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Determining Volume of Predicted Water Loss from Lake Travis During Six Months of Drought

Introduction

The 2011 Central Texas Drought is still in effect. Precipitation this year has helped fill Lake Travis to about half full, but the lake is still significantly low and the drought is a long way from over. The LCRA has forecasted the change in Lake Travis' water level over the next 6 months under different drought conditions, as shown in **Figure 1**.

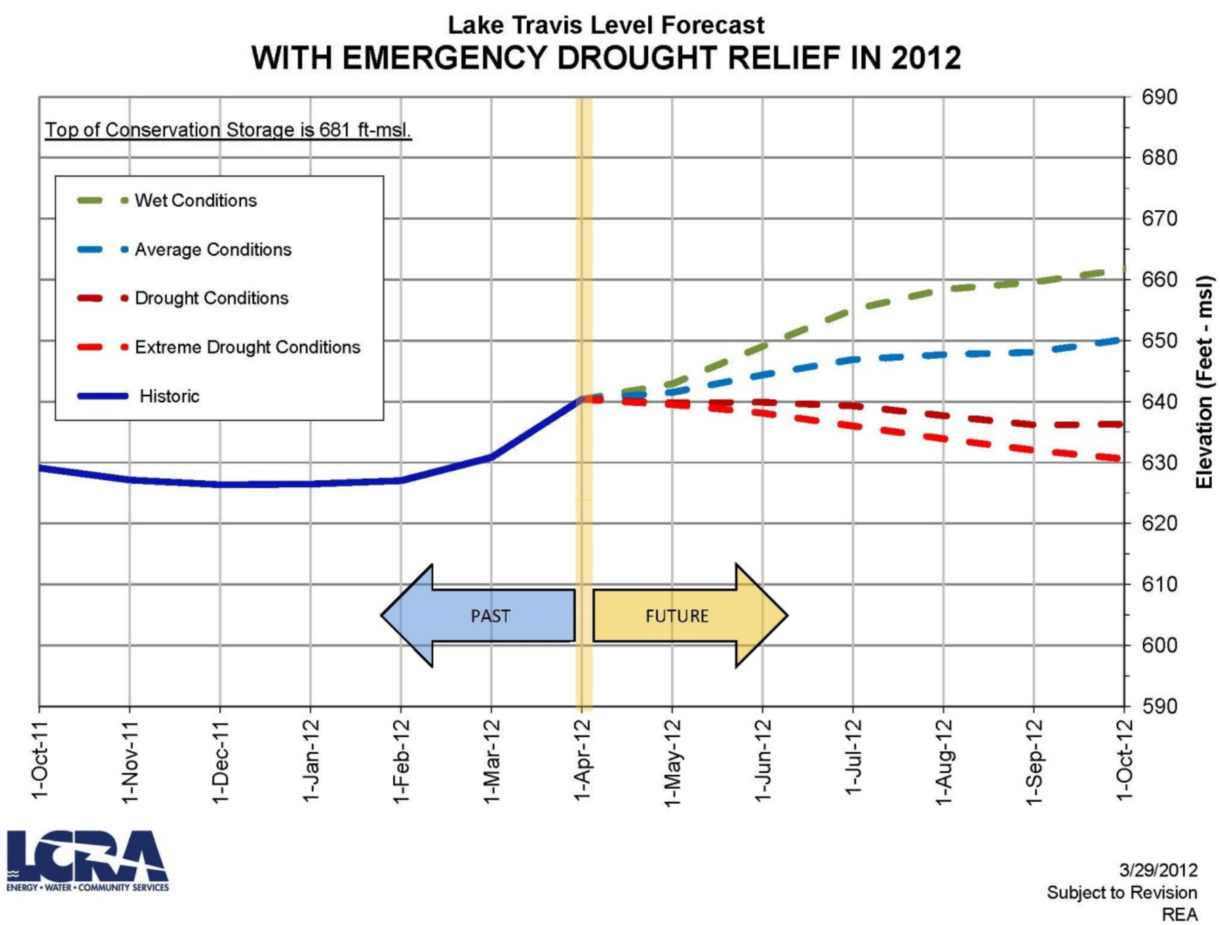


Figure 1. Lake Travis level forecast for the next six months (as of 3/29/2012)

