

Introduction to ESRI's ArcGIS II

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2017 CSDE Workshop

The goal of today's exercises is to expand on the general overview provided by the Intro to GIS I workshop. Topics covered will include acquiring GIS and census data, synthesizing multiple data sources, and basic GIS analysis. We will move more quickly through topics discussed in the prior workshop. Please feel free to **ask questions** as we proceed if something doesn't make sense, and certainly be vocal if you find you've missed a step.

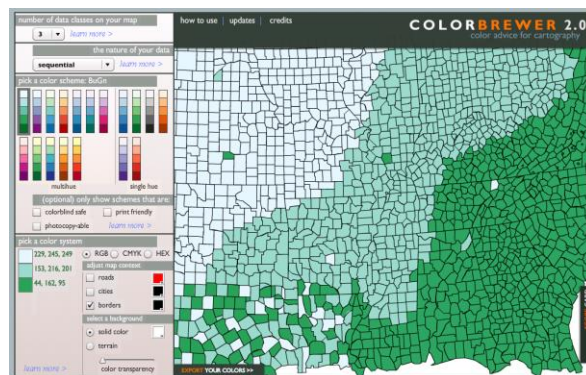
Recap

GIS - Geographic Information Systems: An integrated collection of computer software and data used to view and manage information about geographic places, analyze spatial relationships, and model spatial processes. A GIS Provides a framework for gathering and organizing spatial data and related information so that it can be visualized and analyzed.

Geography – The science of understanding space and place. “Geospatial” technologies, like GIS, allow us to conduct Geography.

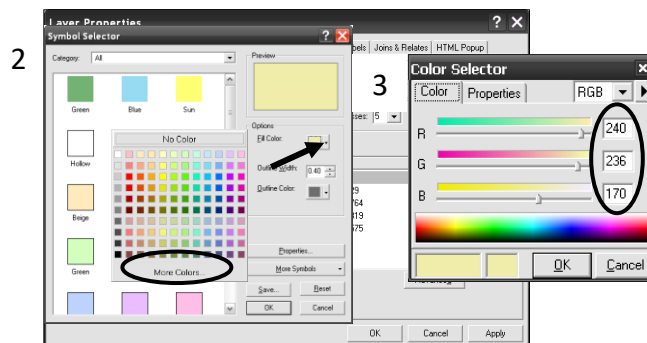
Website: ColorBrewer
(<http://colorbrewer2.org/>)

An online tool designed to help people select good color schemes for maps and other graphics. (Additional mapping guidance at www.typebrewer.org)



Setting Colors in ArcMap - 1) Select a color in the Layer Properties-Symbology Tab, 2) in Fill Color select “More Colors...”, and 3) Enter the color value (RGB or CMYK) from Color Brewer or any other reference source.

*See workshop web page for instructions on loading entire ColorBrewer style into ArcGIS



Exercise Setup

1. Go to the following web site: <http://csde.washington.edu/>. Navigate to **Training->Workshops**, and select the **Introduction to GIS** link, then click the: **EPI Scholars Part 2** link from the Materials section.
2. From “**CSDE_Intro_to_GIS2_EPI.zip**”, extract the complete “**csde_gis2_EPI**” folder into the folder “**C:\temp**”.

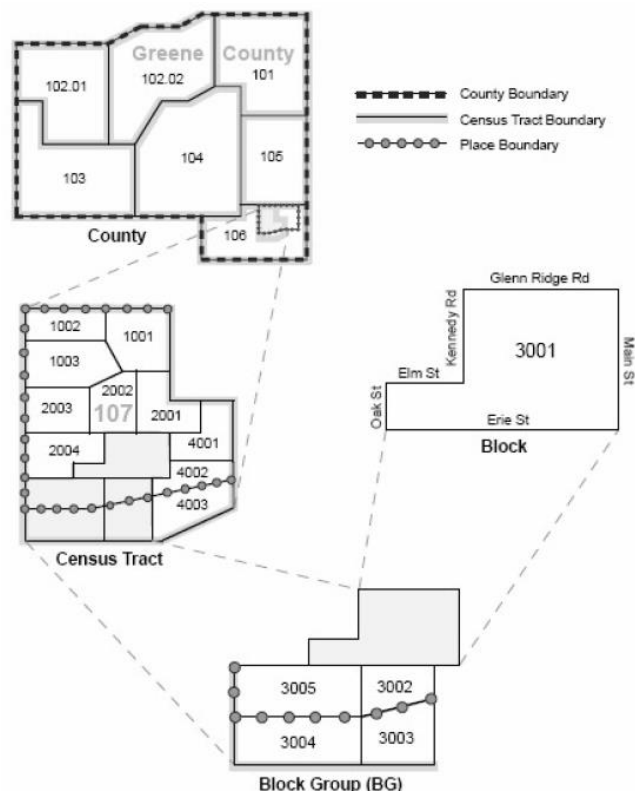
Exercise 1 – Mapping the Youth (Percent Pop Under Age 18) in King County, WA

