

## GIS Semester Project: Working with Water Well Data in the overlying counties of Hueco-Mesilla Bolsons Aquifer

Question: Would it be feasible to recreate the water table heights above sea level in 1950, 1970, 1990, and 2010 in the Hueco- Mesilla Bolsons aquifer based on data ascertained from the internet? How has the water table depth changed over time in the Hueco-Mesilla Bolsons aquifer in West Texas from 1950 to 2010? 1970 to 2010? 1990 to 2010?

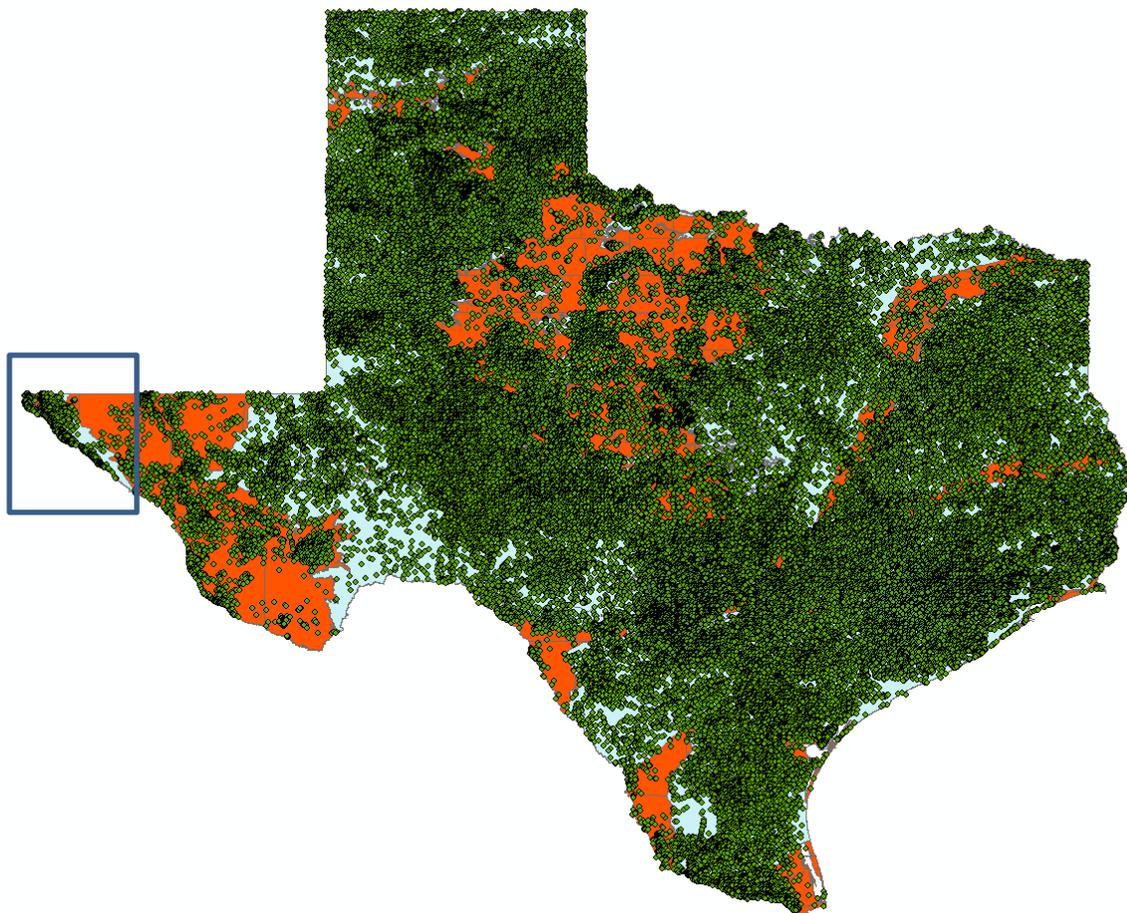
Steps that need to be taken to complete this project:

1. Download applicable data from the internet for the target area (i.e. well data table, water level table, shapefiles, etc.)
2. Use Microsoft Office (Microsoft Excel) and ArcGIS software to process the raw data into usable data to answer my question.
3. Use the information gathered and processed to generate raster surfaces, formulating a map with my desired features.

In addition to these three steps other actions will be taken to finish my project and will be laid out in the rest of this write up.

### **Data Collection**

For the county shapefiles I used the files available in the Lab 3 class folder of Texas counties, this shapefile contained all counties in Texas. To gather the other data I went to Texas Water Development Board website. They had the data I needed readily available on a few different pages. For the shapefile of the major Texas aquifers I went to <http://www.twdb.state.tx.us/mapping/gisdata.asp> and downloaded the shapefile in a zip folder and then extracted it to my class folder. From there I went to <http://www.twdb.state.tx.us/groundwater/data/gwdbbrpt.asp#E> and downloaded the shapefile of the Groundwater Database (GWDB) Reports and extracted it to my class folder. Once I had all the shapefiles in ArcMap, my map looked like Figure 1.



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Figure 1- Map of Texas counties in red/orange, with Major Aquifer locations in blue and water well sites represented as green dots. Boxed area is target area.

As shown in Figure 1, there is an enormous amount of water wells in Texas, but for the purposes of this project, the only wells (well data) I will be needing are the well site located directly over the Hueco- Mesilla Bolsons aquifer in El Paso and Hudspeth counties (inside the box). To remove the unnecessary wells from the map I right clicked on the GWDB layer and made it the only selectable layer. Then I chose to select by rectangle and selected all the wells in my target area and created a new layer with the selected features. I still had some unnecessary wells, so I proceeded to click on the selection tab at the top of the screen and go to select by location as seen in Figure 2. I then set the target layer as the well locations and the source layer as the major aquifers. After clicking apply it selected just the well locations drilled directly above

the aquifer area. This allowed me to right click on the layer again and create a new layer by selection. Now that I had all the wells directly above the aquifer area, I needed to refine my search again for the most relevant wells. I opened the attribute table for the remaining well locations in the GWDB layer and sorted by aquifer code, I then selected all the wells with the codes 112HCBL (Hueco-bolson) and 112MSBL (Mesilla bolson) (Figure 3) because they are the most relevant wells to the project and made a new layer as I had done before (this step effectively removed all the wells that were not taken from the Hueco- Mesilla Bolsons aquifer). After I opened the new attribute table for the layer I just created I exported the table to text and then imported it on excel. This gives me the relevant wells and there state well ID numbers so I can compare them to other tables later.

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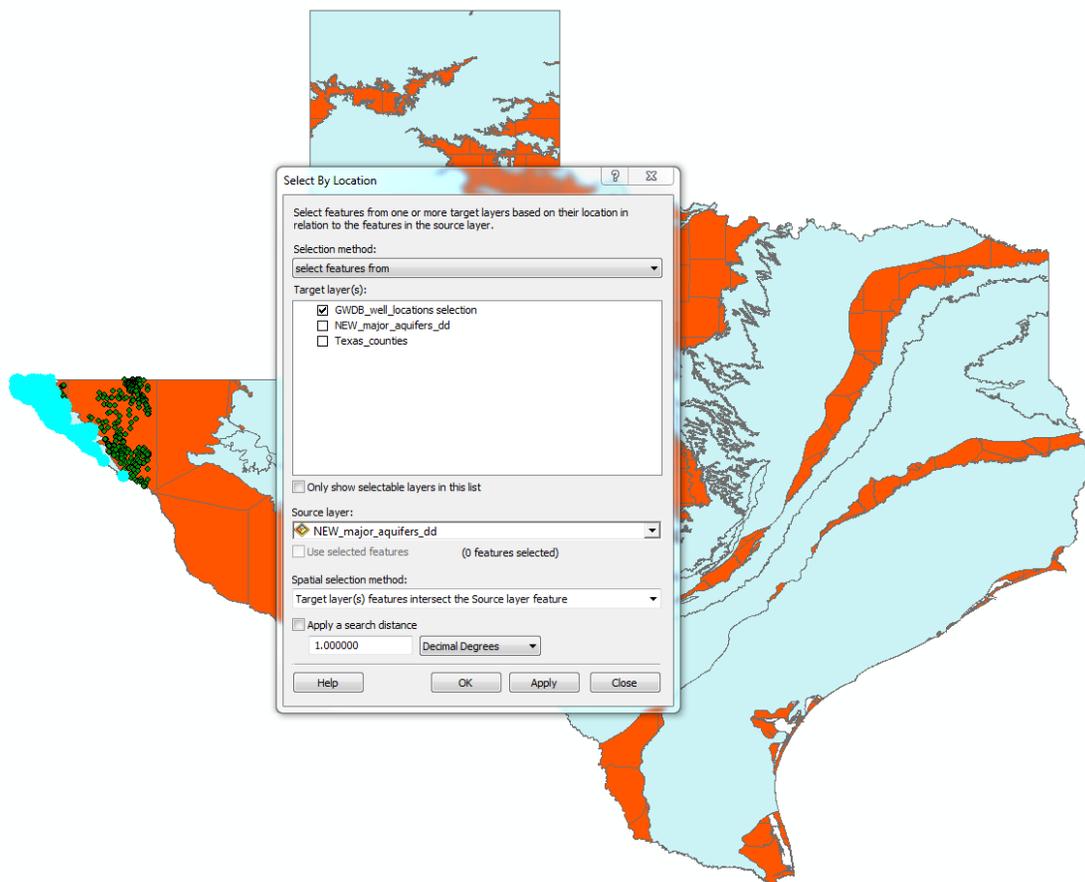


Figure 2- Showing select by location window with the target layer GWDB well locations with the source layer set as the Major Aquifers layer.