When I saw that extreme drought conditions over six months could cause Lake Travis to drop its water level by 10 feet, I had trouble quantify that in my head. I didn't understand how powerful drought conditions can be on Lake Travis, so I wanted to quantify it. How much water from Lake Travis does the LCRA predict will be lost during extreme drought conditions over the next six months? To answer this question, I will use ArcGIS. By editing the bathymetry of Lake Travis in ArcMap to 640 feet above MSL (present conditions) and to 630 feet above MSL (predicted extreme drought conditions), I will be able to use spatial analysis to determine the change in volume. Note that the water elevations are rounded to the nearest multiple of 10 because the available bathymetry is in 10 foot contours.

Data Collecting

Before any processing could be done, I had to download the bathymetry of Lake Travis. I downloaded the ESRI shapefile of the bathymetry of all the major lakes in the CAPCOG region from http://www.capcog.org/data-maps-and-reports/geospatial-data/. I created a new folder called 'GISProject' that would hold all my data for the project and unzipped the shapefile into there. The bathymetry data was published by CAPCOG on May 29, 2009. It uses contours to depict underwater depths of the lakes. The data was created from multiple TWDB datasets in intervals ranging from 2 foot to 10 foot contours. The projected coordinate system is 'NAD_1983_StatePlane_Texas_Central_FIPS_4203_Feet' and the geographic coordinate system is 'GCS_North_American_1983'. The full metadata is provided on CAPCOG's website.

Data Preprocessing

I created a new map in ArcMap and used the 'Add Data' button to load the bathymetry file. Since the file contained contours outside of Lake Travis, I needed to create a shapefile containing only Lake Travis. I used the selection lasso to select Lake Travis, starting at the Max Starcke Dam and ending at the Mansfield Dam. After the entire lake was selected, I right-clicked the layer in the TOC and clicked the 'Export Data' under the Data option. I exported the selected features using the same coordinate system as the source data and named the shapefile 'Lake_Travis.shp'. I added 'Lake_Travis.shp' to the map. This shapefile was the base file I used for all of the spatial analysis. I removed the original bathymetry file and saved the map as Lake _Travis.mxd. **Figure 2** shows the Lake Travis layer.

