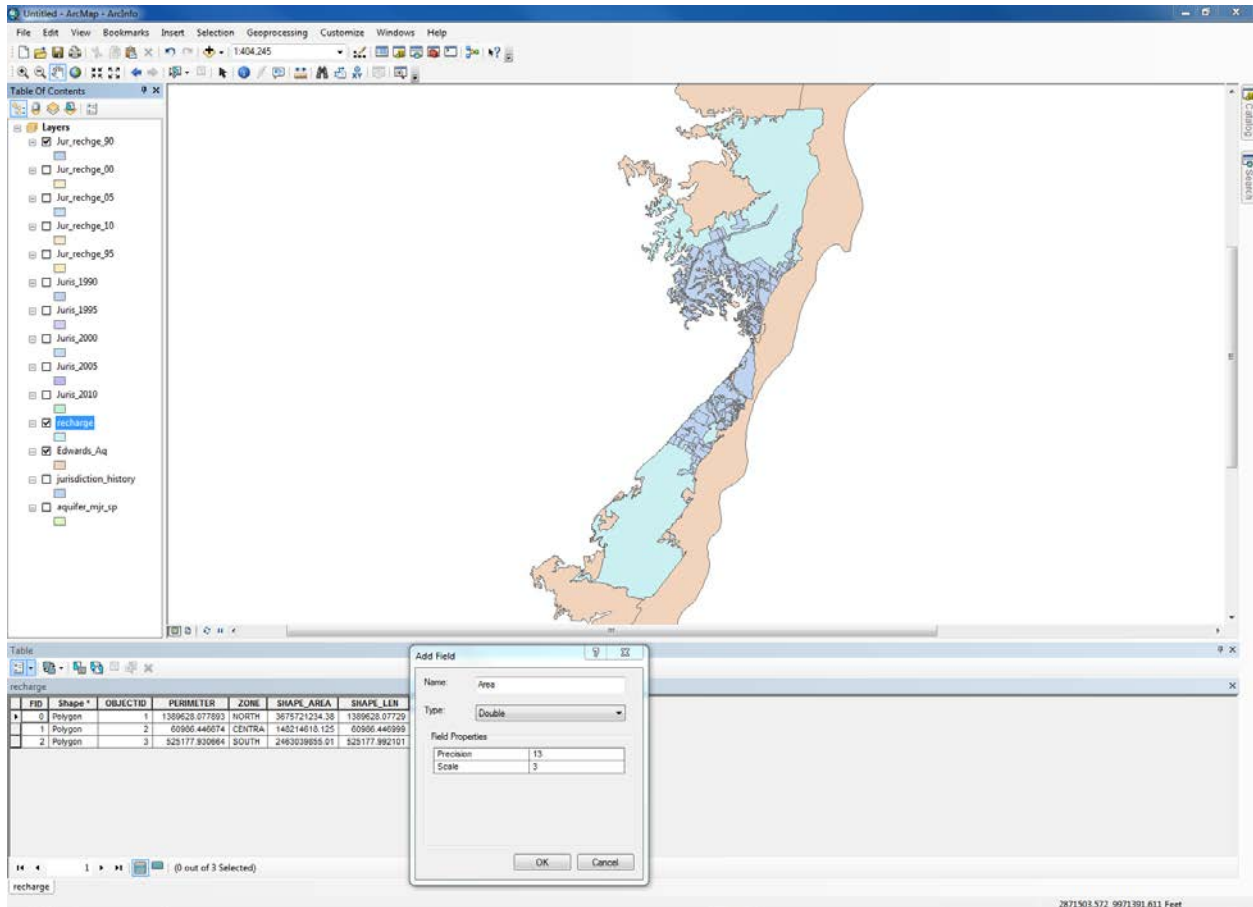   b)   Create a new field: Name=Area, Type=Double, Precision=13, Scale=3 (See Figure 5)