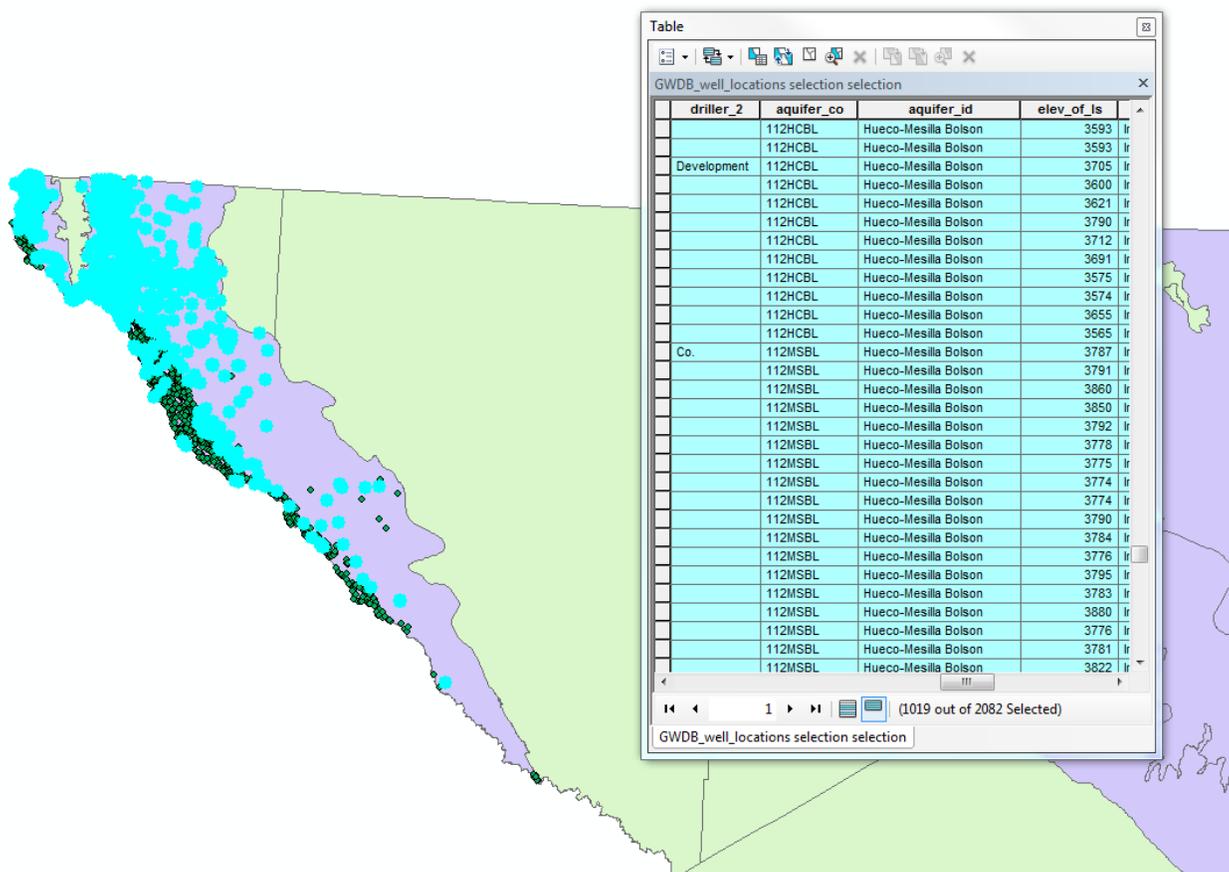


Figure 3- Showing the wells that are drilled above the major aquifer area into the Hueco-Mesilla Bolsons aquifer layer.

On the same page (<http://www.twdb.state.tx.us/groundwater/data/gwdb rpt.asp#E>) I was able to download the text files of Well Data Table and Water Level Table for both El Paso and Hudspeth counties (Figure 4). These two tables contained the state well ID numbers allowing me to join the tables if I needed too (I will later on). Because not all wells drilled in these two counties are drilled directly above the aquifer the state well ID numbers will come in handy later.

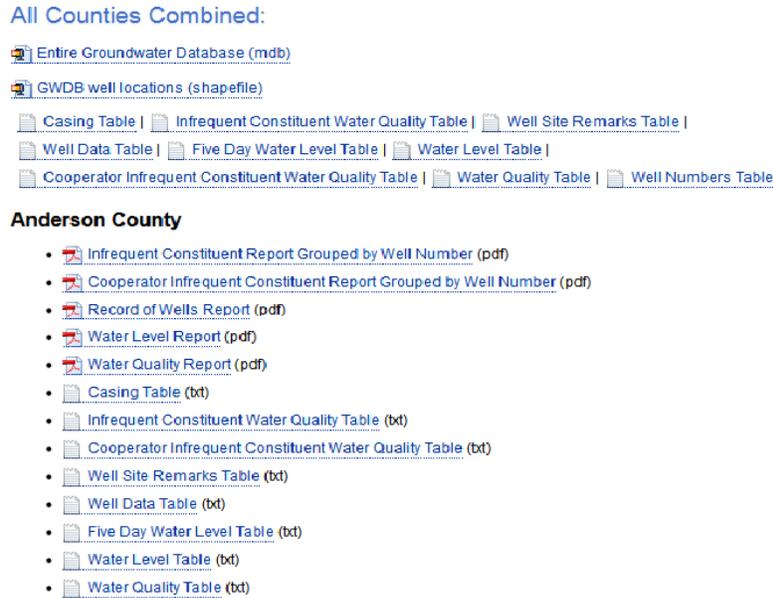


Figure 4 – GWDB shapefile and Well/Water data listed by county

After downloading the .txt files, I imported them into Excel for later use, but in the meantime cross referenced the latitudes and longitudes in the Well Data file with the attribute table in the GWDB layer to make sure they had the same information.

## Data Processing

At this point I have a lot of data to sort through. I went through the well data and water level tables for each county and deleted the columns that didn't have relevant information (i.e. owner, operator, etc.). At this point I had cleaned up excel tables with the information that was pertinent to my project. In the water level table for each county I had to filter for the years that I wanted to get the water level data for (Figure 5). I chose 1950, 1970, 1990, and 2010. So after filtering by year I noticed that some wells had been checked multiple time a year, and if I were to join it in ArcMap with the wells I was using I would get an error. So I then went through and



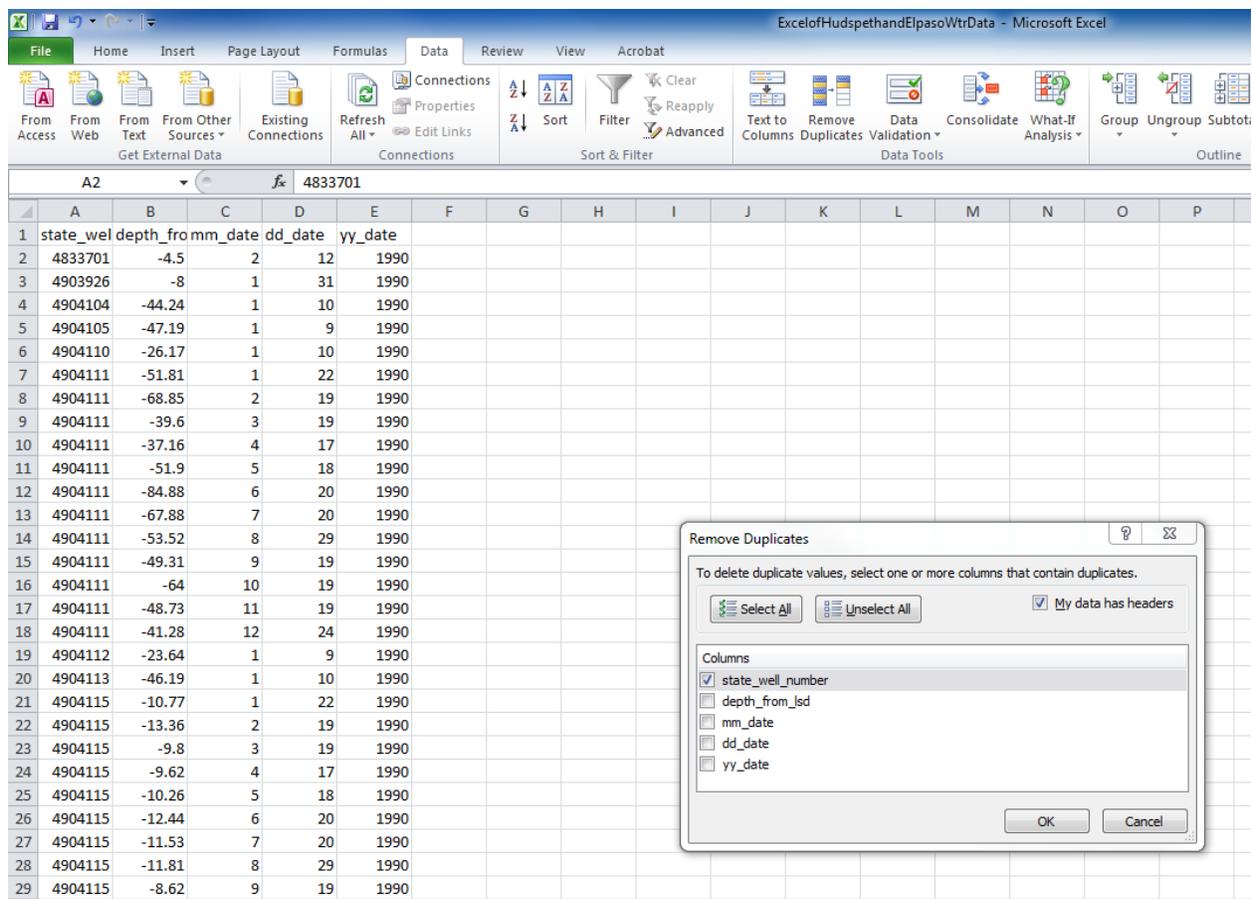


Figure 6- Showing the remove duplicates window open selecting to remove duplicate state well numbers.

After this was done I had eight new tables; a table for each year and for each county. After I had these tables I copied and pasted the data from El Paso County in to the Hudspeth County for the corresponding years and renaming them after the year the data was for so I would know exactly what sheet was which year. Now to compare this water level data (depth of water in feet below the land surface) with the point data I extracted for the well location data relevant to my area. To make this easier I chose to use the join function in ArcMap (Figure 7).

