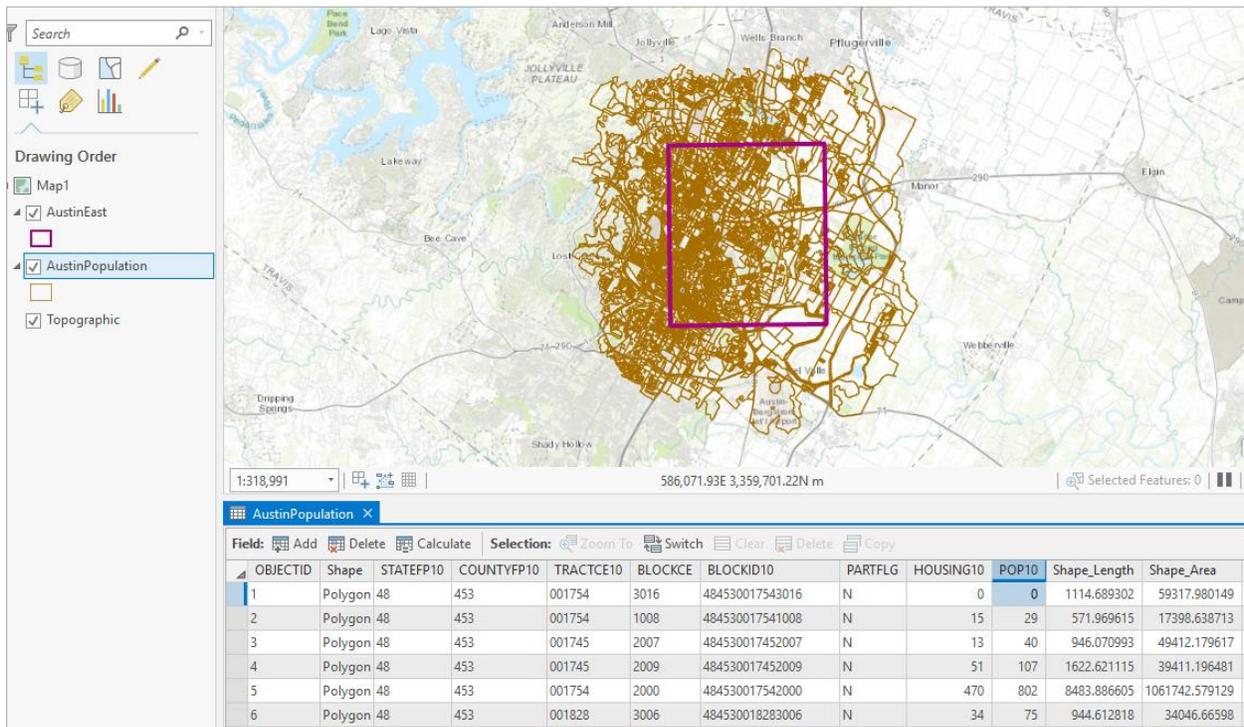


3. Austin Population

The figure below shows two feature classes, one being the extent of the 1:24,000 Austin East topographic map and the other being Census blocks from the 2010 census of the United States. The blocks shown are those within 5 Km of the Austin East map extent. The data are projected into UTM coordinates in a geodatabase and ArcGIS project that can be obtained at:

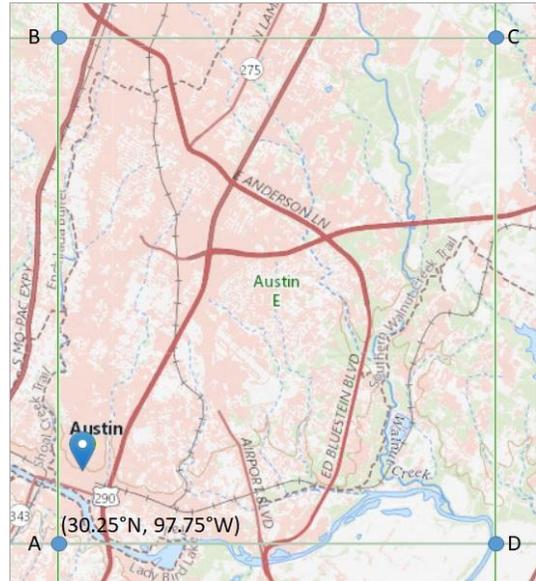
<http://www.caee.utexas.edu/prof/maidment/giswr2018/austin/austin.zip>



The following figure shows additional detail on the extent of the 1:24,000 Austin East topographic map which covers 7.5' x 7.5' (7.5 minute x 7.5 minute) of latitude and longitude.

- (a) The location of point A in the lower left corner of the map is shown. What are the (latitude, longitude) coordinates of the points B, C, D shown in the map in decimal degrees? Complete the table.

Point	Location (Latitude, Longitude)
A	(30.25°N, 97.75°W)
B	(30.375°N, 97.75°W)
C	(30.375°N, 97.625°W)
D	(30.25°N, 97.625°W)



**Solution:** 7.5' of latitude or longitude corresponds in decimal degrees to  $7.5/60 = 0.125^\circ$ . Hence, by incrementing the coordinates for Point A by this amount, the coordinates for Point C are  $\phi_c = \phi_a + 0.125 = 30.25 + 0.125 = 30.375^\circ$  or  $30.375^\circ\text{N}$ , and  $\lambda_c = \lambda_a + 0.125 = -97.75 + 0.125 = -97.625^\circ$  or  $97.625^\circ\text{W}$ . The coordinates for points B and D are computed similarly and the values entered into the table above.

- (b) If the radius of the earth is 6371 Km, determine the lengths AB, BC, CD, and DA in Km. Complete the table.

Line	Length (Km)
AB	13.899
BC	11.992
CD	13.899
DA	12.007

**Solution:** Along the meridian lines, AB and CD, the length, L, is given by

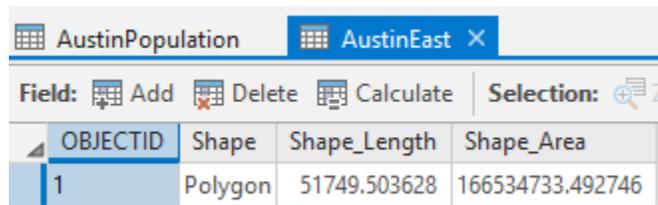
$L = R_e \Delta\phi$ , where  $\Delta\phi = 0.125^\circ * (\pi/180)$  radians = 0.002182 radians. Hence  $L_{AB} = L_{CD} = 6371 * 0.002182 = 13.899$  Km. For the lengths along the parallels,  $L = R_e \Delta\lambda \cos\phi$ , where  $\Delta\lambda = 0.125^\circ = 0.002182$  radians as before. Hence  $L_{AD} = 13.899 * \cos(30.25^\circ) = 13.899 * \cos(0.5279 \text{ radians}) = 13.899 * 0.8638 = 12.007$  Km. Similarly,  $L_{BC} = 13.899 * \cos(30.375^\circ) = 13.899 * \cos(0.5301 \text{ radians}) = 13.899 * 0.8627 = 11.992$  Km.