This exercise will focus on how to acquire demographic data files and the spatial data containing the associated statistical areas. Data will be accessed from the US Census Bureau's American Fact Finder (AFF) and the King County, WA, GIS Data Portal.

To analyze census data, you need two components: (1) The statistical areas as spatial data layers in a GIS compatible format, and (2) The desired demographic data associated with those areas. Think of the demographic data as what you “pour into” your statistical areas.

The Census Bureau collects data for political areas and statistical areas. Political areas include American Indian Reservations, cities, counties, and states. Statistical areas include Census Tracts, Block Groups, and Blocks. Blocks in a city or town are usually the same as a typical city block, bounded on all sides by streets. Blocks in a rural area may be much larger in area, and may be bounded by roads, streams, or a railroad. Groups of blocks are called Block Groups. Groups of Block Groups are called Census Tracts. Census Tracts nest within counties (or parishes in Louisiana, boroughs in Alaska).

Census tracts are analogous to neighborhoods; block groups (sub neighborhood scale) are the smallest statistical area for which the more detailed Census data is available. Diagram shows census statistical area hierarchy.



Exercise 1A: Acquire & Prepare Geographic Information

The goal for this portion of the exercise will be to acquire census block group geographic data for King County, WA and to prepare it for map making by removing water bodies. There is a lot of freely available GIS data on the web - unfortunately, it is not located in one, centralized place. Individual state, county, and local governments have online GIS repositories or data centers. Many colleges and universities maintain online geospatial repositories with data for the state and city they are located in, often in concert with state or local agencies. ESRI, the maker of ArcGIS, provides online datasets and bundles data DVD's with their software.

When deciding which sources to use, you should consider the following factors:

- Available geographies: Do they match the data you wish to map?
- Currency: Are the data layers recent enough for your mapping needs, or are they outdated?
- Accuracy: Are the layers generalized? Can the source be trusted?
- Download unit: Can you download all counties in the US at once, or just one at a time?
- Projection: Is the projection known or defined? Will it match other layers you are using or will you have to make conversions?
- Formats: Will the available format work with my software?
- Identifiers: Do the data layers have ID fields that you can use for joining to data tables?
- Use: Is use of the data restricted to certain purposes?

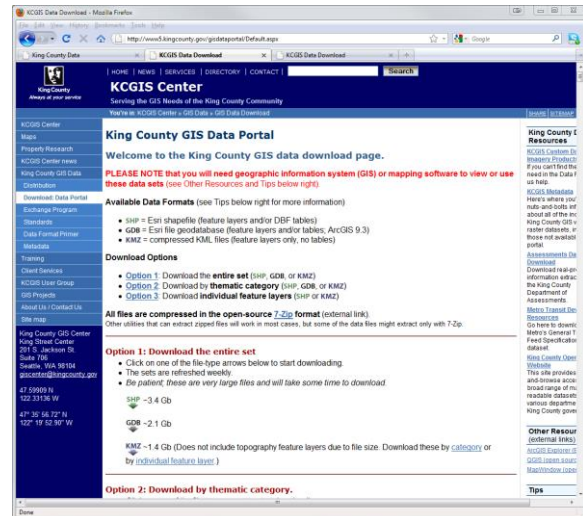
Download Geographic Data from King County GIS Center

1. **Open a web browser.** Make sure you can choose where to download files.
2. Navigate to the King County GIS Data Portal website:
“<http://www5.kingcounty.gov/gisdataportal/>”.
3. Press the “**I accept**” button, agreeing to the “as is” nature of the data and the fact that King County provides no warranty with data.



- On the following Data Portal page, note that you can choose between a variety of data formats (hopefully several are familiar to you after the first GIS workshop) and if you'd like to download individual, thematically grouped, or all layers.