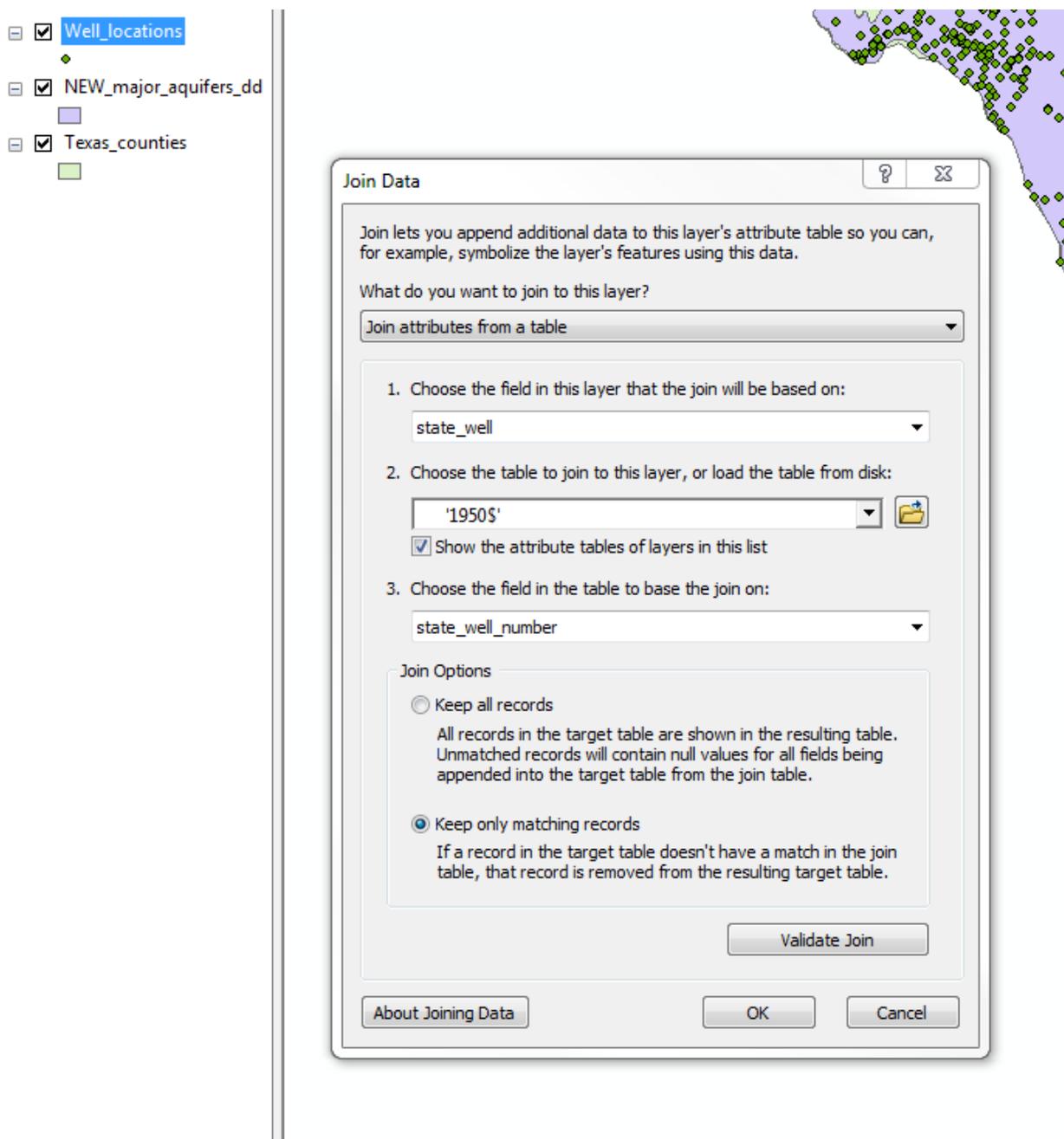


Figure 7- Showing the Join Data window open in ArcMap.

Since I am trying to see which wells in my area were measured through time the field I will be joining the tables with is the state well number (ID). I had to browse for the table that I filtered and removed duplicates from for each year, then selected the same field as box 1. It gave me the option of keeping all records, but since I only want to know the well numbers that match I selected keep only matching records. After this ArcMap left only the wells in my area that had

water level data for the year I selected (1950), and I opened up the attribute table to see if the join worked, and it did (Figure 8).

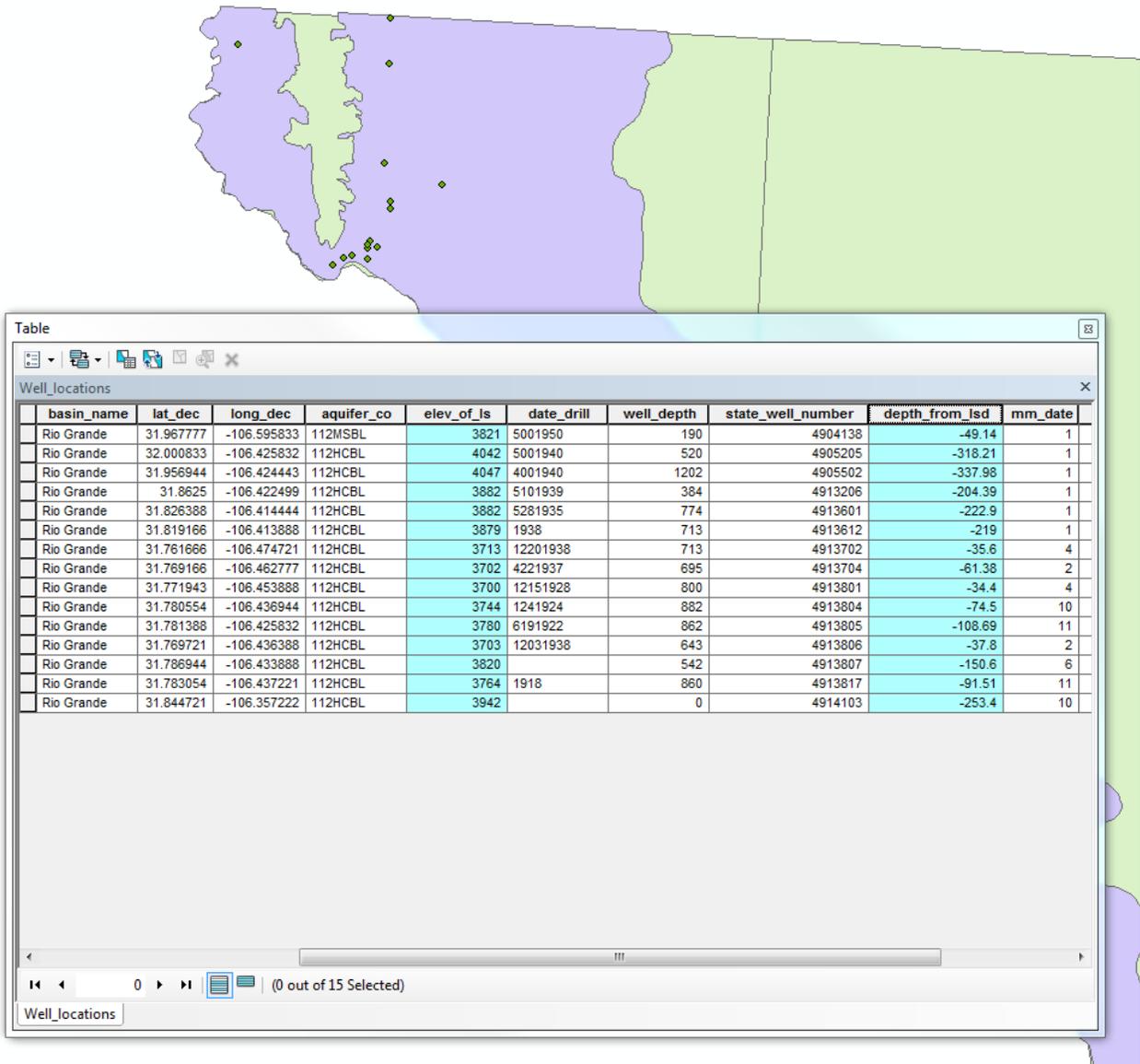


Figure 8- Showing the successfully joined tables, I have the elevation of the land in feet above sea level and the depth of water in feet below land surface highlighted to show it was successful.

I then exported the attribute table as a text file (.txt) (Figure 9), and then imported it into excel through the get external data from text tool (Figure 10).

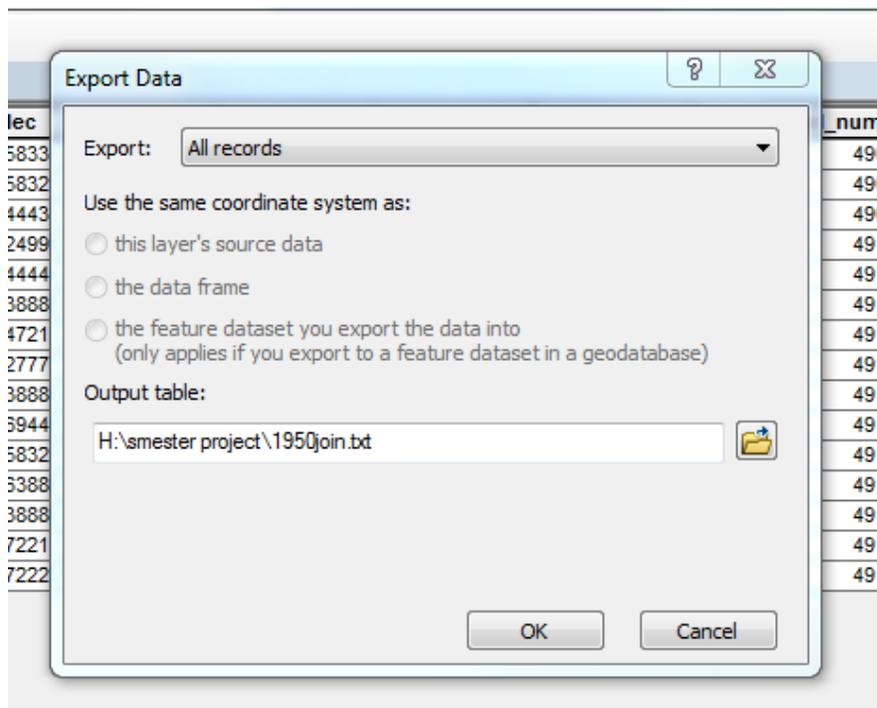


Figure 9- Showing export data window open after selecting the option in the attribute table. I gave it the name of the 1950join and exported it as a text file.

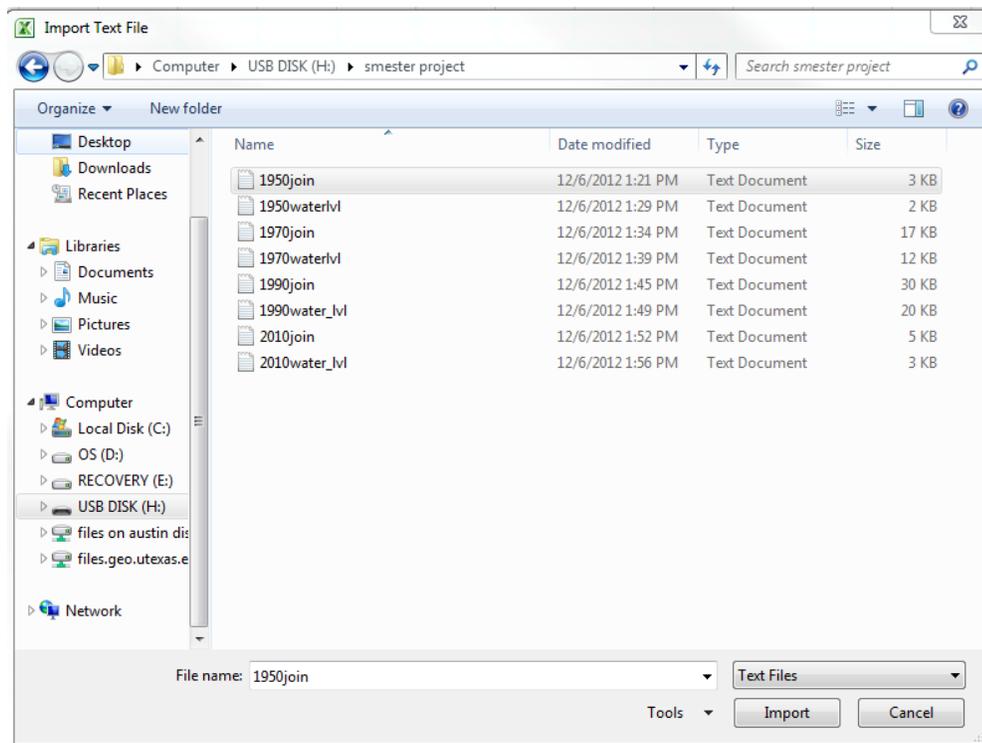


Figure 10- Showing import into excel of the joined attribute table.