(c) Determine the area ABCD (Km<sup>2</sup>).

**Solution: Area = 13.899 \* (11.992 + 12.007)/2 = 13.899 \* 11.999 = 166.78 Km<sup>2</sup>**

(d) Compare the area for the Austin East map extent that you obtained above with the value given in the ArcGIS geodatabase.

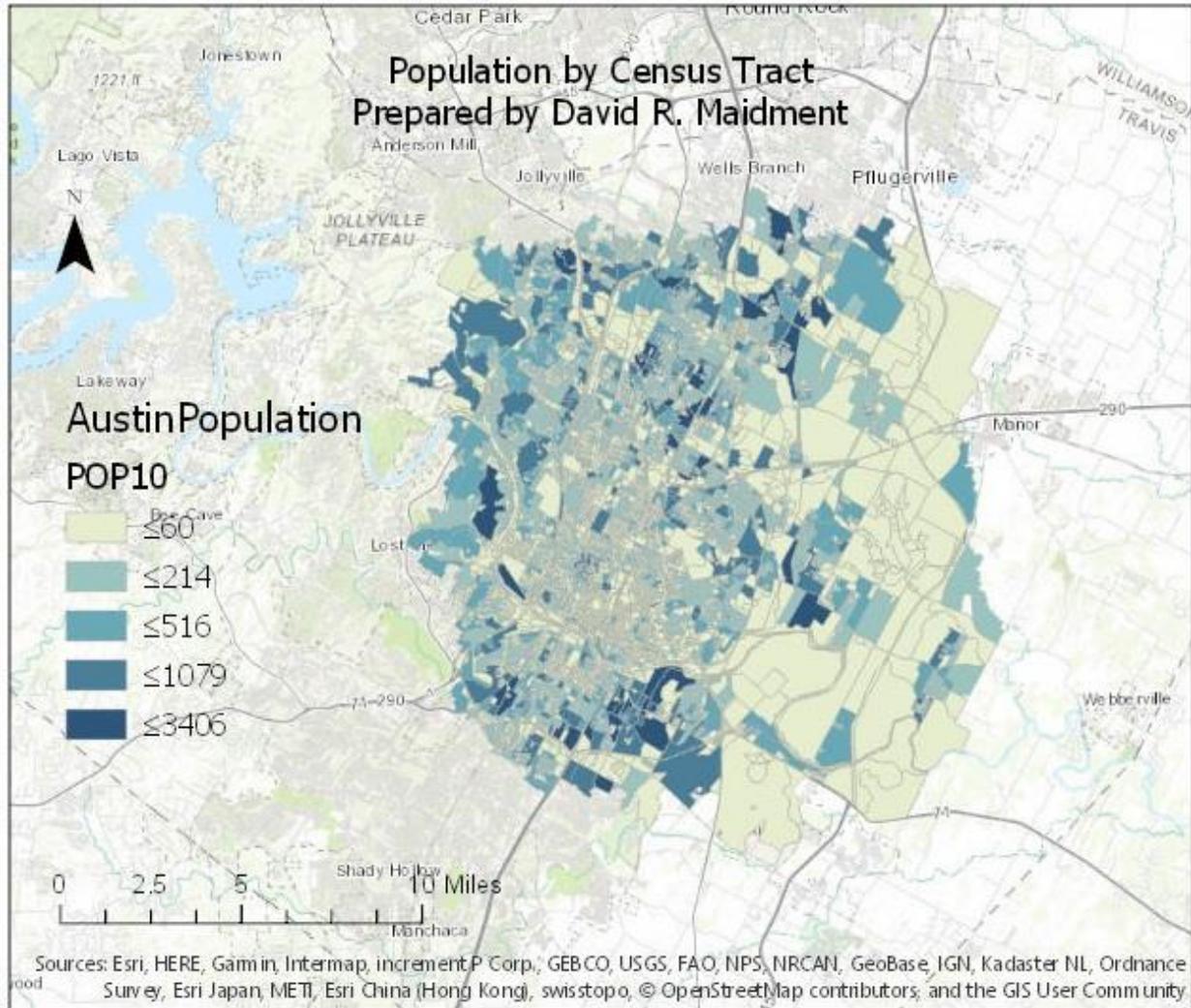
**Solution: The ShapeArea value is 166534733 m<sup>2</sup>, or 166.53 Km<sup>2</sup>. This is very similar to the value computed in (c).**