Figure 5

c) Use the Calculate Geometry tool to calculate the area of the recharge zone: right click the new field "Area" -> Calculate Geometry: Property = Area, use the coordinate system of the data source, Units = Square meters US (see Figure 6)
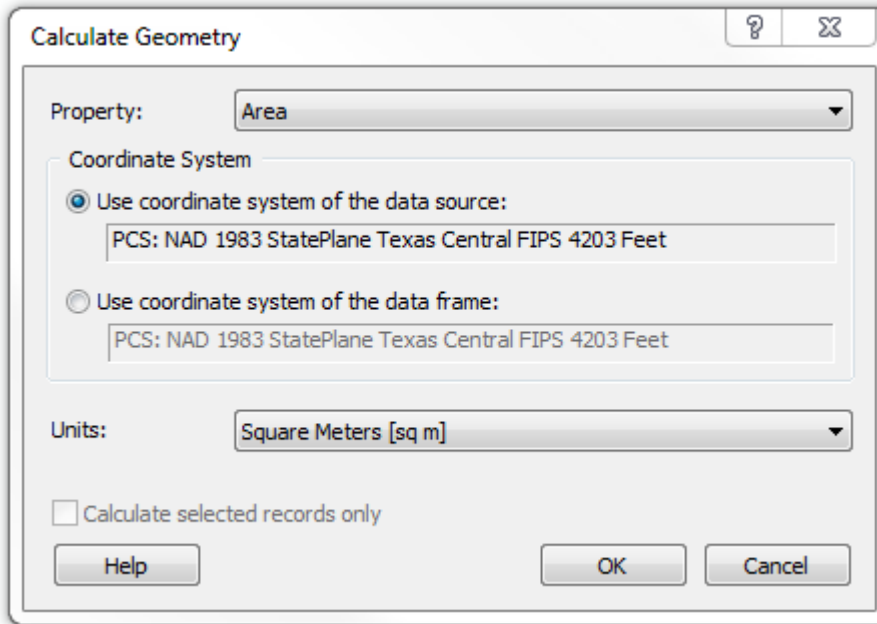
Figure 6

d) Use the Statistics tool to find the sum of the Areas in meters^2 and record value in excel table: right click the "Area" field -> Statistics (see Figure 7)
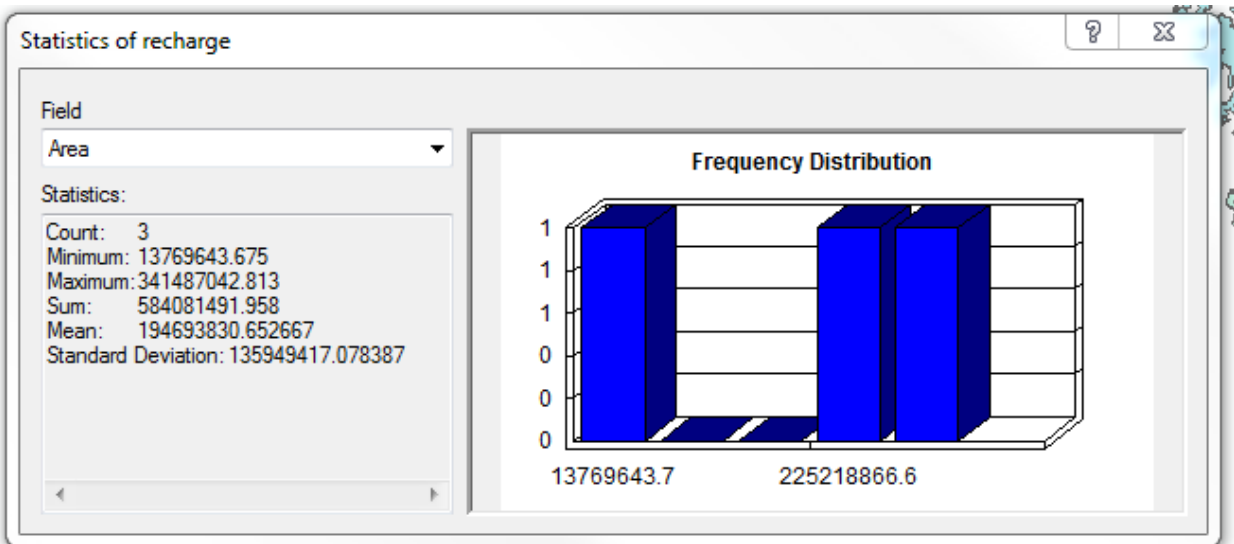
Figure 7