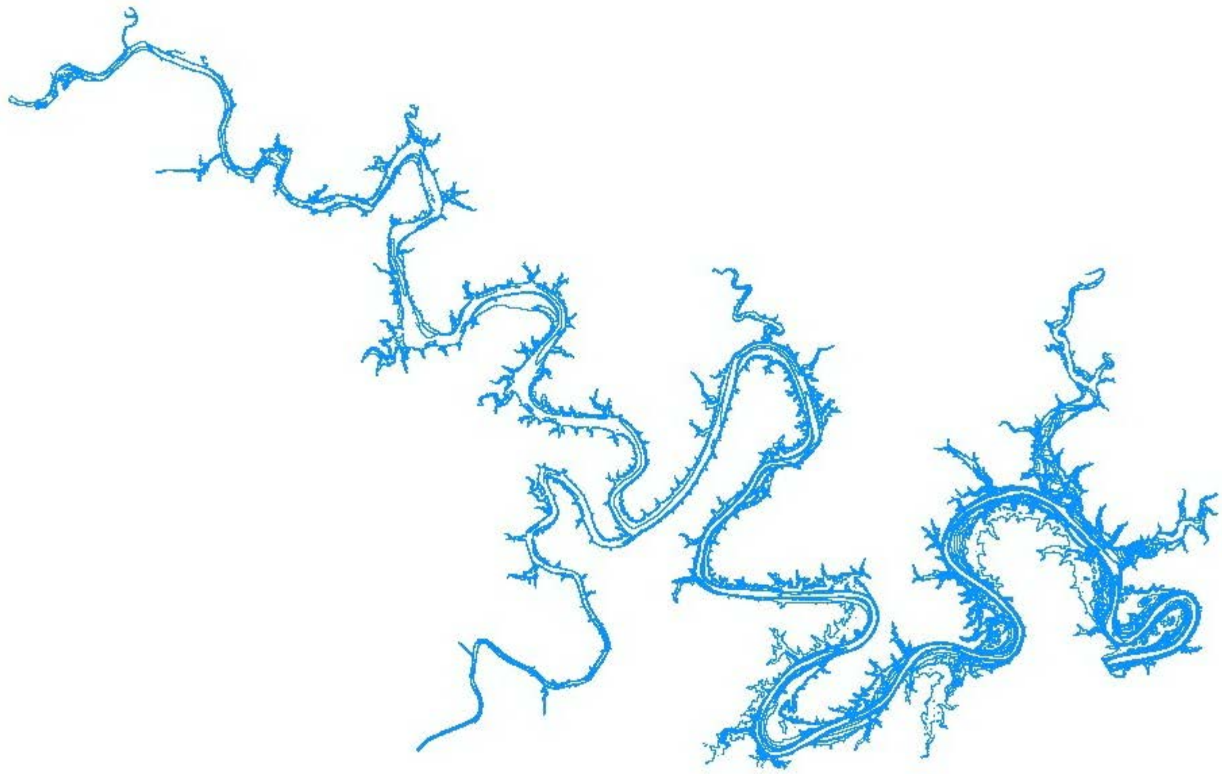


Figure 2. Lake Travis bathymetry

Data Processing

First, I used the 'Select By Attributes' option under Selection to select all contours that were 630 feet above MSL or below. **Figure 3** shows the exact settings I used.

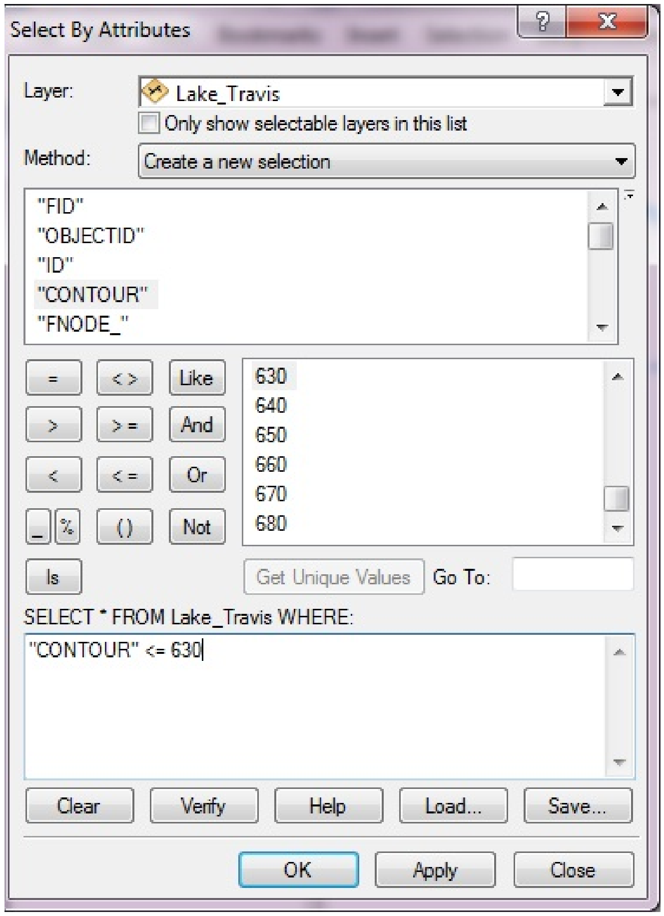


Figure 3. Selecting Lake Travis at 630 feet above MSL

After the selection was made, I right-clicked the layer in the TOC and clicked the 'Export Data' under the Data option. I exported the selected features using the same coordinate system as the source data and named the shapefile '630.shp'. This file presented Lake Travis at extreme drought conditions, six months from March 29, 2012. To begin spatial analysis, I added '630.shp' to a new map. I decided to use the 'Create TIN' tool to create a three-dimensional surface for the volume calculation because I was familiar with it. **Figure 4** shows the settings I used to create the TIN.