OBJECTID	Shape	Shape_Length	Shape_Area
1	Polygon	51749.503628	166534733.492746

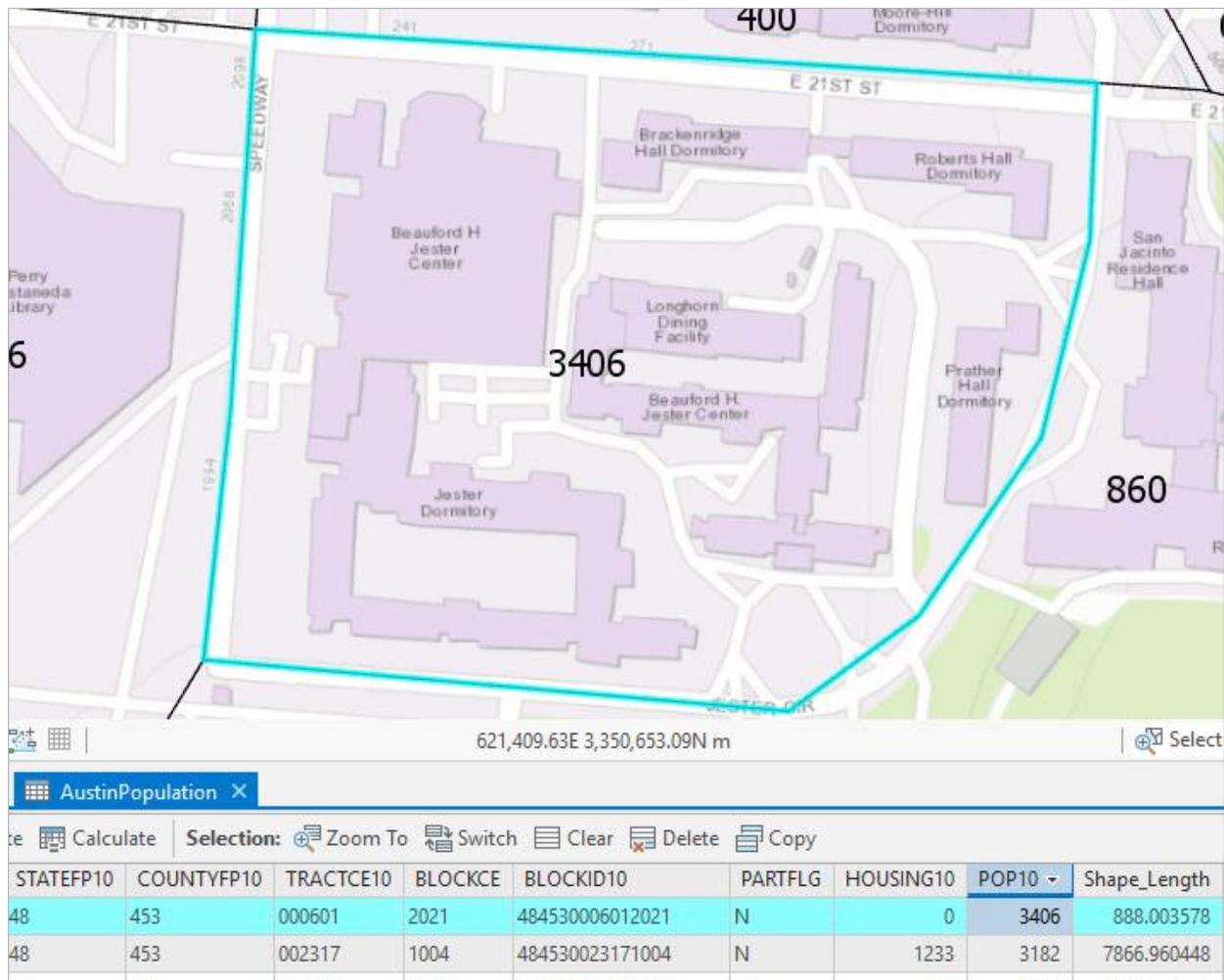
(e) The attribute **Pop10** in the AustinPopulation feature class gives the population in each census block. Make a map and layout that shows the population distribution across this area of Austin.

**Solution: The map and Layout are shown on the next page.**



(f) Find the census block with the highest population. What is this population? What is located in this block that makes this so?

**Solution: The census block with the highest population is 484530006012021 with a population of 3406, as shown in the image on the next page. There are four student dormitories on the University of Texas campus in this census block (Jester, Brackenridge, Roberts, Prather). The entire residential population in this census tract comprises students living in dormitories. Effectively, the population of a small town lives within this single census block during the academic year.**

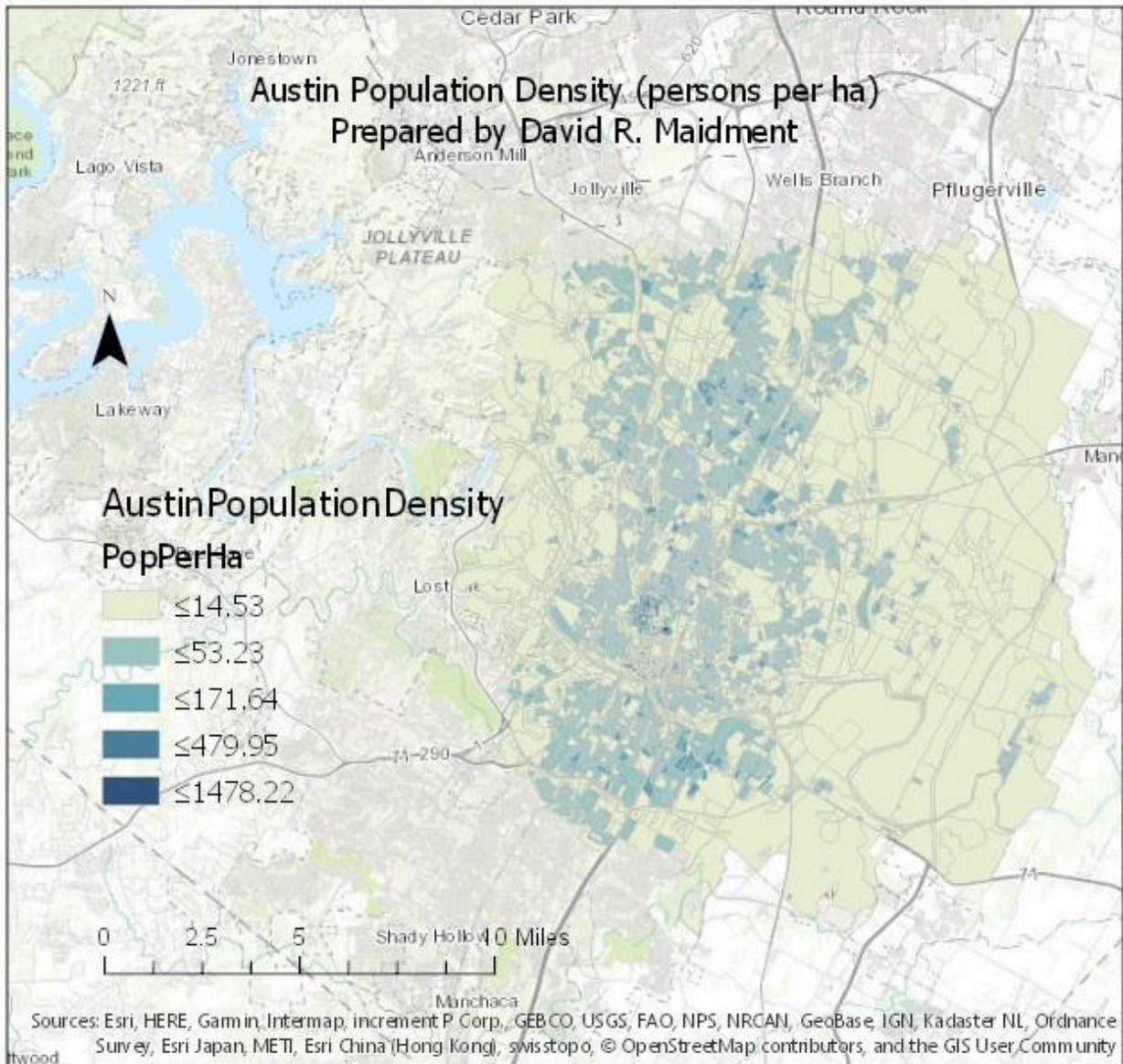


(g) Calculate the population density in persons/hectare (1 hectare = 10,000 m<sup>2</sup>). Make a map and layout that shows the population density across this area of Austin. Discuss the differences between population distribution (e) and population density maps. Indicate which better depicts the spatial pattern of population and why.