After selecting the 1950join.txt file to import the text import wizard window pops up; to ensure that my information was represented in a way I could use it. In the first step I chose Delimited text, the second step I chose the delimiter of comma, and didn't change anything on the third step. After this I finally had the joined attribute table in excel so I could make water level calculations. I made a new column at the end of the table with the header water\_lvl and inserted the function =sum(H2,L2), and dragged it down to the bottom giving me an effective water level (Figure 11). To make the values easier to work with I formatted the cells in the water\_lvl column to numbers and made them integers by taking away the decimal spots. I then formatted the top row as text so I could select a Z value in ArcMap later.

elev_of_ls	date_drill	well_depth	state_well_number	depth_from_lsd	mm_date	dd_date	yy_date	water_lvl
3821	5001950	190	4904138	-49.14	1	10	1950	=SUM(H2,L2)
4042	5001940	520	4905205	-318.21	1	23	1950	SUM(numbe
4047	4001940	1202	4905502	-337.98	1	23	1950	3709
3882	5101939	384	4913206	-204.39	1	23	1950	3678
3882	5281935	774	4913601	-222.9	1	23	1950	3659
3879	1938	713	4913612	-219	1	20	1950	3660
3713	12201938	713	4913702	-35.6	4	27	1950	3677
3702	4221937	695	4913704	-61.38	2	21	1950	3641
3700	12151928	800	4913801	-34.4	4	27	1950	3666
3744	1241924	882	4913804	-74.5	10	26	1950	3670
3780	6191922	862	4913805	-108.69	11	26	1950	3671
3703	12031938	643	4913806	-37.8	2	10	1950	3665
3820		542	4913807	-150.6	6	22	1950	3669
3764	1918	860	4913817	-91.51	11	24	1950	3672
3942		0	4914103	-253.4	10	4	1950	3689

Figure 11- Showing the two columns that I used for the function. Where elev\_of\_ls is the elevation of the land in feet above sea level, and depth\_from\_lsd is the depth of water in feet below land surface. This also shows the function for the first well and the integers for the rest of the wells.

After these steps I saved the table as a text file under 1950waterlvl.txt so I could distinguish later what water level table went to what year. After this I went back into ArcMap went to the File tab at the top and selected the Add XY data option under Add Data... tab. In the Add XY Data window I had to browse to my newly created text file and set the X, Y, and Z fields. I also had to make sure that the projected coordinate system was the same as the rest of my layers (NAD 1983.prj) (Figure 12).

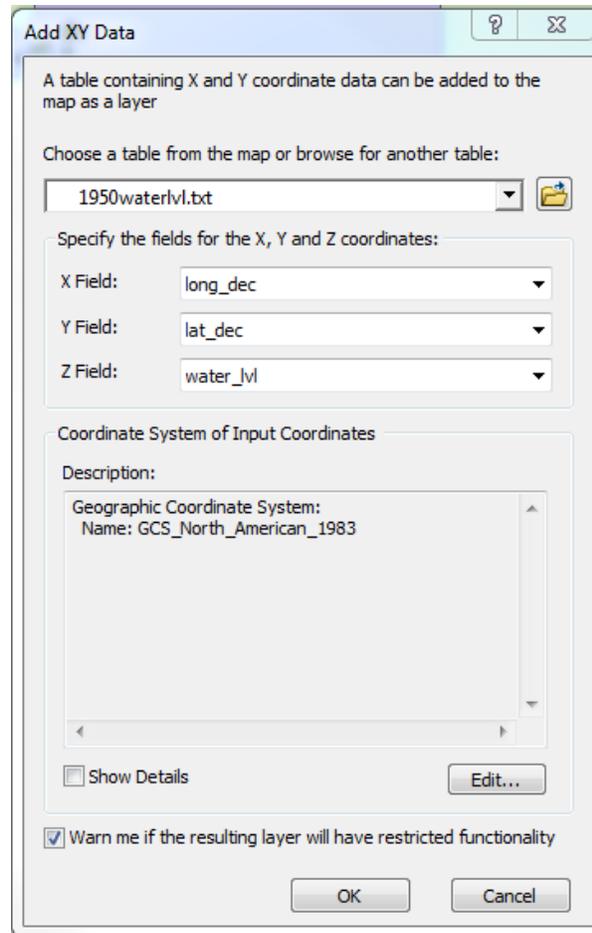


Figure 12- Showing the Add XY Data window open with the X and Y fields in longitude and latitude in decimal degrees respectively, and the Z field with the newly made water\_lvl column (this is why I formatted the first row of cells as text so they would show up on this list).

After clicking OK, a 1950waterlvl.txt Events layers showed up in my Table of Contents (TOC). I want to make this a shapefile so it is easier to use when creating my raster. I right clicked on the newly added layer went down to data and clicked on export data. The export data window showed up and I gave my data file the name of 1950\_wells and changed the save as type from File and Personal Geodatabase feature classes to shapefile (Figure 13).

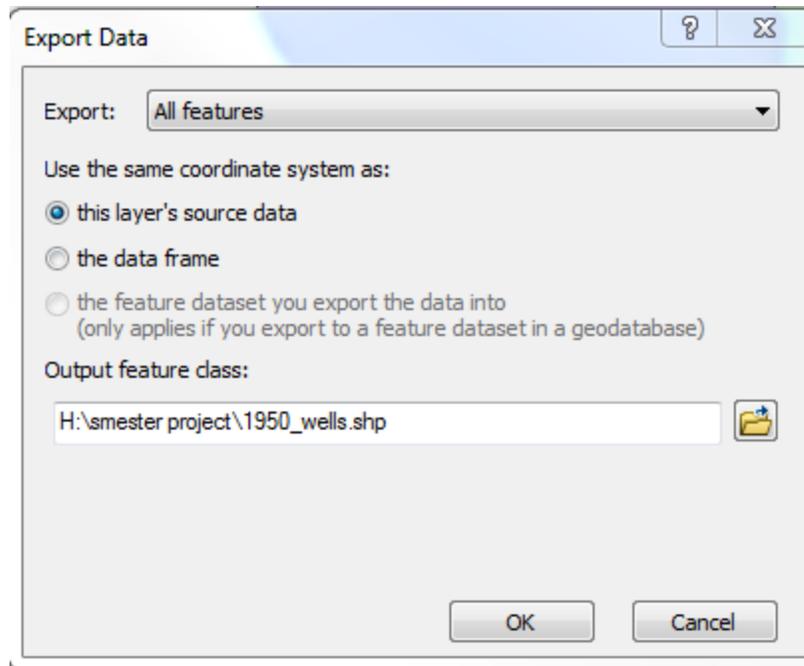


Figure 13- Showing the export data window to create the shapefile desired.

After the shapefile is created I removed the joins on the well location layers attribute table and deleted the events layer for the 1950 wells. This allowed me to start over the process for 1970 water level data, 1990 water level data, and 2010 water level data. All of these actions make the water level data easier to use in ArcMap and help make the raster creation process easier. All of my water levels (effectively the water depth from surface) had large integer values telling me that none of the wells water levels reached the surface and that none of them were deeper than the well depth.

Before I begin the raster creation I would like to remove the Major aquifer layer excluding the Hueco- Mesilla Bolsons area. To do this I right clicked on the Major aquifer layer in the TOC and made it the only selectable layer, and as for the pertinent well locations earlier I selected the polygon of the area I wanted and created a new layer from my selection, allowing me to delete the old layer. I then did the exact same thing for the counties of Texas I was interested in (i.e. El Paso and Hudspeth) (Figure 14).

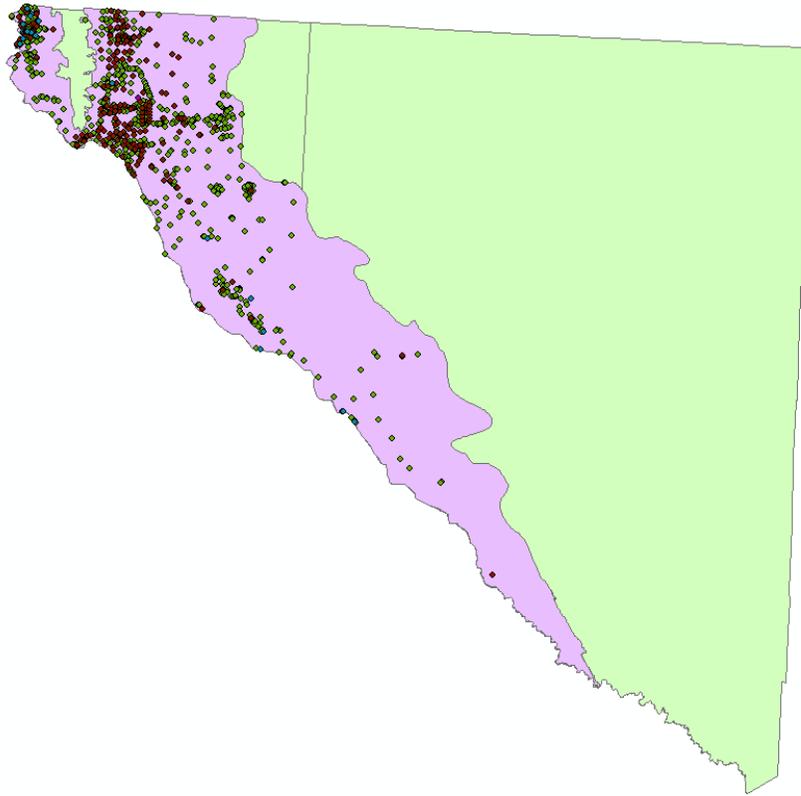


Figure 14- Showing the El Paso, Hudspeth, and Hueco- Mesilla Bolsons polygons without the rest of Texas and its major aquifers.

## ArcGIS Processing

Now that I have all the data organized and in a file format that can be used in ArcMap I will be creating individual raster layers for each year and then a map showing the difference in between 1950 and 2010. The first step is to open the ArcToolbox find the Spatial analyst toolbox, go to the Interpolation tools and open the spline tool.

The reason I chose the spline interpolation tool is because when looking through the ArcHelp to find which method of interpolation would be best for my project I came across a section that explained that spline interpolation is used to "... interpolate best-fit surfaces to the sample points using polynomial and least-squares methods, respectively. Spline interpolation fits a mathematical surface through the points that minimizes sharp bending; it is useful for surfaces

that vary smoothly, such as water table heights.” So according to the ArcHelp the spline tool would be the best tool for my project.

Before opening the Spline tool, I had to go to the Customize tab at the top of ArcMap and open the Extensions option to turn on the Spatial Analyst extension. I could then open the Spline tool and select the input point features I was creating a raster for, add a Z value field, specify the output raster, and open the environments section at the bottom (Figure 15 and 16).