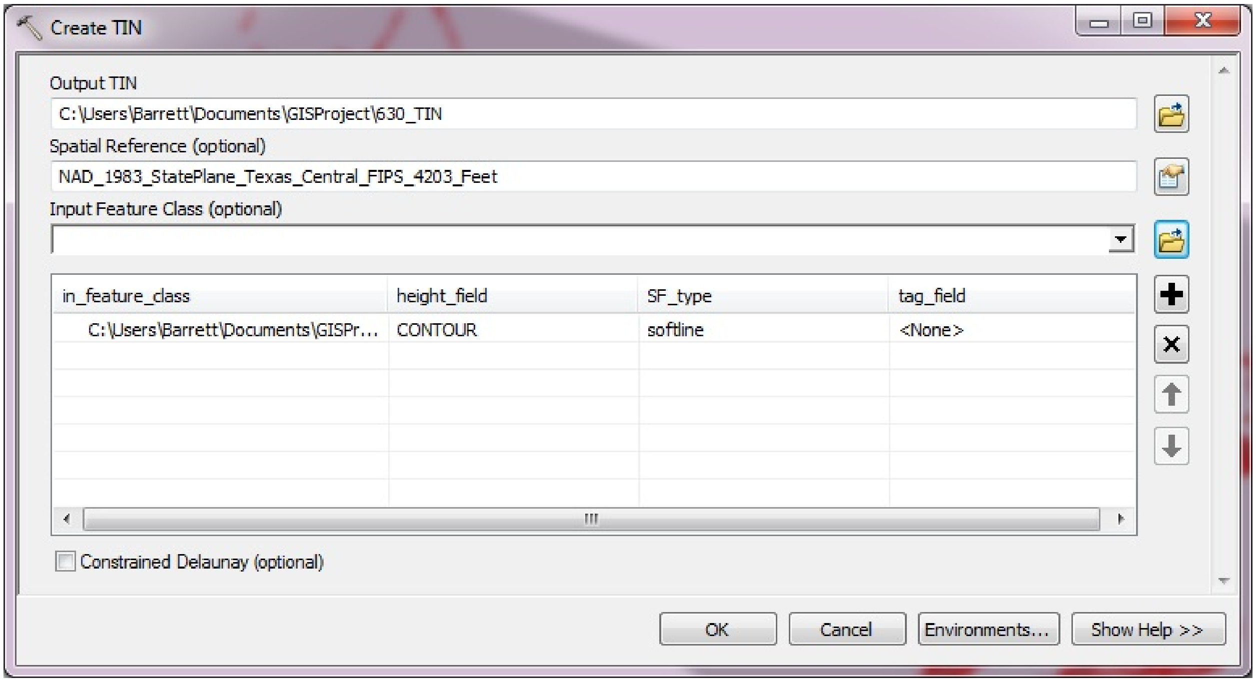


Figure 4. Creating the TIN file

I did not constrain the Delaunay triangulation because that would produce more long, skinny triangles, which is not good for surface analysis. I chose softline as the 'SF_type' to create a surface similar to the lake, which is smoothed due to sediment buildup. **Figure 5** shows the TIN that was produced.