**Solution:** To avoid conflicts with my previous map layout, I added AustinPopulation to the map display a second time and renamed it AustinPopulationDensity. I added two new fields (Type Double) to the attribute table of this feature class and called them Hectare and PopPerHa, respectively. I set the number of decimal places for these fields to 2 to make the data more interpretable. I computed Hectare = ShapeArea / 10000 since 1 Ha = 10,000 m<sup>2</sup>. I then computed PopPerHa = Pop10 / Hectare. For example, for the census block described in part (f), Hectare = 50505.999 / 10000 = 5.05 and PopPerHa = 3406 / 5.05 = 674.38 persons per ha.

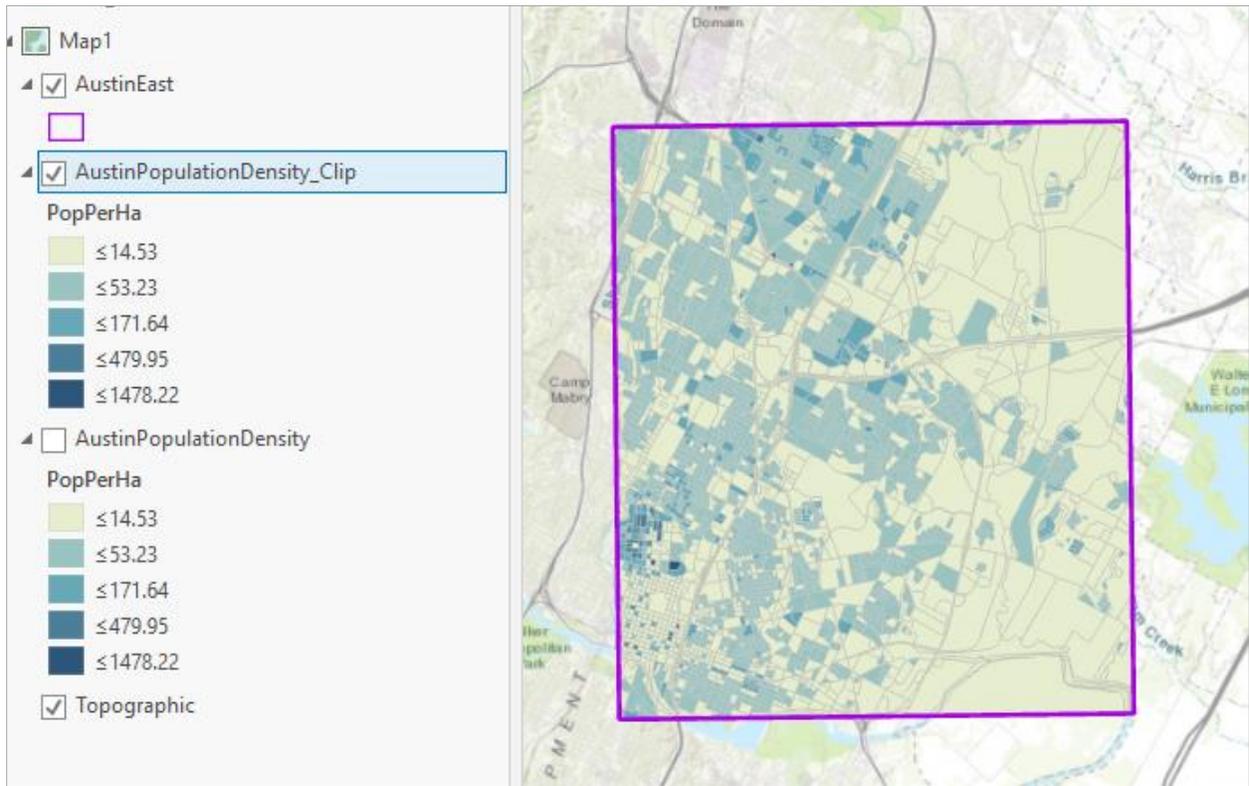
JNTYFP10	TRACTCE10	BLOCKCE	BLOCKID10	PARTFLG	HOUSING10	POP10	Shape_Length	Shape_Area	Hectare	PopPerHa
	000601	2021	484530006012021	N	0	3406	888.003578	50505.99939	5.05	674.38
	002317	1004	484530023171004	N	1233	3182	7866.960448	1229041.294649	122.9	25.89

The map and layout of population per hectare is shown below. I think that compared to the map in section (e), this map more correctly shows the denser population in the center of the City of Austin and the lesser population density away from the center of the city.



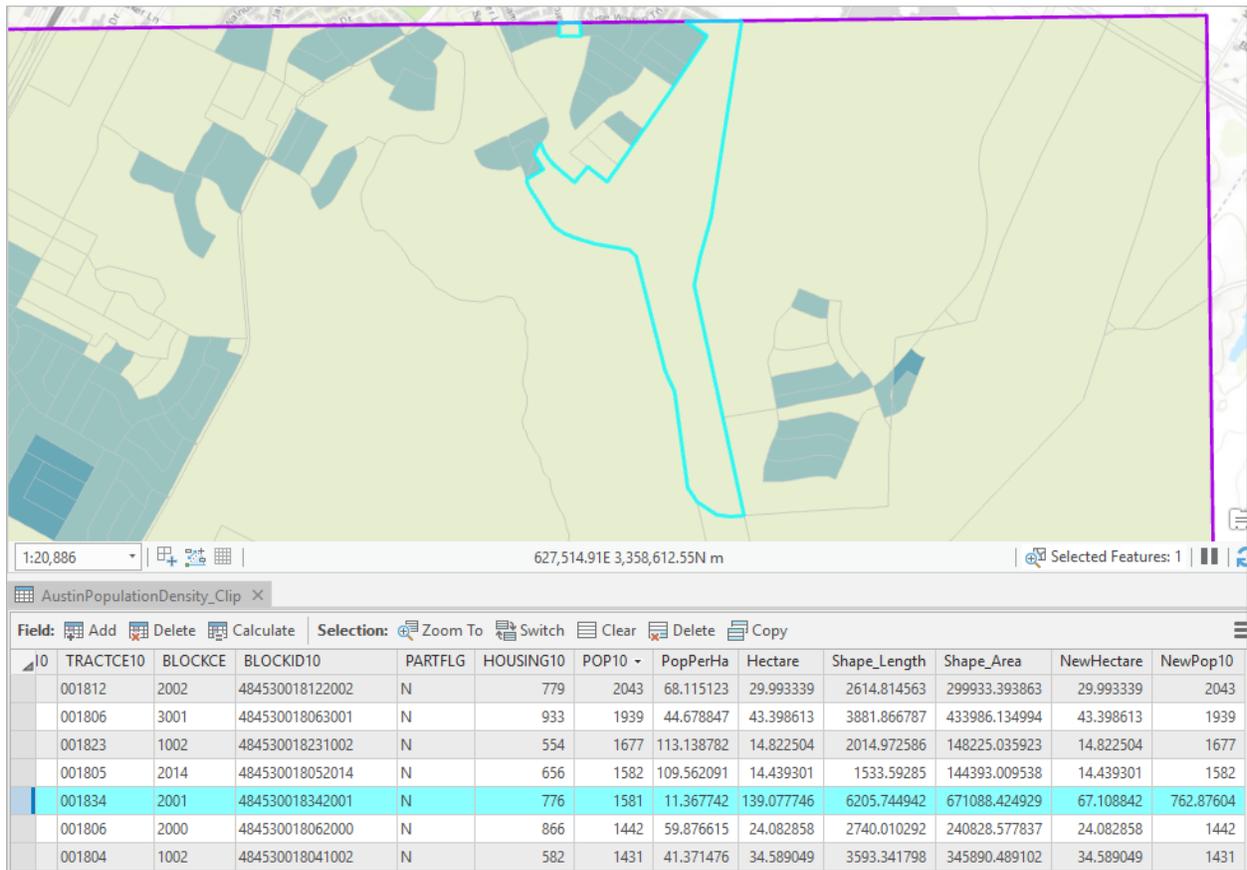
- (h) Calculate the population living in 2010 within the **extent of the Austin East map**. Round off your final answer to an integer value. Show your working and explain how you dealt with census blocks lying across the boundary of the Austin East map extent.