- We would like to download the "Census 2000 Block Groups" and "Open water for King County"



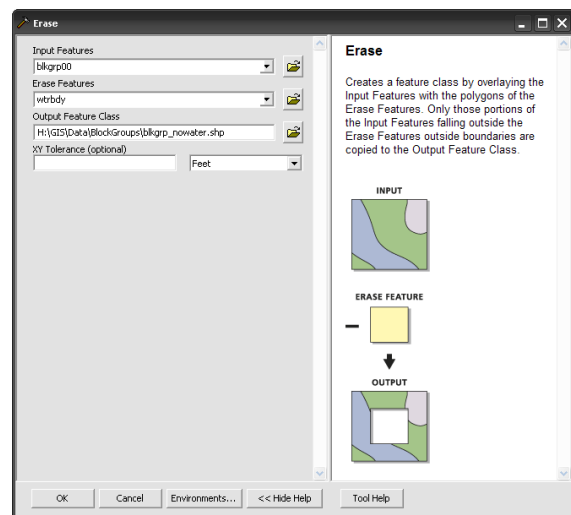
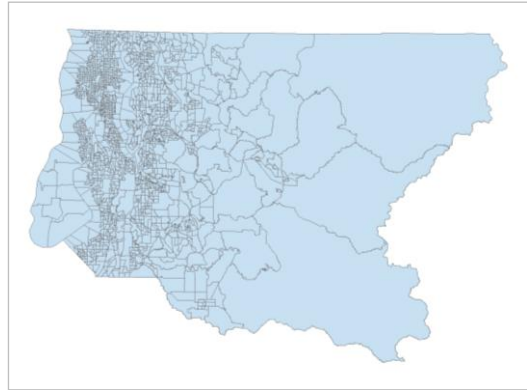
- Find the layers you are looking by pressing Control-F and typing in text you'd like to search for.
- First find the text **"Block Groups"** and locate the layer **Census 2000 Block Groups (blkgrp00)**. Click the **SHP download icon** for this layer. Choose to **"Save File"** and place it in **"C:\temp\csde_gis2_EPI\Downloads\"**.
- Next, find the text **"Open water"** and locate the layer **Open water for King County and portion of adjacent counties (wtrbdy)**. Click the **SHP download icon** for this layer. Choose to **"Save File"** and place it in **"C:\temp\csde_gis2_EPI\Downloads\"**.

Extract Shapefiles from .zip Archives

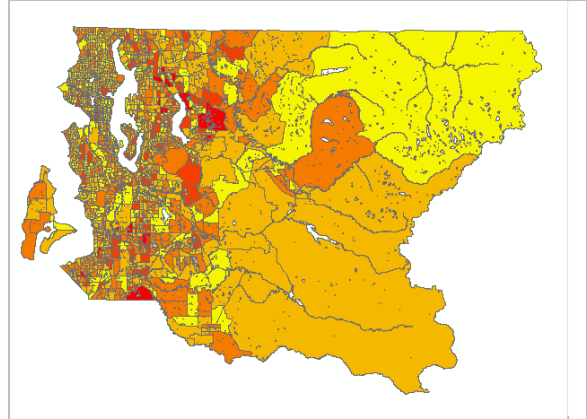
- Open **Windows File Explorer** (press the Windows and E-keys together), navigate to **"C:\temp\csde_gis2_EPI\"** and make a new folder called **"Data"**.
- Inside this folder, create two new folders: 1) **"BlockGroups"** and 2) **"Water"**.
- Expand the block group zip archive at **"C:\temp\csde_gis2_EPI\Downloads\blkgrp00_SHP.zip."** Copy all the files in the archive to the folder **"C:\temp\csde_gis2_EPI\Data\BlockGroups\"**.
- Extract all files from the water body zip archive at **"C:\temp\csde_gis2_EPI\Downloads\wtrbdy_SHP.zip"** into the folder **"C:\temp\csde_gis2_EPI\Data\Water\"**.