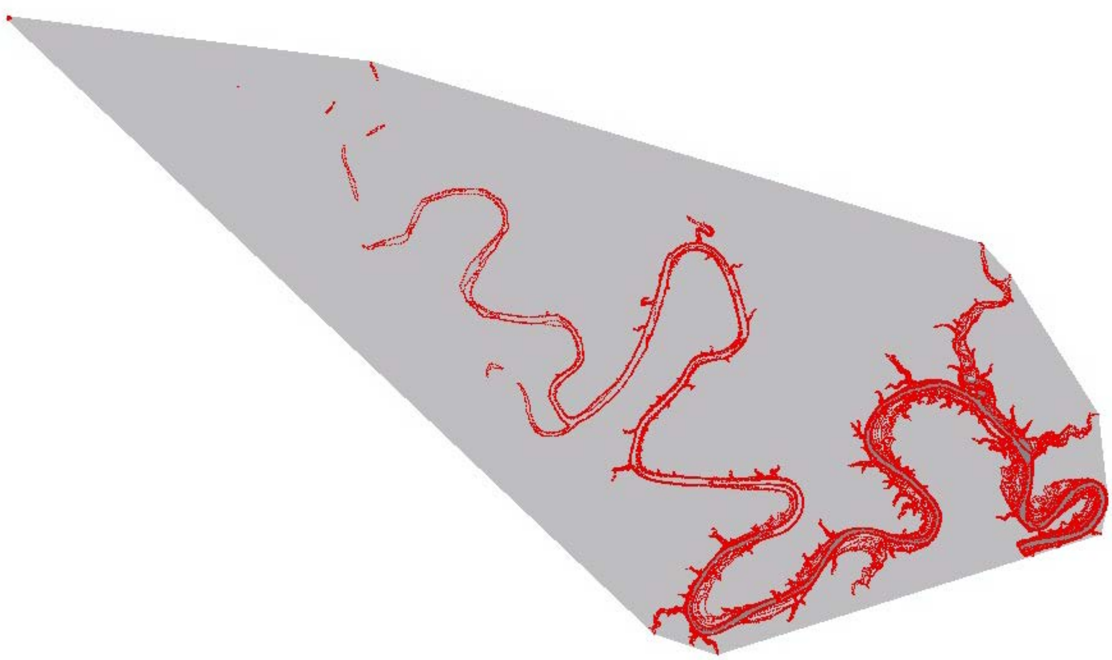
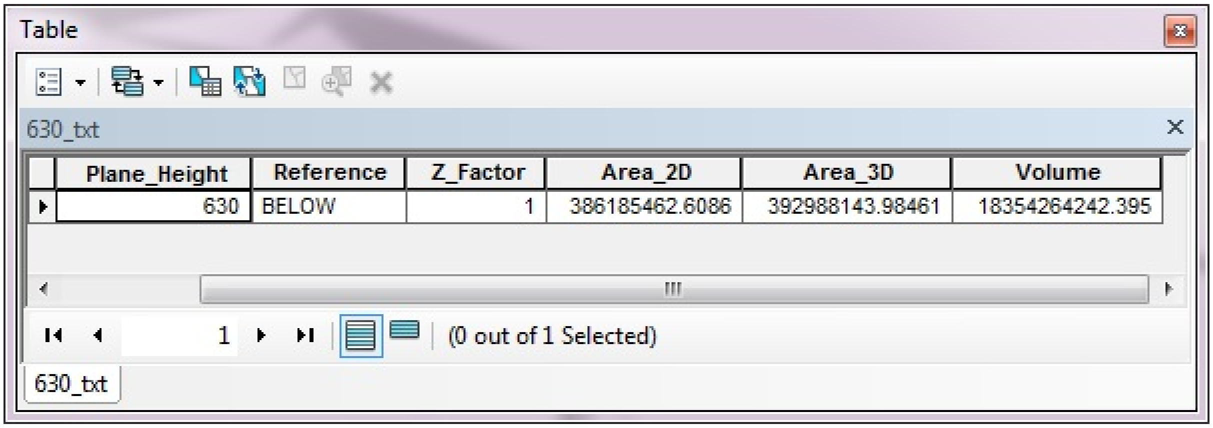


Figure 5. TIN of Lake Travis at 630 feet above MSL

Now I was able to calculate the volume of the lake. I used ‘Surface Volume’ tool to calculate the volume. In the ‘Surface Volume’ window, I set the reference plane to ‘BELOW’ and left the Z factor at 1 to keep the units in cubic feet. **Figure 6** shows the results.



Plane_Height	Reference	Z_Factor	Area_2D	Area_3D	Volume
630	BELOW	1	386185462.6086	392988143.98461	18354264242.395

Figure 6. Calculation of volume of Lake Travis

I converted the volume from cubic to acre feet by multiplying the number in the Volume column by $2.295683411\text{x}10^{-5}$. I repeated all the steps starting at ‘Data Processing’ in this paper, but with Lake Travis at 640 feet above MSL, the height of Lake Travis on March 29, 2012.

Results

According to my calculations, Lake Travis on March 29, 2012 contained **517,589.730 acre feet of water** while at 640 feet above MSL. If Lake Travis is under extreme drought conditions from March 29, 2012 to October 1, 2012, the LCRA predicts Lake Travis will contain **421,355.928 acre feet of water** while at 630 feet above MSL. That is a total loss of **96,233 acre feet of water** lost over six months, **18.6%** of its volume. If Lake Travis continued to lose 96,233 acre feet of water every six months, it would take less than 3 years for the lake to be dry. **Figure 7** and **Figure 8** show the shoreline of Lake Travis at both the levels observed to visually compare how the lake would change.