Solution: I used the Clip (Analysis Tools) geoprocessing function to isolate the census blocks lying either wholly or partly within the Austin East map extent.



**In the resulting feature class, *AustinPopulationDensity\_Clip*, I created a new field called  $\text{NewHectare} = \text{ShapeArea} / 10000$ , and then a new population field called  $\text{NewPop10} = \text{PopPerHa} * \text{NewHectare}$ . As shown in the image on the next page, this results mostly in area values in hectares that are the same as before (for census blocks that are in the interior of the Austin East map extent), but that for census blocks on the boundary, the *NewHectare* and *NewPop10* values are smaller than the ones that were there before. These are also indicated by *NewPop10* values that have decimal places. For example, for Census Block 483530018342001, the *Pop10* value is 1581 people in 139.07 ha, and for the clipped coverage the *NewPop10* value is 762.87 people on a *NewHectare* area of 67.11 ha. Obviously, there cannot be fractional people even in a clipped census block, so we'll round the total population up to the nearest integer. Running a Summary Statistics function on the *NewPop10* attribute yields a total 2010 population of 245,338 people within the Austin East map extent.**

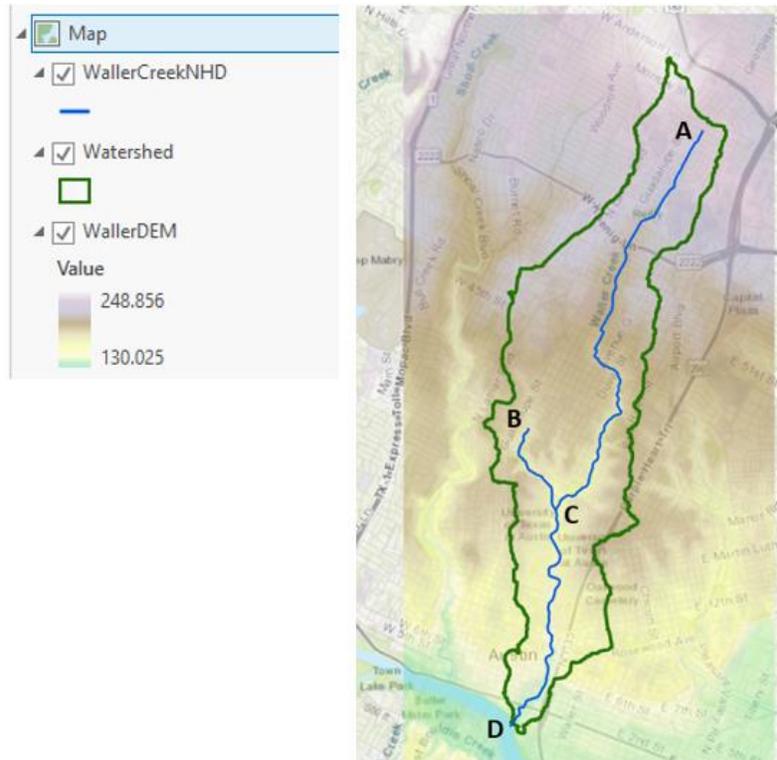
OBJECTID	FREQUENCY	SUM_NewPop10
1	3733	245337.827313



*Show and explain the work done in performing each calculation. Don't just state the result.*

#### 4. Waller Creek

Waller Creek is the Creek that drains the area of Austin containing UT Austin. The figure below shows Waller Creek streams as mapped by NHD.

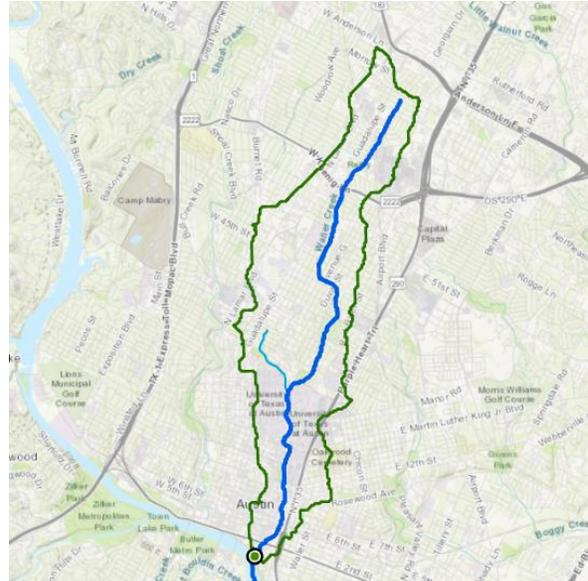


The file austin.zip provided for problem 3 includes a 10 m digital elevation model (DEM) for this area obtained from the National Map (WallerDEM) and the NHD streams within the Waller Creek Watershed, both projected into UTM coordinates.

- (a) Obtain the Waller Creek Watershed upstream of the point (D on the map) where it drains into the Colorado River and determine its drainage area ( $\text{Km}^2$ ). You may use any watershed delineation method you know or have learned in this class.