Prepare Geographic Data using ArcMap and ArcToolbox

1. **Start ArcMap.**
2. Use the **Add Data Layers** button and select **“C:\temp\csde_gis2_EPI\Data\BlockGroups\blkgrp00.shp”**.
3. Your map display should be updated with the block group boundaries for King County, WA.
4. **Right click on the “blkgrp00” layer** and open its **attribute table**. Notice the fields contained in this table and the **number of records (1580)**.
5. These are the correct statistical areas for this exercise, but it can be difficult to make out the shape of the geographic area in question as the block group boundaries extend into the water.
6. Next **add “C:\temp\csde_gis2_EPI\Data\Water\wtrbdy.shp”**. The map should redraw, with the water bodies overlaid on top of the census block groups. This gives an idea of what our ideal map should look like. However, instead of always drawing every water body on top of our block groups, it would be more effective to remove these areas from the block group shapefile.
7. To perform this operation, we will use some of the geoprocessing functionality contained in ArcToolbox. **Open ArcToolbox** from the main menu. If **ArcToolbox** is not visible, go to **Geoprocessing -> ArcToolbox**. Take a moment to explore the **Geoprocessing Options** under the same menu. **Uncheck “Enable”** under background processing and set Results Management to **“Never Delete”**.
8. Navigate to **“Analysis Tools > Overlay”** and double-click on the **“Erase”** tool. Read the tool summary provided.
9. Input Feature: **“blkgrp00.shp”**
Erase Features: **“wtrbdy.shp”**
Output Feature Class:
“C:\temp\csde_gis2_EPI\Data\BlockGroups\blkgrp_nowater.shp”



10. Check your inputs, and then click the **“OK”** button to begin the process. This operation will take approximately **1 minute to complete**. When finished, click **“Close”**.
11. **Turn off** the **“wtrbdy”** and **“blkgrp00”** layers. The **“Erase”** tool removed all water bodies from the Block Group layer, leaving a clean and easy to interpret view of King County.



12. **Zoom in to the waterfront near downtown Seattle** and notice the detail contained in the block groups at the water's edge. This complex geometry suggests why the erase procedure took some time to perform.
13. **Open the attribute table for “blkgrp_nowater”**. Confirm that there are still **1580 records** in our new shapefile. Pay close attention to the **GTFID field**, as this will be used in a later exercise as the unique identifier for our Census Block Groups.
14. Before moving on, let's use that statistic of population by block group to make a simple thematic choropleth map (areas are shaded in proportion to the statistical variable being mapped). **Right-click on the “blkgrp_nowater”** layer and select **“Properties”**. On the **“Symbolology”** tab, choose the **“Quantities”** option. For the **“Value”** field, choose **“TOTAL_POP”**. Accept the defaults and click **“OK”** to generate the map.
15. Recall that we often prefer to represent population as a density (people/area) instead of raw counts. Recall from last week how to **“Normalize”** one display variable by another. **Change your map to present Population Density**. *What units is density presented in? **Is the “SHAPE_area” field still correct?*
16. To update the area: **Open the attribute table, right-click on the field and select “Calculate Geometry...”**. Click **Yes** to accept the warning and **OK** to accept tool defaults.
17. **Set the symbology** for blkgrp_nowater **back to the same Population Density display**. Notice how the waterfront blockgroups have all increased in Population Density. Try setting the symbology to **Standard Deviations, with ½ std. dev. Intervals**.
18. When you are ready to move on, **remove the layers “wtrbdy” and “blkgrp00”** from the map (right-click each layer and choose **“remove”**).
19. **Save the map as “C:\temp\csde_gis2_EPI\BlockGroup.mxd”**. Minimize ArcMap.

Exercise 1B: Acquire Census Data Table

In this exercise, we will initially use American Fact Finder's (AFF) search capabilities to find information about a data table for a specific geographic area: King County, Washington.

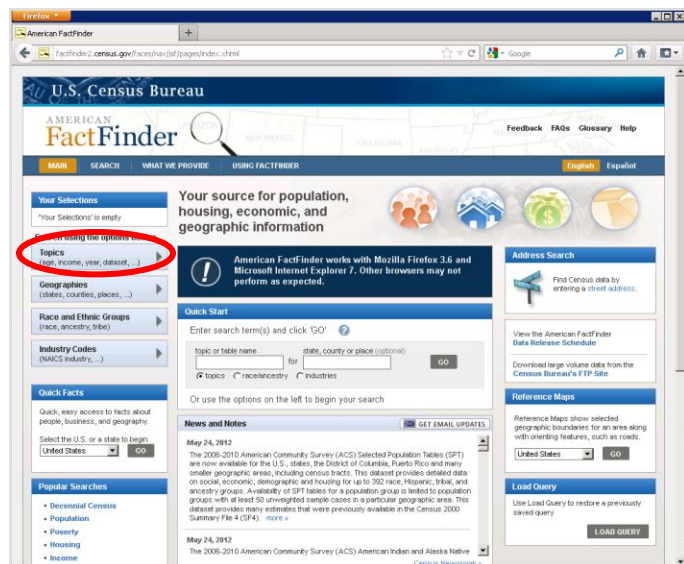
The basic steps for AFF searches are:

- Access search functions from the main page or the Search link in the AFF banner
- Select keywords or geographic area
- Enter your search term. Use search tips for help if necessary
- Chose the desired reports or maps for viewing
- View and download the results

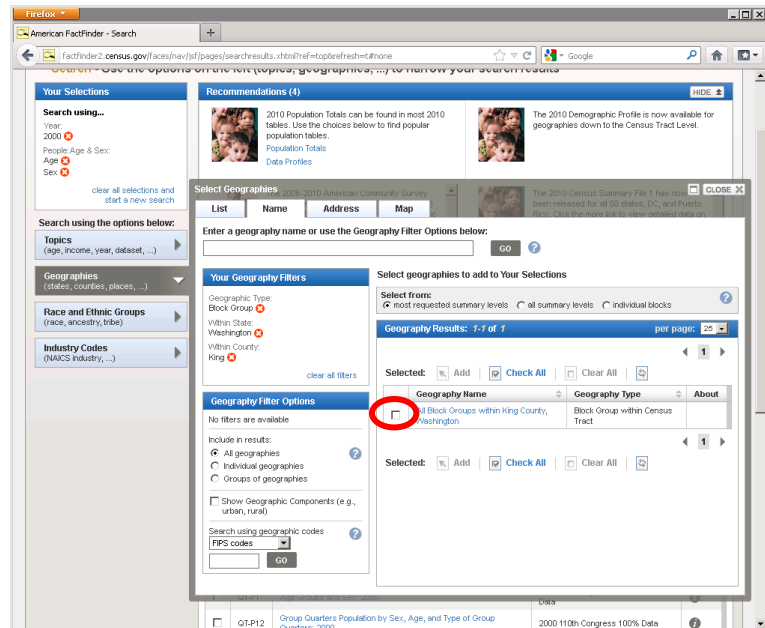
In the following steps you will download data from AFF which will contain variables describing the population in King County by age, specifically the population under age 18. These variables were derived from the Census 2000 Summary File 1 Data.

Locate Data on American Fact Finder: Sex by Age

1. **Open Firefox** and navigate to <http://factfinder2.census.gov>.
2. Click on the **“Advanced Search”** option, followed by **“Show Me All”** on the left side of the page to begin narrowing down the search results to the specific dataset you would like to locate.
3. Select **“Topics”** from the options on the left side of the screen.
4. First, expand **“Year”** and then select **“2000”** to add this filter.
5. Next, expand **“People”** and then **“Age & Sex”**. Select **“Age”** and then select **“Sex”** to add these two additional filters.
6. Now we will narrow down the locations (Geographies) to only select the Block Groups in King County, Washington.



- Begin by selecting the **“Geography”** button on the left side of the page.
- Within the Select Geographies window, choose the **“Name”** tab for more fine-grained search options.
- Under the **“Geographic Type”** heading, select **“Block Group”**.
- Next, expand the **“Within State”** heading and select **“Washington”**.
- Finally, expand the **“Within County”** heading, and choose **“King County”**.
- You Geography Results should show a single option **“All Block Groups within King County Washington”**. Click the check box next to this result and select **“Add”** to update your selection. Close the **Select Geographies** window.
- Choose **“All Block Groups”** from the resulting list and click the **“Add”** button below. **“Close”** the Geographies window.



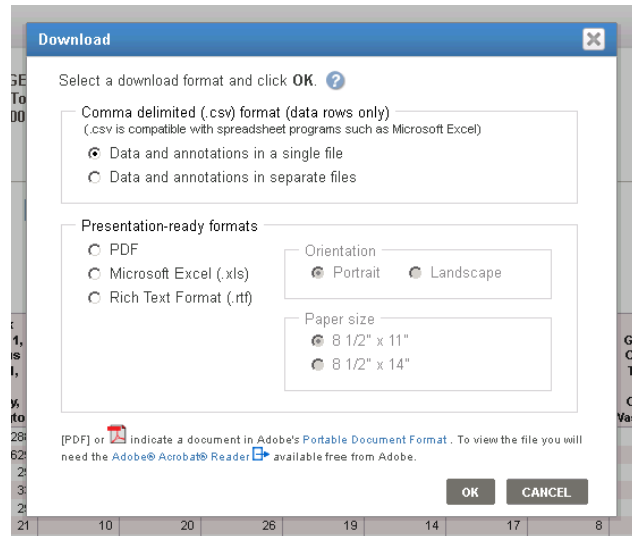
- By providing these parameters, we have narrowed down our search to only 38 tables. We would like table ID P012 **“Sex by Age [49]”**. Locate this table and click on the table name.
- AFF should return a window that contains the first 18 records of 1580 that meet our criteria, which is all Census Block Groups within King County, Washington.