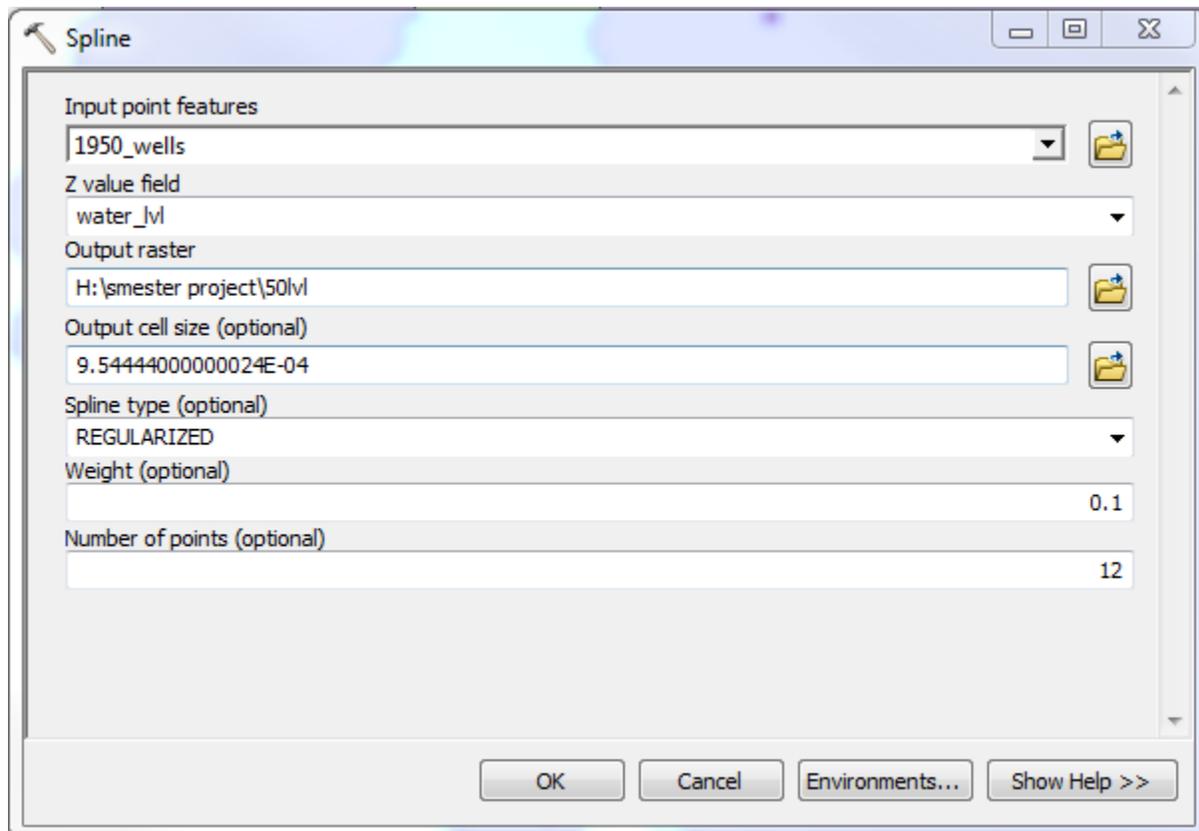


Figure 15- Showing the Spline tool window open with the 1950\_wells point data shapefile as the input point features, the water\_lvl field showing the height of the water table above sea level, and the output raster as 50lvl. I kept everything else the same.

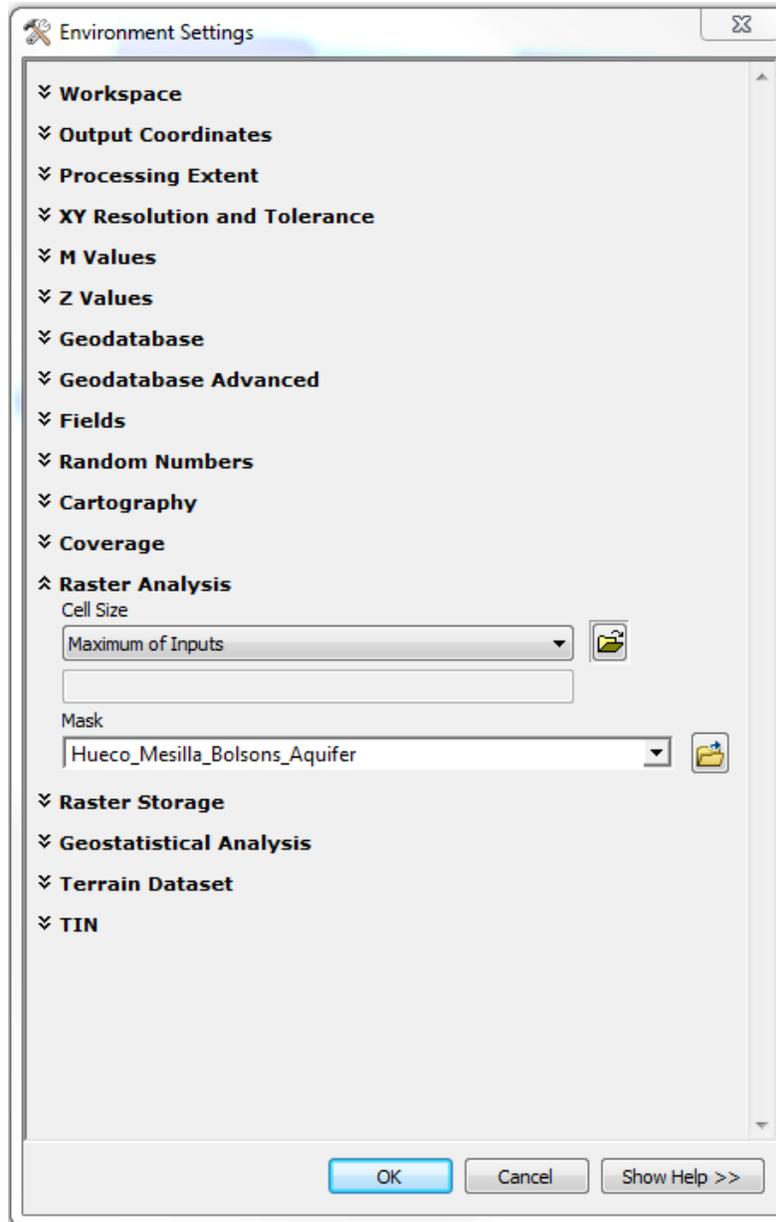


Figure 16- Showing the environment settings I kept everything default except under the Raster Analysis tab, where I made the mask the Aquifer layer so I would not have to extract by mask later.

After allowing the tool to execute, it created a raster that covered the area that it had data for. I repeated these steps for 1970, 1990, and 2010. Because not all of the water wells drilled in the Hueco- Mesilla Bolsos Aquifer had data for 1950 the raster it created only covered a limited area, and for the purposes of this project that is fine. There are a couple of reasons that this dataset is limited. One of the reasons for this maybe that these were the only water wells around

in 1950 that drilled into this aquifer; another reason could be that whoever was collecting this data only collected data for these wells and didn't get to collect data for the other wells until after 1950. This raster also does not cross county lines, seeing that all of the well data for 1950 was in El Paso County this makes sense. Since there were more wells spread out over a larger area that had applicable data in 1970, the raster created was much larger showing the water table heights for a much greater area. The 1990 raster is coming up with negative heights above sea level, but considering there are no wells above it, the spline tool interpolated that that was a low region, so low that the water table fell below sea level, which isn't likely. All of the water table heights in the 1990 well attribute table are positive. I was not able to resolve the issue; please disregard the negative values for this map.

The following figures (Figure 17, 18, 19, and 20) show the water table height above sea level for my target years of 1950, 1970, 1990, and 2010.

### Water Table Height for 1950 Well Data in the Hueco-Mesilla Bolsons Aquifer

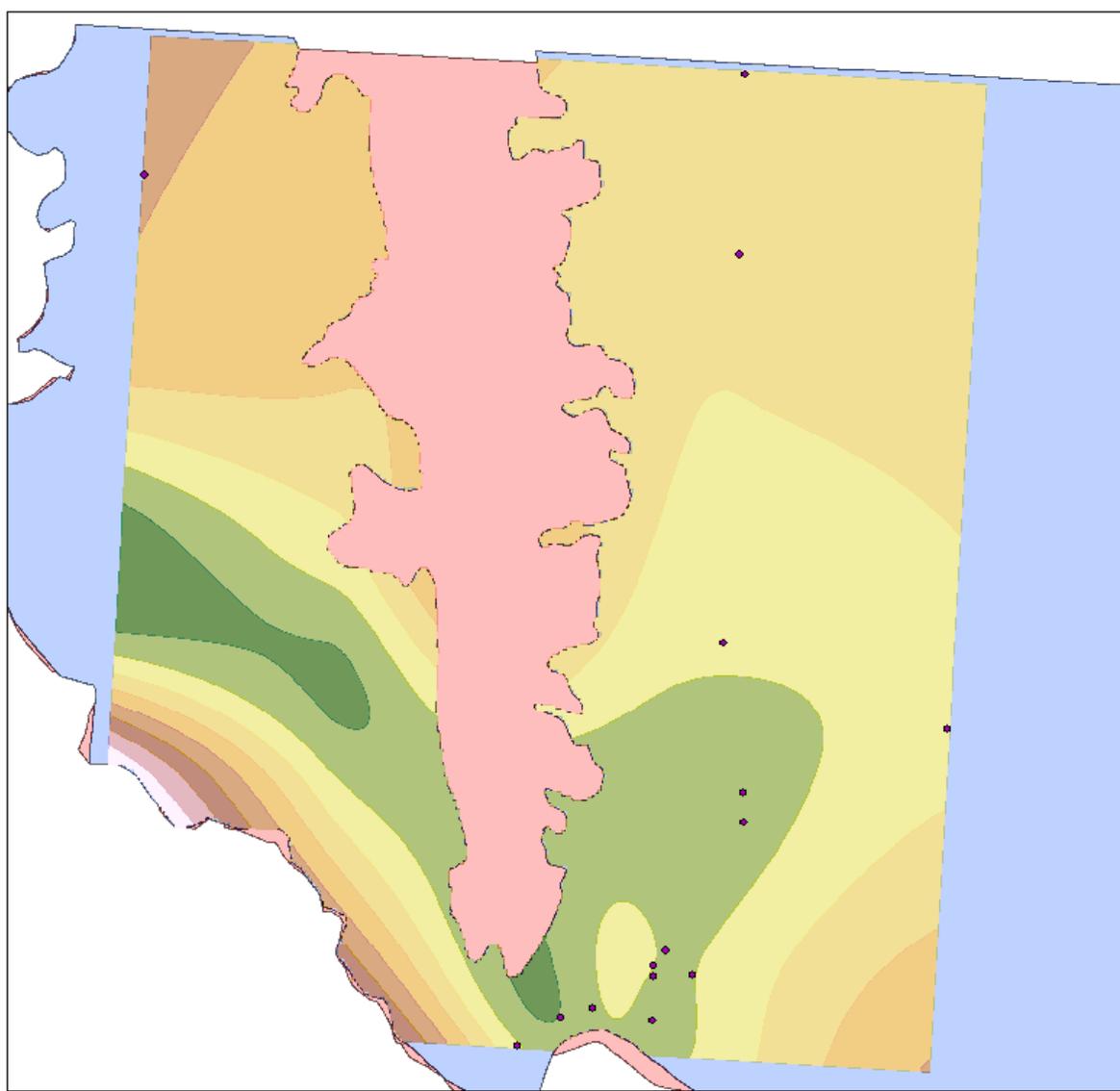


Figure 17- Showing the finished map of the 1950 water table heights above sea level. The Hueco-Mesilla Bolsons aquifer is divided by the Franklin Mountains which results in El Paso county cutting through the map.