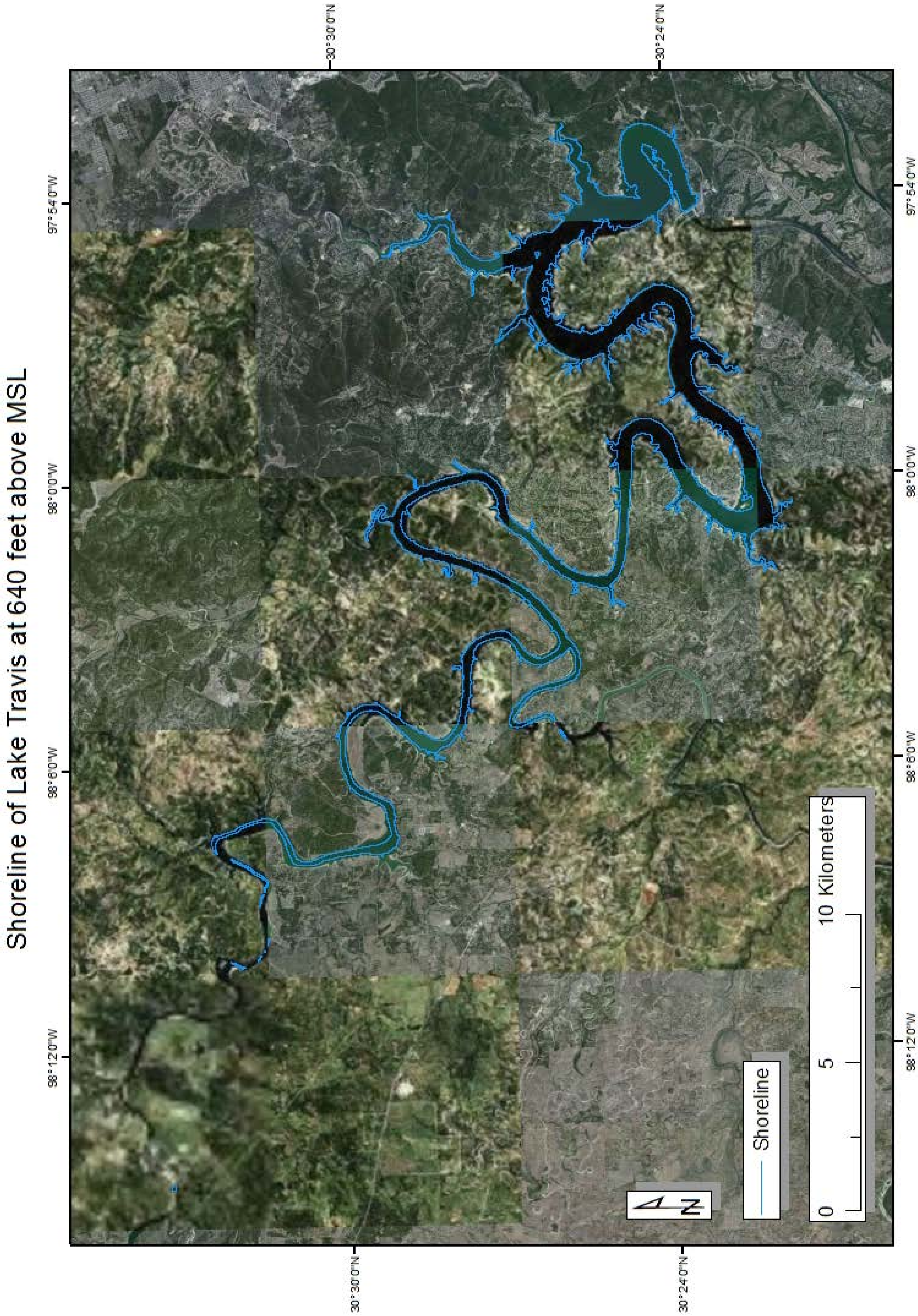


Figure 7. Lake Travis shoreline on March 29, 2012

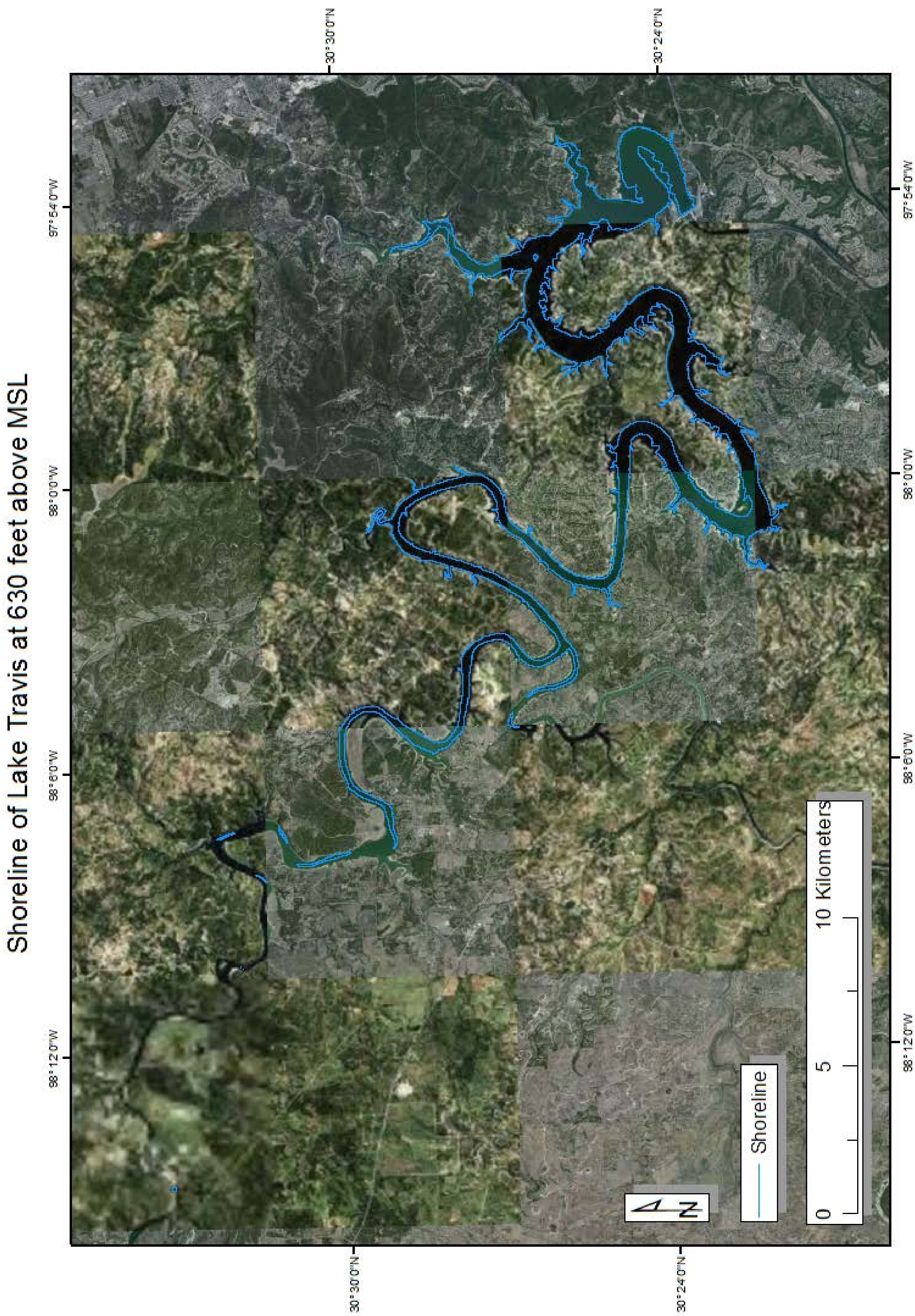


Figure 8. Predicted Lake Travis shoreline after six months of extreme drought conditions

Conclusion

It was surprising to see how much water Lake Travis could lose in six months. Although many factors go into the LCRA prediction, the results give me a better idea of extreme drought conditions. The shoreline did not change much, except far upstream. Note that far upstream is not an accurate shoreline, since base elevation changes and water would be flowing from further up the Colorado River. ArcGIS was essential in this project and these methods can be applied elsewhere, where volume calculations are needed.