	Block Group 1, Census Tract 1, King County, Washington	Block Group 2, Census Tract 1, King County, Washington	Block Group 3, Census Tract 1, King County, Washington	Block Group 4, Census Tract 1, King County, Washington	Block Group 5, Census Tract 1, King County, Washington	Block Group 6, Census Tract 1, King County, Washington	Block Group 7, Census Tract 1, King County, Washington	Block Group 8, Census Tract 1, King County, Washington	Block Group 9, Census Tract 1, King County, Washington	Block Group 10, Census Tract 1, King County, Washington	Block Group 11, Census Tract 1, King County, Washington	Block Group 12, Census Tract 1, King County, Washington	Block Group 13, Census Tract 1, King County, Washington	Block Group 14, Census Tract 1, King County, Washington	Block Group 15, Census Tract 1, King County, Washington	Block Group 16, Census Tract 1, King County, Washington	Block Group 17, Census Tract 1, King County, Washington	Block Group 18, Census Tract 1, King County, Washington
Total	1,288	1,327	1,548	1,367	1,048	783	1,516	1,092	754	780	1,372							
Male	628	681	793	735	493	369	757	502	369	375	649							
Under 5 years	29	47	43	48	28	21	35	22	21	26	29							
5 to 9 years	33	26	42	44	35	18	27	26	19	18	40							
10 to 14 years	29	23	28	27	18	18	20	14	23	17	29							
15 to 17 years	21	10	20	26	19	14	17	8	18	12	16							
18 and 19 years	10	17	22	17	7	6	24	8	9	5	9							
20 years	0	16	10	20	6	3	23	10	7	6	10							
21 years	6	24	19	19	4	6	17	9	3	5	10							
22 to 24 years	21	78	65	78	20	10	63	32	12	113	45							
25 to 29 years	36	106	105	91	44	33	99	55	36	36	64							
30 to 34 years	30	96	77	79	50	31	74	49	26	49	65							
35 to 39 years	50	62	53	67	47	23	67	37	26	37	53							
40 to 44 years	59	45	60	61	49	38	57	38	31	32	57							
45 to 49 years	65	37	66	64	44	30	44	33	47	37	66							

Download Data: Sex by Age

You have now developed a data table which reflects the demographic characteristics that we're interested in studying. Before any mapping or analysis of the data can be done, you must download the Census data table to your computer.

1. From the “Actions” list in the Table View, choose the **“Download”** option.
2. When the download format window appears, choose the **“Comma delimited (.csv) format”** with **“Data and annotation in a single file”**.
3. Click the **“OK”** button. The AFF website will create a downloadable a zip file containing several data files. When the file is complete, select **“Download”**.



4. When the file download window appears, select the **“Save File”** option and click **“OK”**.
5. Name the file **“agepop.zip”** and save it to the **“C:\temp\csde_gis2_EPI\Downloads\”** folder.

Extract Data Table from Census Archives

1. Open **Windows File Explorer**, navigate to **“C:\temp\csde_gis2_EPI\Data”** and make a new folder called **“Tables.”**
2. **Expand** the zip archive located at **“C:\temp\csde_gis2_EPI\Downloads\agepop.zip.”** Copy the file **“DEC_00_SF1_P012_with_ann.csv”** to the folder **“C:\temp\csde_gis2_EPI\Data\Tables\”**.

Exercise 1C: Use Microsoft Excel to Prepare Census Data Table for Display and Analysis

In this exercise, you will use Microsoft Excel to manipulate the P12 data table from AFF, which contained the 2000 Census data of age by sex. This table will be critical to the thematic mapping that will be conducted in the next exercise. We will begin by exploring the original tables in Microsoft Excel. Then, to streamline processing and to support more meaningful analysis, we will create a simplified table containing Population Age < 18.