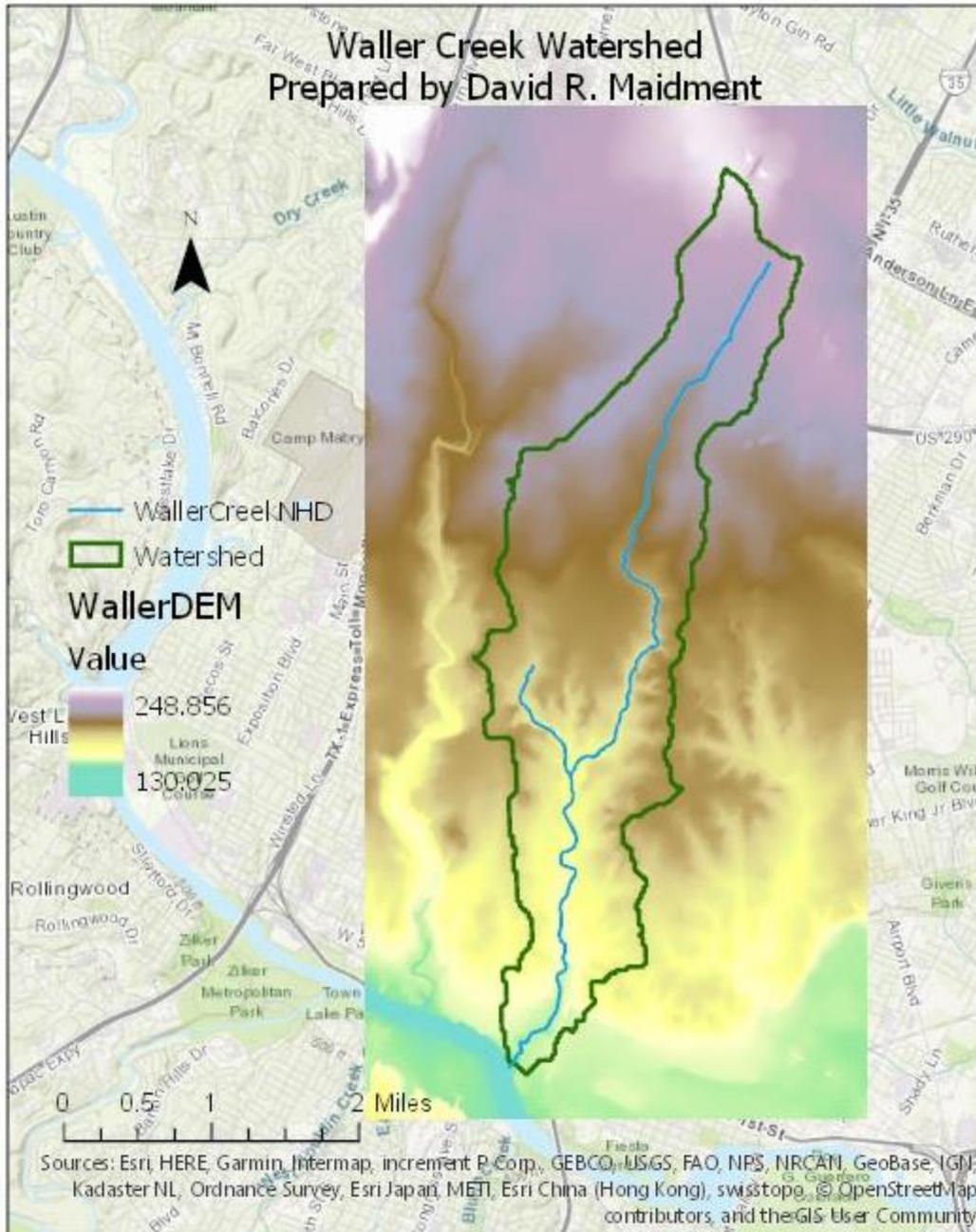
**Solution:** I used the Hydrology tools within the Geoprocessing Portal and used a Trace Downstream on the FINEST resolution topography (which turns out to be a 30m DEM) to identify where the DEM stream is located for Waller Creek. Then I used the Watershed tool with an outlet point placed at the intersection of Waller Creek with a bicycle path bridge near the junction of Waller Creek with Lady Bird Lake. The area of the delineated watershed is 14.29  $\text{Km}^2$ .

OBJECTID	Shape	Pour Point ID	Description	Data Resolution	Area Square Kilometers	Shape_Length	Shape_Area
1	Polygon	1	NED 30m processed...	30.0	14.2893	30840	14289300



(b) Prepare a map of the Waller Creek Watershed (as a polygon) and the NHD stream network within Waller Creek Watershed. Depict the topography within this watershed in a nice way. Present this map as a layout with appropriate title, legend and scale.

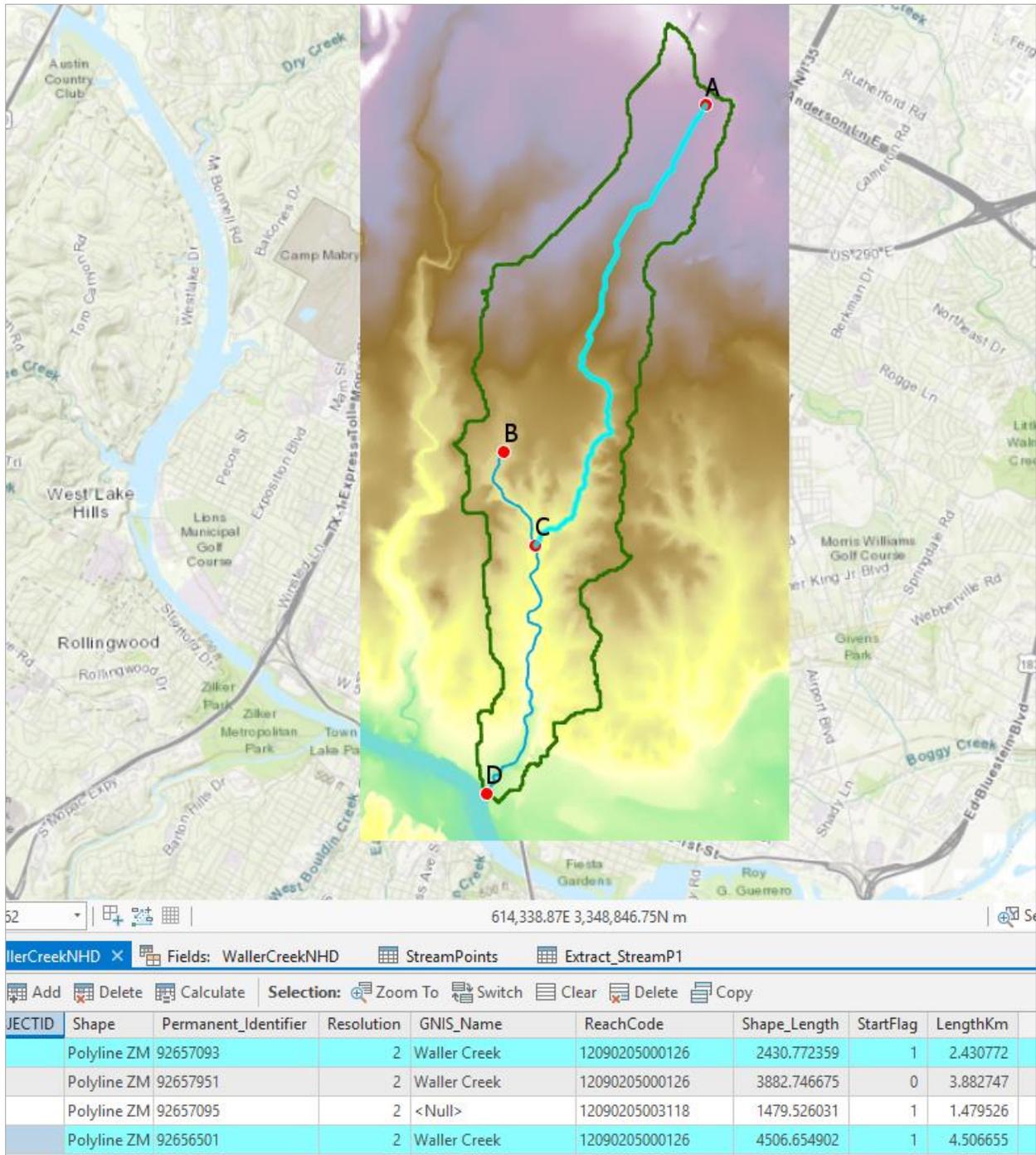
**Solution: this map is shown on the next page.**