5. Calculating the Austin Jurisdiction Area

a) Open the attribute table for "Jur_rechge_90"
b) Create a new field: Name=Area, Type=Double, Precision=13, Scale=3
c) Use the Calculate Geometry tool to calculate the area of the 1990 Austin jurisdiction: right click the new field "Area" -> Calculate Geometry: Property = Area, use the coordinate system of the data source, Units = Square meters US

d) Use the Statistics tool to find the sum of the Areas in meters^2 and record value in excel table: right click the "Area" field -> Statistics (see Figure 8)

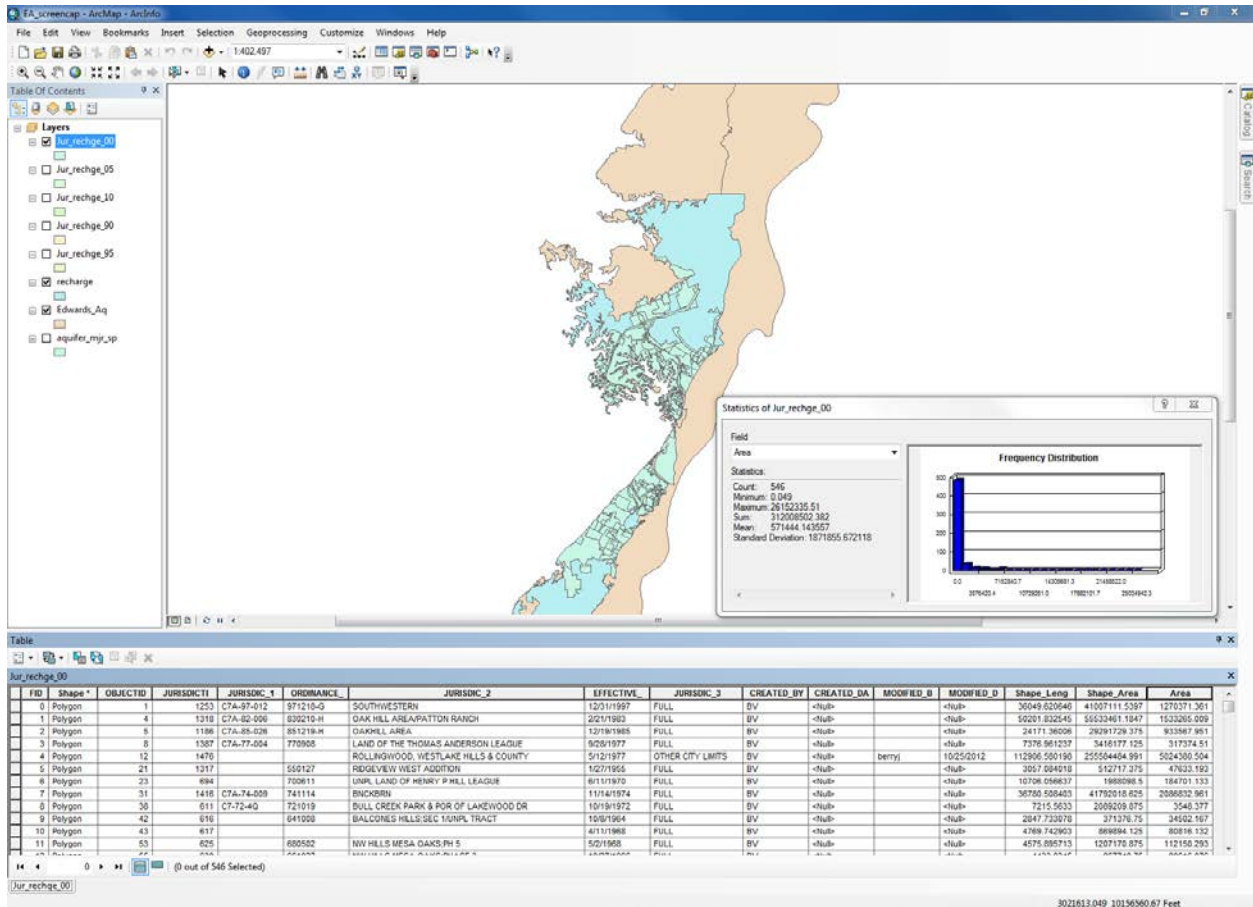e) Repeat steps a-d for "Jur_rechge_95" "Jur_rechge_00" "Jur_rechge_05" and "Jur_rechge_10"