Filter the agepop AFF Data Table using Excel

Due to the specific needs for the next exercise you will create a new field which represents the summation of the population whose age is less than 18. The field names from the original table "P12 Sex by Age" that will be needed to calculate this value are:

<i>VD03 - Males Under 5 years</i>	<i>VD27 - Females Under 5 years</i>
<i>VD04 - Males 5-9 years</i>	<i>VD28 - Females 5-9 years</i>
<i>VD05 - Males 10-14 years</i>	<i>VD29 - Females 10-14 years</i>
<i>VD06 - Males 15-17 years</i>	<i>VD30 - Females 15-17 years</i>

1. ArcGIS is very particular about field names, especially when working with Excel files. We are now going to prepare the Excel file so that it will work with ArcGIS and contains only those data values we require for our analysis.
2. Open Windows Explorer.
3. Navigate to "**C:\temp\csde_gis2_EPI\Data\Tables**" and double-click on the file "**DEC_00_SF1_P012_with_ann.csv**" to open it in Microsoft Excel.
4. First we will make a copy of the data. Go to **File-> Save As -> Excel Workbook 97-2003 Workbook**.
5. Navigate to "**C:\temp\csde_gis2_EPI\Data\Tables**" and name the file "**agepop.xls**" and select save.
6. We have now created a copy of the file and left the file we downloaded from American FactFinder as a backup. When working with data, it is a good idea to have an original, unmodified version of the data in case you make a misstep and need to start over.

- Notice the “GEO.id” field contents look similar to the “GTFID” field from our King County Block Groups shapefile from Exercise 1A. This is the FIPS (Federal Information Processing Standards) code that will be used as the unique identifier to join these two tables together in the next exercise.

	A	B
1		
2		
3	GEO.id	GEO.id2
4	Id	Id2
5	1500000US530330001001	5.3033E+11
6	1500000US530330001002	5.3033E+11
7	1500000US530330001003	5.3033E+11
8	1500000US530330001004	5.3033E+11
9	1500000US530330002001	5.3033E+11

- Begin by **selecting and highlighting cell A1**, which contains the text, “**GEO_ID.**”
- Navigate to **cell AZ1**. To quickly navigate to **cell AZ1**, hold down “**Ctrl**” and press the **right arrow key** once. This will make active the last cell in the block of cells that are not blank (cell BA1). This field will contain the total population, female 85 years and older. **Press the right arrow key once more to get to cell BA1**. In **cell BA1**, type, “**u18_Pop**”.
- Navigate around the table and notice that **columns F - J** contain our first variables of interest, “VD03 – males under 5 years” through “VD05 – males 15-17 years.” Also notice that **columns AD - AG** contain our second variables of interest, “VD27 – females under 5 years” through “VD30 – females 15-17 years”.

- In **cell BA2**, type “**=SUM(F2:I2) + SUM(AD2:AG2)**” This will produce a sum of male and female populations less than 18 years of age.

	BA	BB
1	P012049	u18_Pop
2	Total population: Female; 85 years and over	
3	18	240
4	30	210
5	17	244
6	3	275
7	5	197
8	10	136
9	30	190
10	12	138
11	3	163

- Highlight **cells BA5 through BA1584**: Left click on **cell BA5** and hold the left mouse button down. While holding the left mouse button down, gently drag the cursor straight down toward the bottom of the screen. Once all cells **from BA3 through cell BA1581** are highlighted, press “**ctrl+D**”. This is the keyboard shortcut to “fill down.” You have now filled in the same formula, with the corresponding cell references, in **cells BA3 through BA1581**.

- We are going to make the population sums permanent. Highlight **cells BA1 through BA1581**. Right click in **cell BA1** and select “**copy**”. Right click again in **cell BB1** and select “**paste special**”. On the menu that pops up, select “**Values**” and then press “**OK**”. The values are now in each cell instead of the equations.

- Now that we have calculated the under 18 age population value we need, let’s remove the excess data contained in columns C through BA. Highlight **columns C through BA** by

left-clicking on the letter C, holding the left mouse button down, and slowly dragging the cursor over to column **BA**.

15. **Right-click on any highlighted cell** and select **“delete”**.

16. There should now be **three columns: A, B, and C**.

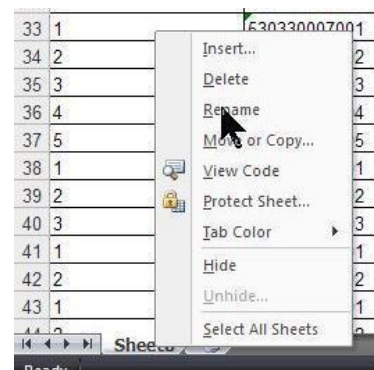
Note: Sometimes, there is extra formatting or text in the blank cells. While not visible to us, it causes ArcGIS to interpret the formatting as additional fields.