(c) Determine the length (Km) of each of the NHD stream sections AC, BC and CD.

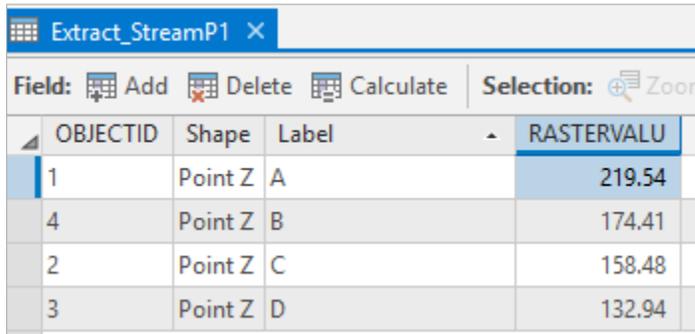
**Solution:** I added a field called LengthKm to the WallerCreekNHD feature class and computed its values as  $\text{LengthKm} = \text{ShapeLength} / 1000$ . It turns out that there are four line features in this feature class, of which BC and CD are comprised of a single line feature while AC comprises two line features, as shown in the map on the next page. The LengthKm for line AC =  $2.43 + 4.51 = 6.94$  Km. The values for BC and CD are just read from the attribute table as 1.48 Km and 3.88 Km, respectively.

Line	Length (Km)
AC	6.94
BC	1.48
CD	3.88



(d) Calculate the slope of each of the NHD stream sections AC, BC, and CD.

**Solution:** I created a new point feature class called StreamPoints at locations A, B, C, D and used the Extract by Value geoprocessing function to determine the values of the Digital Elevation Model at these locations (called RasterValu) in the table below. These are elevations above geodetic datum in meters.



OBJECTID	Shape	Label	RASTERVALU
1	Point Z	A	219.54
4	Point Z	B	174.41
2	Point Z	C	158.48
3	Point Z	D	132.94

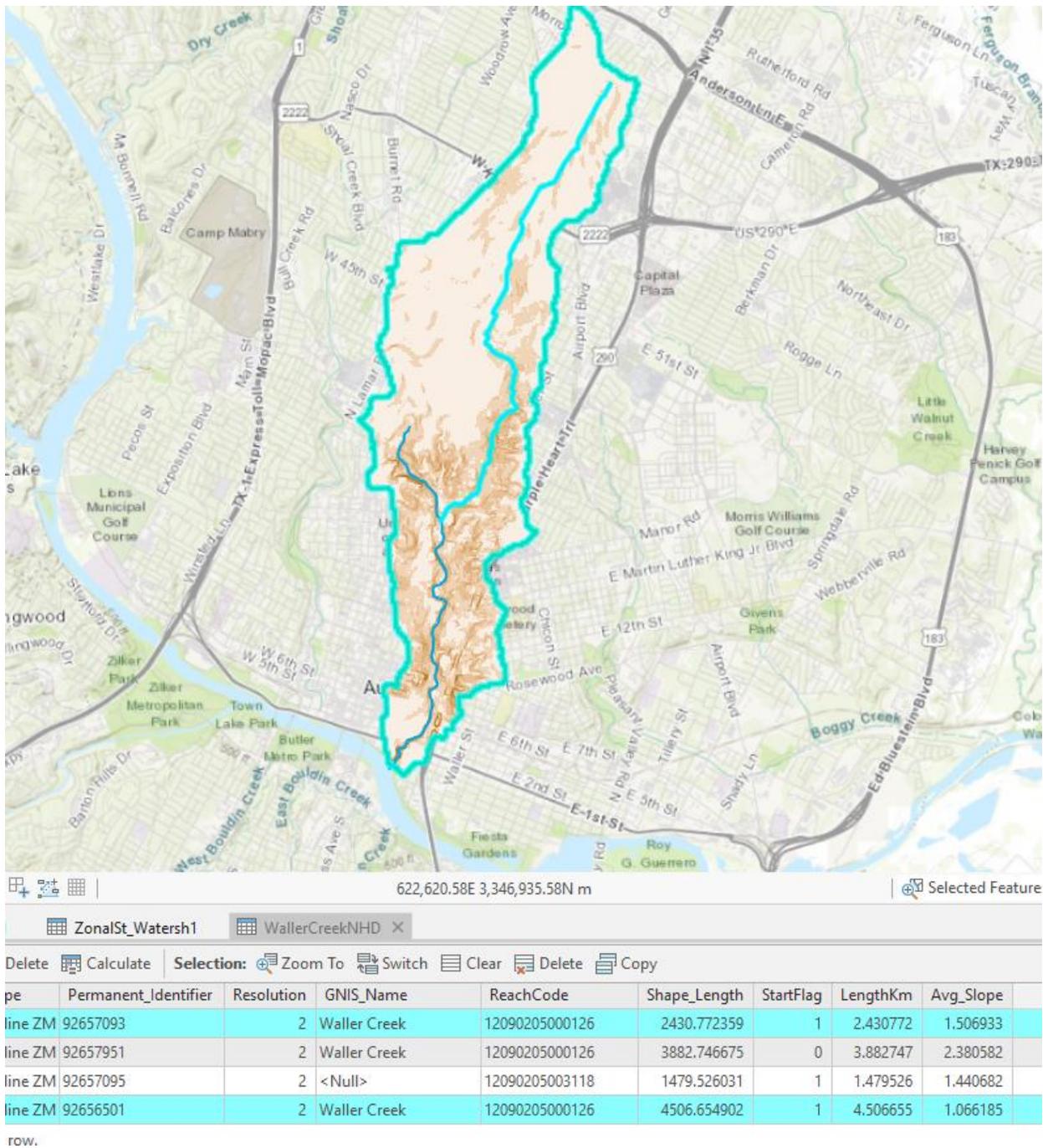
These values are added to the table below as upstream or downstream elevations for the corresponding lines, and the slope as a percentage value computed as  $\text{Slope (\%)} = ((\text{UpElev} - \text{DownElev}) / (\text{Length} * 1000)) * 100$ . The resulting values are given in the table below. These values are around 1% for stream slope, which is reasonable for the Austin area.