### Water Table Height for 1970 Well Data in the Hueco-Mesilla Bolsons Aquifer

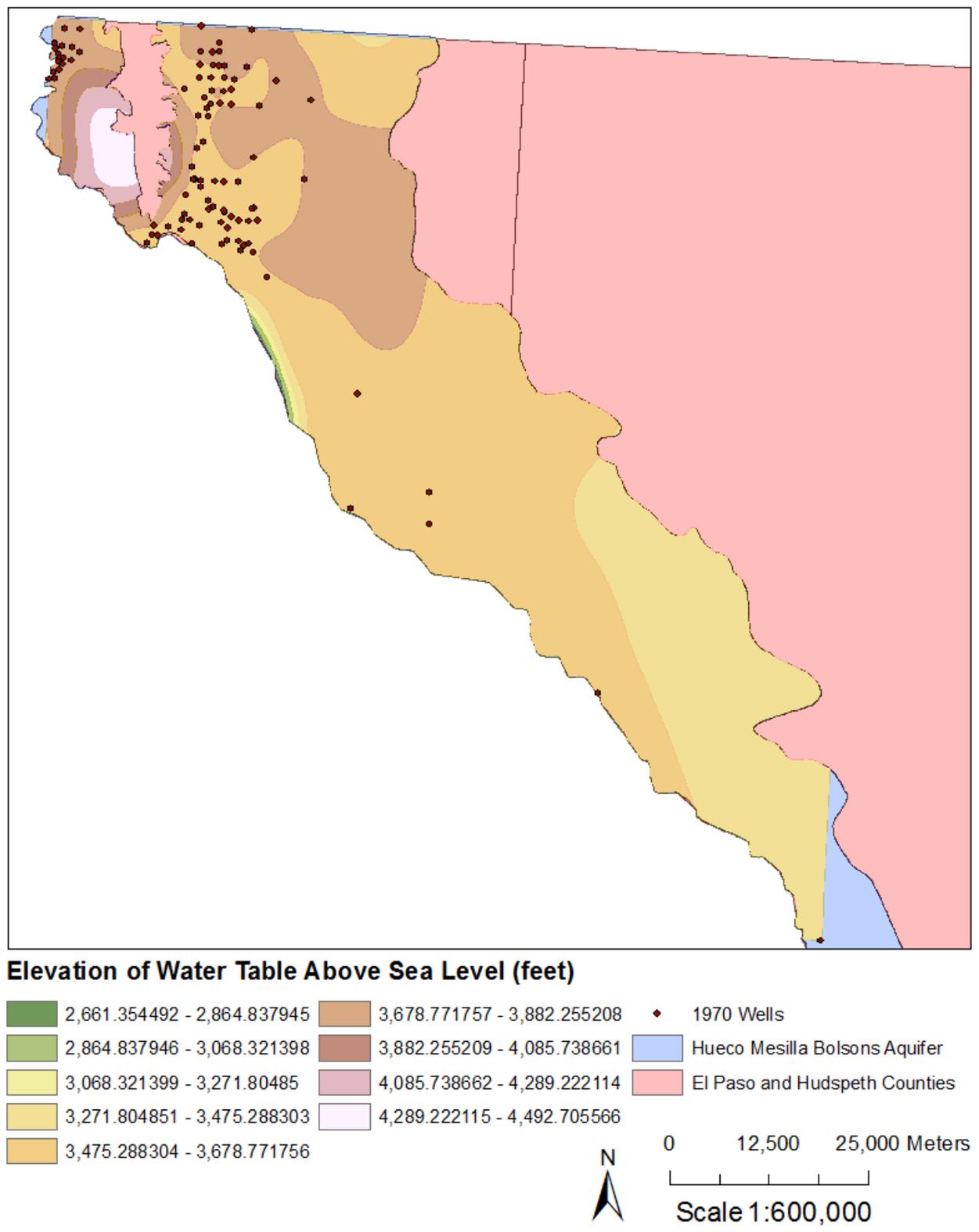
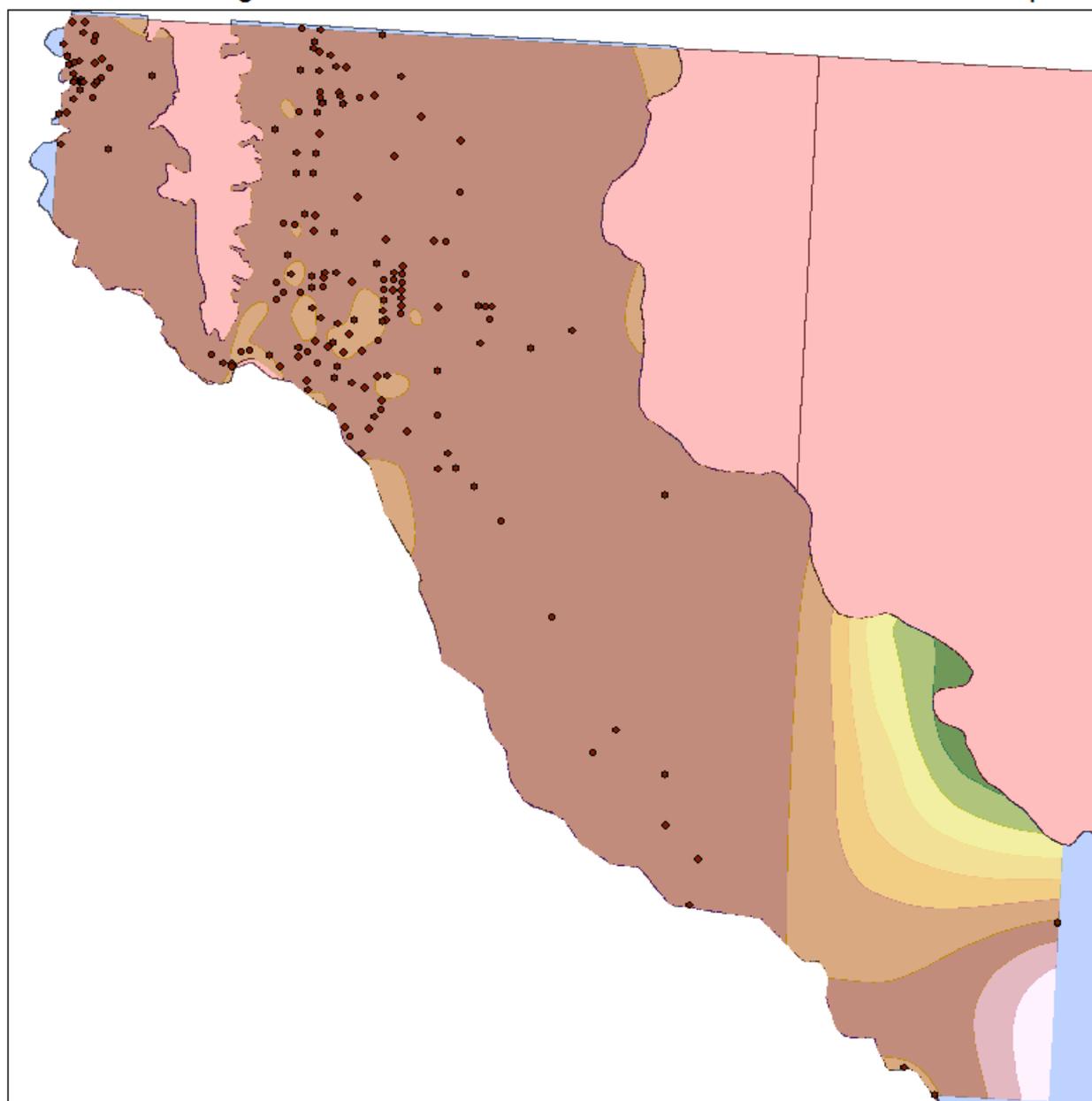


Figure 18- Showing the finished map of the 1970 water table heights above sea level.

### Water Table Height for 1990 Well Data in the Hueco-Mesilla Bolsons Aquifer



#### Elevation of Water Table Above Sea Level (feet)



Figure 19- Showing the finished map of the 1990 water table heights above sea level.