Figure 8

6. Final Touches to Map

a) Add basemap: File-> add data-> add basemap (Bing Maps Hybrid)

b) Add data: texas_counties_shape from project folder

c) Create 6 new data frames: Insert -> new data frame ; Rename the data frames "1990" "1995" "2000" "2005" "2010" and "Texas Outline"

d) Change the coordinate system of each data frame to NAD_1983_StatePlane_Texas_Central_FIPS_4203_Feet: right click data frame-> properties-> coordinate system

e) Copy appropriate files into each data frame

The following steps outline the procedure taken in Microsoft Excel to complete the data analysis portion of the project.

1. Calculate the percentage of Edwards Aquifer recharge zone covered by Austin for the years, 1990, 1995, 2000, 2005, and 2010: divide the Austin jurisdiction area by the area of the recharge zone
2. Calculate the percent increase of covered recharge zone for each 5 year period: 89-90, 90-95, 95-2000, 00-05, and 05-10: subtract latter year from the former
3. Plot year vs. percent increase of covered recharge zone to assess any trends in the data for projection into the future

Results

See the end of the write-up for the final map representing a timeline of the extent of Austin, Texas on the Edwards Aquifer recharge zone created in ArcGIS.

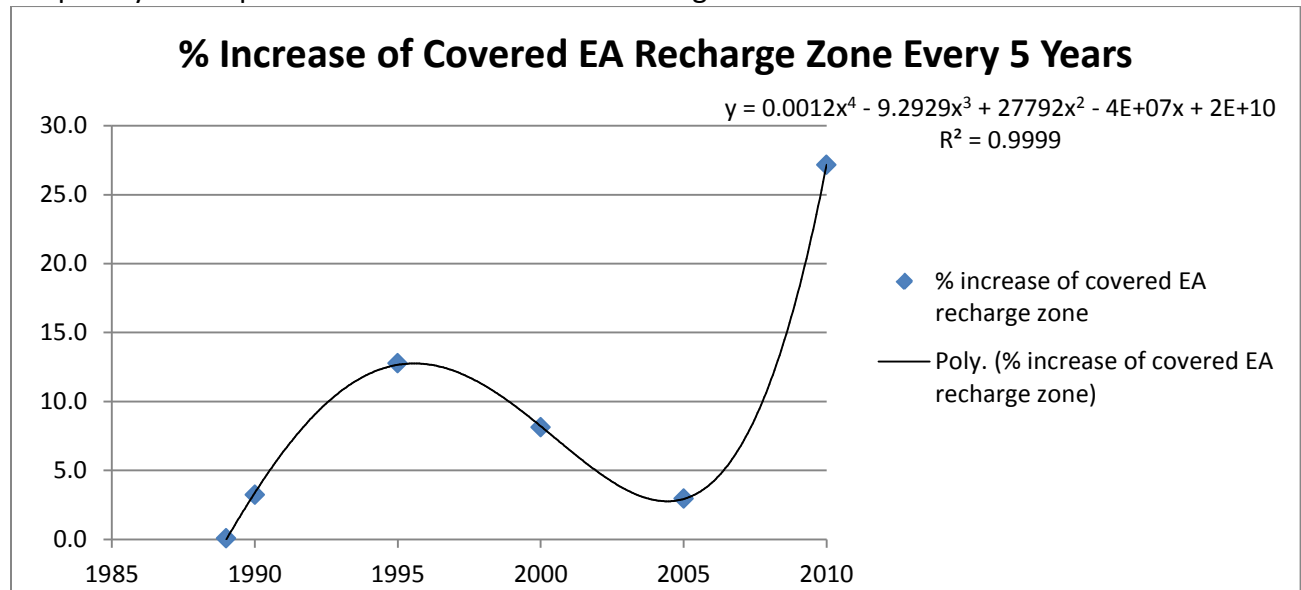The following results were calculated in Microsoft Excel.