Line	Length (Km)	Up Elev (m)	Down Elev (m)	Slope (%)
AC	6.94	219.54	158.48	0.88
BC	1.48	174.41	158.48	1.08
CD	3.88	158.48	130.68	0.72

There is an alternative approach called “Add Surface Information in the 3D Analyst, which computes the slope along a line that has a DEM underlying it. The results of applying this tool are shown on the next page. For line AC, a weighted average of the line slopes are needed since there are two lines, and  $\text{slope} = (2.431 * 1.506 + 4.507 * 1.066) / 6.94 = 1.22$

Line	Length (Km)	Slope (%)
AC	6.94	1.22
BC	1.48	1.44
CD	3.88	2.38

These results are significantly different than those computed by the taking the end points model. They represent somewhat different interpretations as to what stream slope means. I decided to accept either version as correct.



(e) Calculate the average slope of the topographic surface within Waller Creek Watershed.

**Solution:** I used Extract by Mask to isolate the DEM values for the Waller Creek Watershed only. Then I computed the Slope using the Spatial Analyst Slope function with the Planar method. This means it uses Cartesian coordinates for (x,y,z) for all the computations, which is ok since the map units are in meters and the elevation values on the DEM are also in meters. I summarized the result using the PercentRise option which gives

slope values in %, comparable to those computed in part (d). Then I used Zonal Statistics as Table, to compute the mean value of the slope in this watershed. This yields a mean value for the slope of 3.68%. Indeed I could have gotten to the same result by computing the slope over the whole DEM and then summarizing the statistics of the cells within the watershed using Zonal Statistics as Table function. It is reasonable to find that the slope of the streams within a watershed is less than the slope of the watershed that drains to them.

Statistics

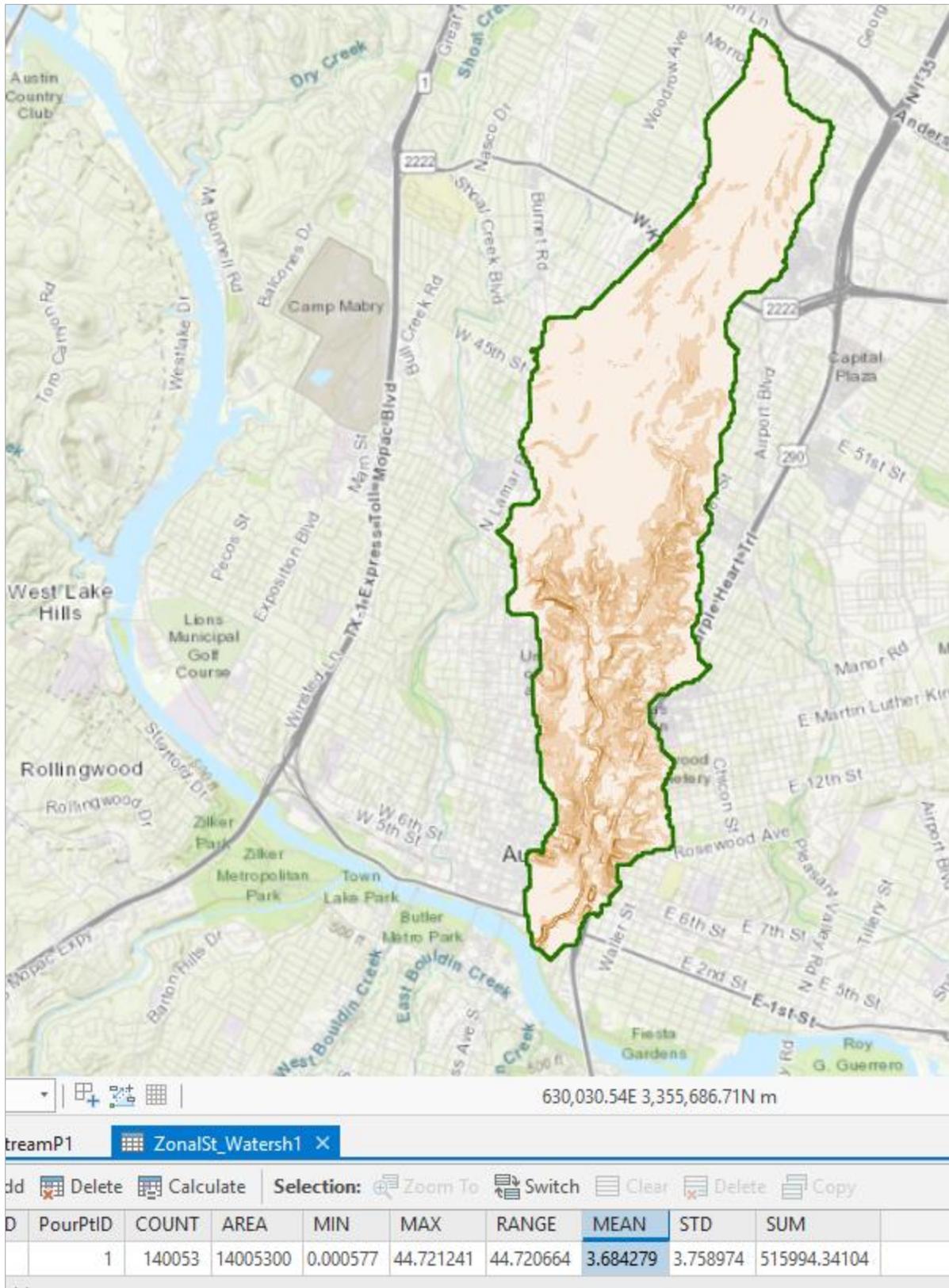
Build Parameters: skipped columns: 1, rows: 1, ignored value(s):

Band Name	Minimum	Maximum	Mean	Std. Deviation
Band_1	0.00057663791	44.7212409973	3.68427910177	3.75898743389

If the result is summarized in degrees, the corresponding table is

Band Name	Minimum	Maximum	Mean	Std. Deviation
Band_1	0.000330389186274	24.0947875976563	2.1041109346847	2.12612827385517

And the average slope is 2.1°.



Show and explain the work done in performing each calculation. Don't just state the results.