### Water Table Height for 2010 Well Data in the Hueco-Mesilla Bolsons Aquifer

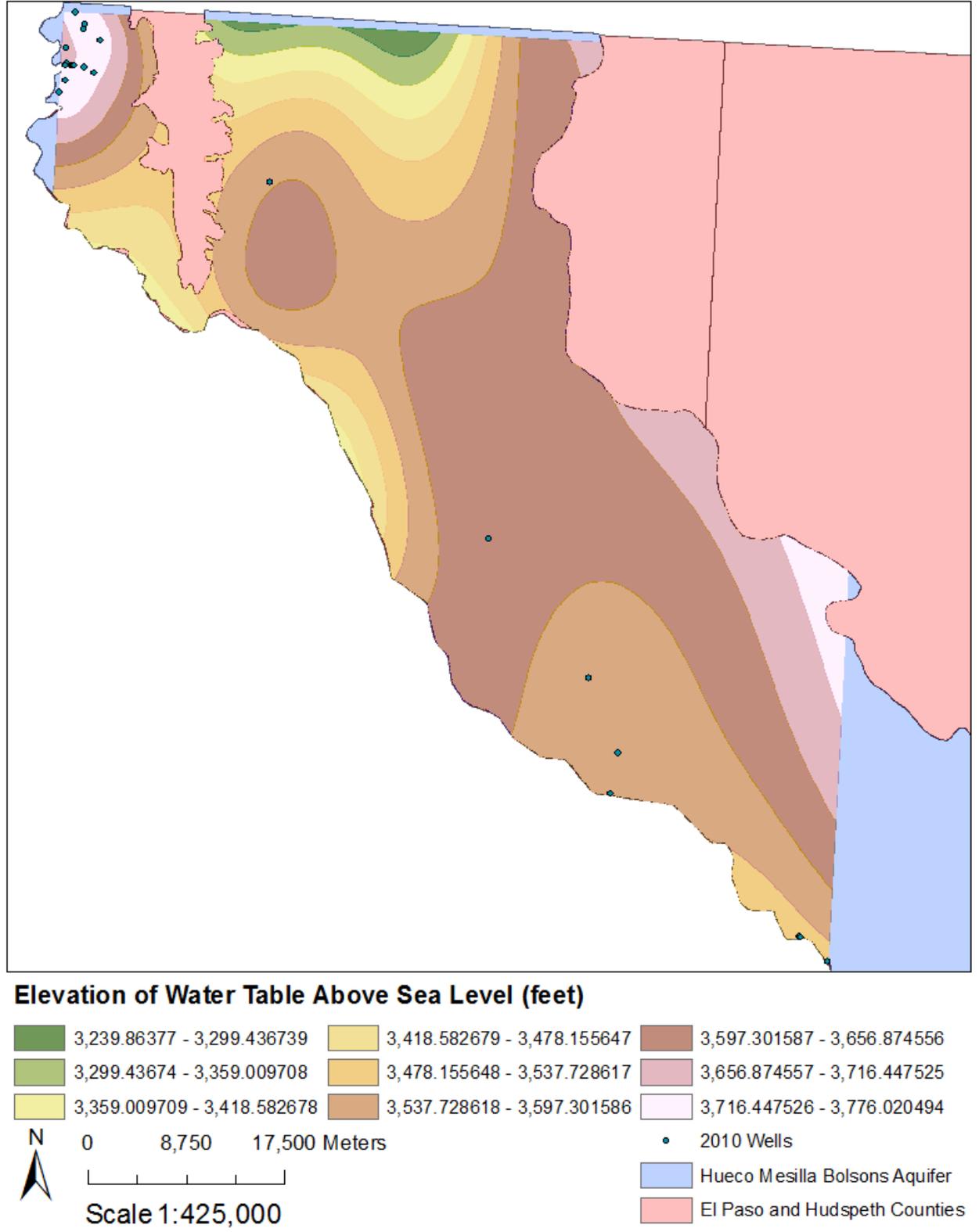


Figure 20- Showing the finished map of the 2010 water table heights above sea level.

The next step in the process was to use the Raster calculator under the Map Algebra toolbox, which is under Spatial Analyst Toolbox. I simply subtracted the 2010 raster from the 1970 raster, as shown in Figure 21. I did this for the comparison map between 2010 and 1950, as well as the 2010 and 1990 comparison maps shown in Figures 22-24.

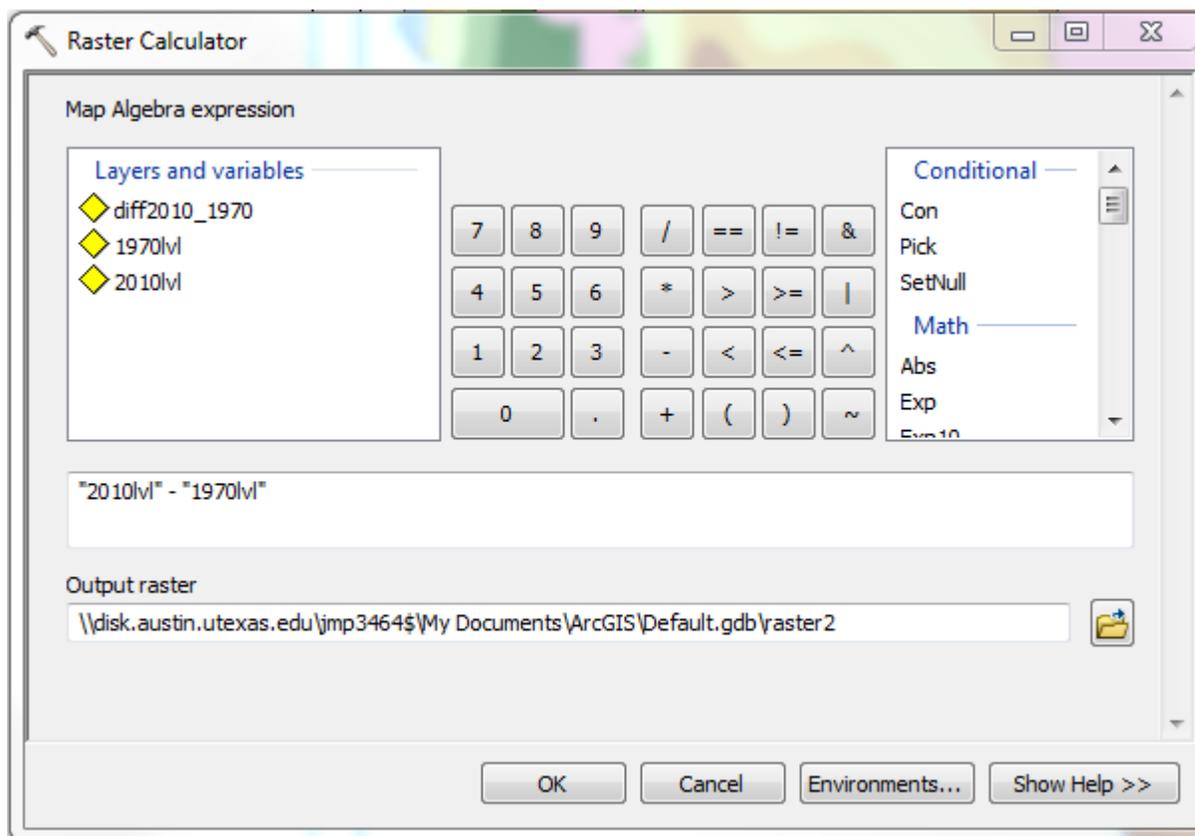
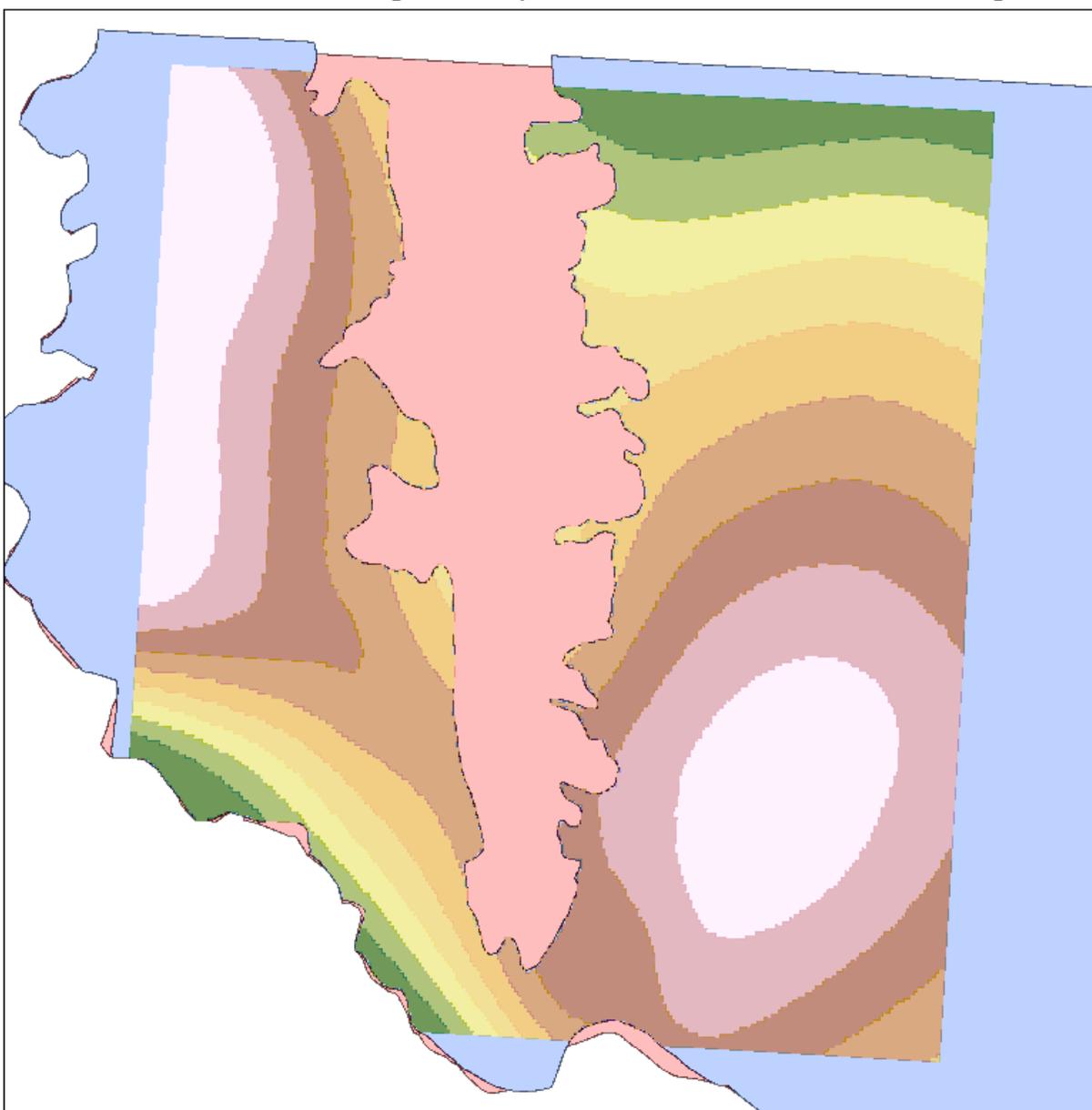


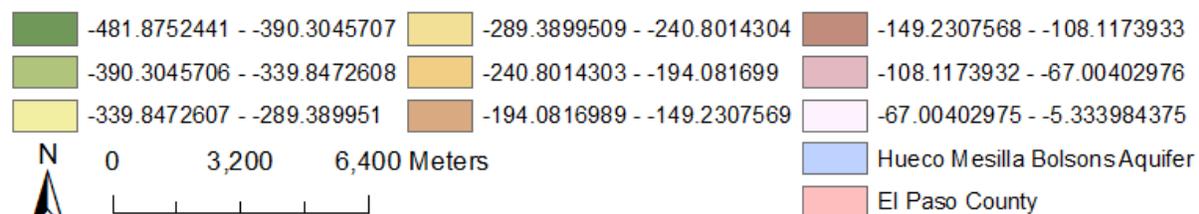
Figure 21- Showing Raster Calculator window open. I also went into the environment tab at the bottom and under Raster analyst set the mask to the aquifer layer, same as before.

The 2010 water table has lower levels compared to the water table heights in 1950. But the raster calculator uses the smaller of the rasters as the maximum extent of the resulting raster so it does not show the southern extent of the water table levels because there was no 1950 data to for the calculator to compare to the 2010 water table levels. When the 2010 raster and the 1970 raster were compared, the resulting raster data shows that in the northern region of the aquifer the water table level are much lower in 2010, but the southern regions are higher. When comparing the 2010 raster to the 1990 raster it is the same, the northern aquifer levels are much lower compared to the southern region.