The percentage of the Edwards Aquifer recharge zone covered by Austin:

Year	Area (m^2) of Austin Jurisdiction over Recharge Zone	Area (m^2) of EA Recharge Zone	% of EA Recharge Zone Covered by Austin
1989	218,111,067.067	584,081,491.958	37.3
1990	218,589,390.147	584,081,491.958	37.4
1995	237,486,625.015	584,081,491.958	40.7
2000	312,008,502.382	584,081,491.958	53.4
2005	359,479,155.687	584,081,491.958	61.5
2010	376,784,721.981	584,081,491.958	64.5

The percent increase of covered recharge zone for each 5 year period:

Years	% Increase of Covered EA Recharge Zone
1989-1990	0.1
1990-1995	3.2
1995-2000	12.8
2000-2005	8.1
2005-2010	3.0
TOTAL	**27.2**

Graph of year vs. percent increase of covered recharge zone:

% Increase of Covered EA Recharge Zone Every 5 Years

$$y = 0.0012x^4 - 9.2929x^3 + 27792x^2 - 4E+07x + 2E+10$$
$$R^2 = 0.9999$$

- ◆ % increase of covered EA recharge zone
- — Poly. (% increase of covered EA recharge zone)

Conclusions

The goal of quantifying the extent and growth of the city of Austin over the Edwards Aquifer recharge zone in Travis, Williamson, and Hays counties from the years 1990 to 1910 using online public data and ArcGIS software was successful. In the year 1990, roughly 37 percent of the recharge zone was covered by urban area. By 2010, an estimated 64.5 percent of the recharge zone was covered, a 27 percent increase in the overall amount of covered recharge zone.

The attempt made to project the city's growth into the future to assess the amount of recharge coverage for future years and to estimate the year of 100 percent coverage was unsuccessful. A plot of year vs. percent increase of covered recharge zone was created to assess any trends in the data. The data lacked any significant trend and a fourth order polynomial was required to fit the data. In conclusion, there was no linear trend between year and percent increase in covered recharge zone. Therefore, data outside of these two parameters must be needed to accurately project the city's growth into the future and to estimate the year of 100 percent coverage of the Edwards Aquifer recharge zone in Travis, Williamson, and Hays counties.

TIMELINE: Urban Extent of Austin, TX on the Edwards Aquifer Recharge Zone

Edwards Aquifer
WILLIAMSON
Recharge Zone
TRAVIS
HAYS

Urban Area

Recharge Zone

Edwards Aquifer
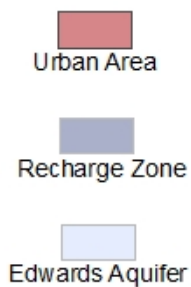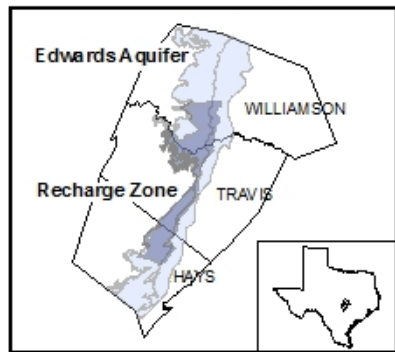
NAD 1983 StatePlane Texas Central FIPS 4203 Feet
Projection: Lambert Conformal Conic
By: Jessica Hinojosa
12/7/12

N

1990

1995

2000

2005

2010