## 2010 Water Table Height Compared to 1950 Water Table Height



### 2010 Water Table Height Minus 1950 Water Table Height (feet)



0 3,200 6,400 Meters



Scale 1:150,000

Hueco Mesilla Bolsons Aquifer  
 El Paso County

Figure 22- Showing the difference in water table heights between 2010 and 1950.

### 2010 Water Table Height Compared to 1970 Water Table Height

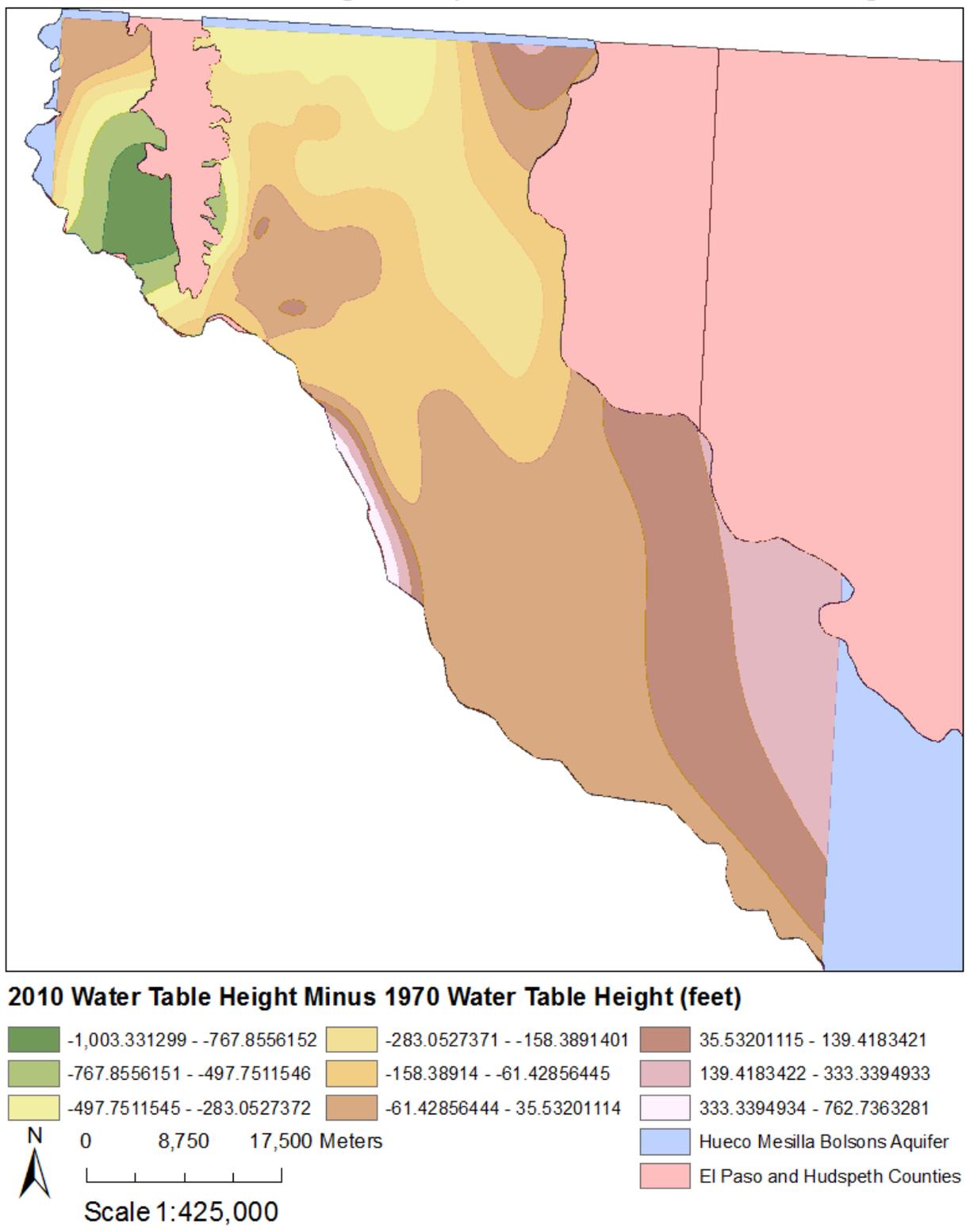
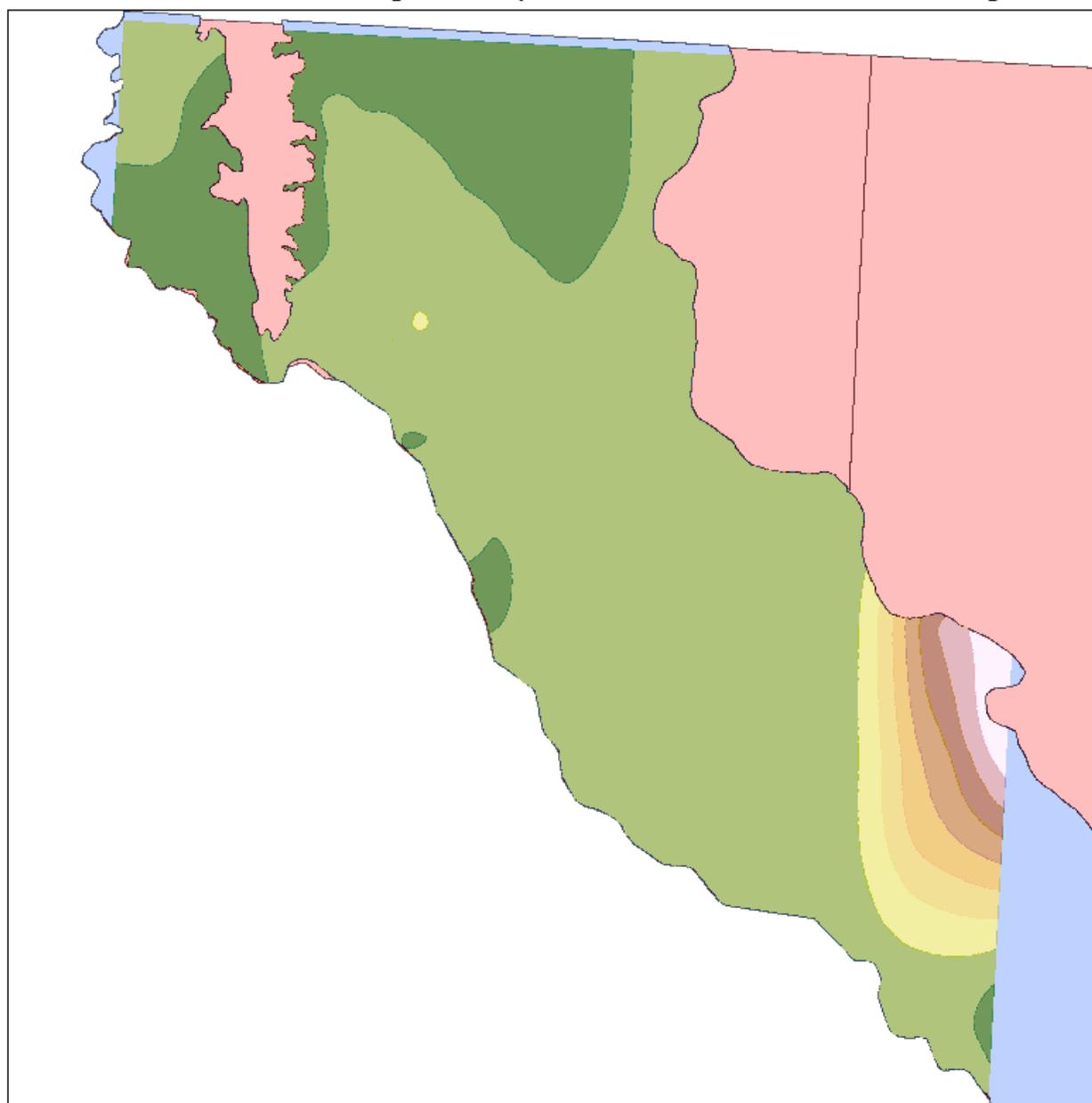


Figure 23- Showing the difference in water table heights between 2010 and 1970.

## 2010 Water Table Height Compared to 1990 Water Table Height



### 2010 Water Table Height Minus 1990 Water Table Height (feet)

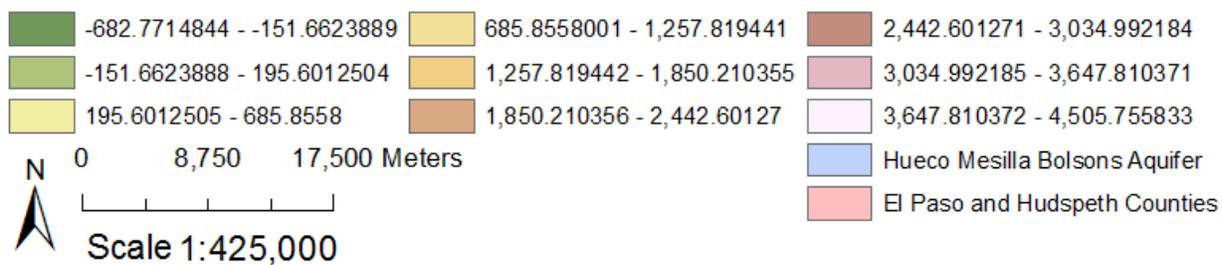


Figure 24- Showing the difference in water table heights between 2010 and 1990.

## Conclusion

After completing my project I was able to accomplish my goal of creating individual raster layer of Water Table heights above sea level for 1950, 1970, 1990, and 2010 based on the data available on the Internet. But due to the lack of information in 1950 well data, the raster of water table heights above sea level and the comparison of the water table levels between 2010 and 1950 was lacking.

As far as answering my initial questions (Would it be feasible to recreate the water table heights above sea level in 1950, 1970, 1990, and 2010 in the Hueco- Mesilla Bolsons aquifer based on data ascertained from the internet? How has the water table depth changed over time in the Hueco-Mesilla Bolsons aquifer in West Texas from 1950 to 2010? 1970 to 2010? 1990 to 2010?), if there had been more data collected in 1950 for wells that were drilled into the Hueco-Mesilla Bolsons aquifer a more relevant water table raster could have been produced. The other years seemed to be a more accurate portrayal of the water table level. Same goes for the comparison maps, 2010 water table levels compared to 1950 water table levels map seemed to be unusable for any real analysis, but as far as the other comparison maps go they seem to show valid information. The reason the 2010 water table levels are so low compared to other years in the past may be a function of the difference between recharge/discharge rates in the area, permeability of the layers above the aquifer, and the rainfall history in the area through time.

With all of that on the table I would say the project was a success in that before choosing the years I should have sifted through the dataset available and found years with more data to create a more complete raster of the water table for this aquifer.

If I had been given a dataset with the water table levels for the same wells through time, with all the wells covering the entire aquifer and reasonably spaced, I could have created a more comprehensive raster showing more pertinent information resulting in better answers to my questions. After this project I am much more comfortable with my GIS skills and plan on learning more about GIS in the future.