17. Rename column B, **“GTFID”**.

18. Replace the contents of column B with the results of the formula: **“=RIGHT(A2,12)”**. This will create a version of the FIPS code, in a similar format to that which is present in our Block Groups shapefile that we downloaded from King County.

19. **Cut and PASTE VALUES of column B into column A.**
Delete Column B.

20. Right click on the word **“Sheet0”** at the bottom of the lower left portion of the screen and select **“rename”**. Type **“AgePop”**. We are renaming the worksheet so it is easier to work with in ArcGIS.



21. There should now be **1,580 rows** of data in **two columns**.

22. **Save your table**, and **close Microsoft Excel**.

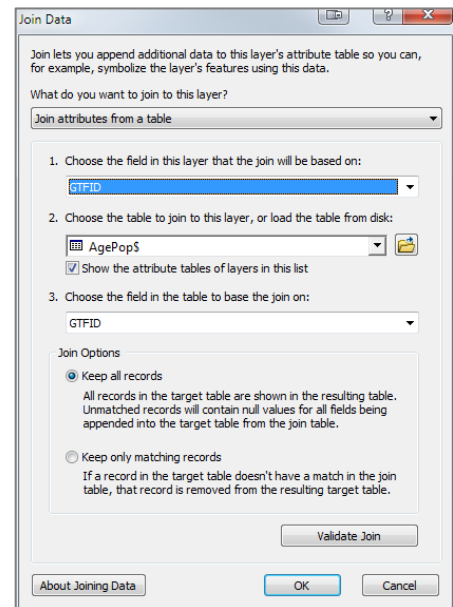
To summarize, we now have a sheet in an Excel workbook with the number of people under ages 18, per block group in all of King County, WA.

Exercise 1D: Creating Quantitative Displays

In this exercise, you will create a map that will help you visualize the distribution of the Youth of King County as captured by the 2000 Census. Specifically, you will map percentage of the population under age 18.

Join Tables

1. Return to ArcMap. If ArcMap is closed, restart it and open the "C:\temp\csde_gis2_EPI\BlockGroup.mxd" project. **Close ArcToolbox** if it is still open.
2. Using the **Add Data** button, navigate to and add "C:\temp\csde_gis2_EPI\Data\Tables\agepop.xls\ **AgePop\$**" to your map document.
3. You will **set up a "Join"** so that you can symbolize the data in the tables that you created from American FactFinder. **Right-click on the "blkgrp_nowater" feature and select "Joins and Relates > Join"**.
4. The join will be **based on the field "GTFID"**. To this layer, join the **table "AgePop\$"** and base the join on the field **"GTFID"**.
5. **Open and view the attribute table for "blkgrp_nowater"**. Notice that the table has been appended with two new columns, including "u18_Pop".



Create New Shapefile and Remove Extra Fields

1. We will now perform some housekeeping. In this step we will create a copy of the block group shapefile, permanently including the joined fields from our census table. Then we will delete some unnecessary fields from our table.
2. **Close the attribute table for "blkgrp_nowater"**. Right click on the "blkgrp_nowater" layer and select **Data>Export Data...**
3. **Change the "Output shapefile or feature class:" field to "C:\temp\csde_gis2_EPI\Data\BlockGroups\ blkgrp_u18pop.shp"**. Click **"Save"** and then **"OK"**. Select **"Yes"** to add the data to the map.

4. **Open and view the attribute table for “blkgrp_u18pop”**. Notice that it looks almost identical to our “blkgrp_nowater” attribute table with joins, except duplicate fields (i.e. GTFID_1) have a number suffix added to them. What has changed is that our new shapefile is not dependent on the .xls tables for data as the joined fields are now part of the shapefile’s attribute table.
5. Unlike attributes joined to a shapefile, we can remove extra attributes contained in our new shapefile. **Right-click** on the attribute **“GTFID_1”** and select **“Delete Field”**. Select **“Yes”** to confirm. This field has been permanently removed from our new shapefile.
6. **Close the attribute table for “blkgrp_u18pop”**.
7. **Remove “blkgrp_nowater”, and the “AgePop\$” table from the project. Switch** the Table of Contents (Layer list) back to the **“Display” tab**.

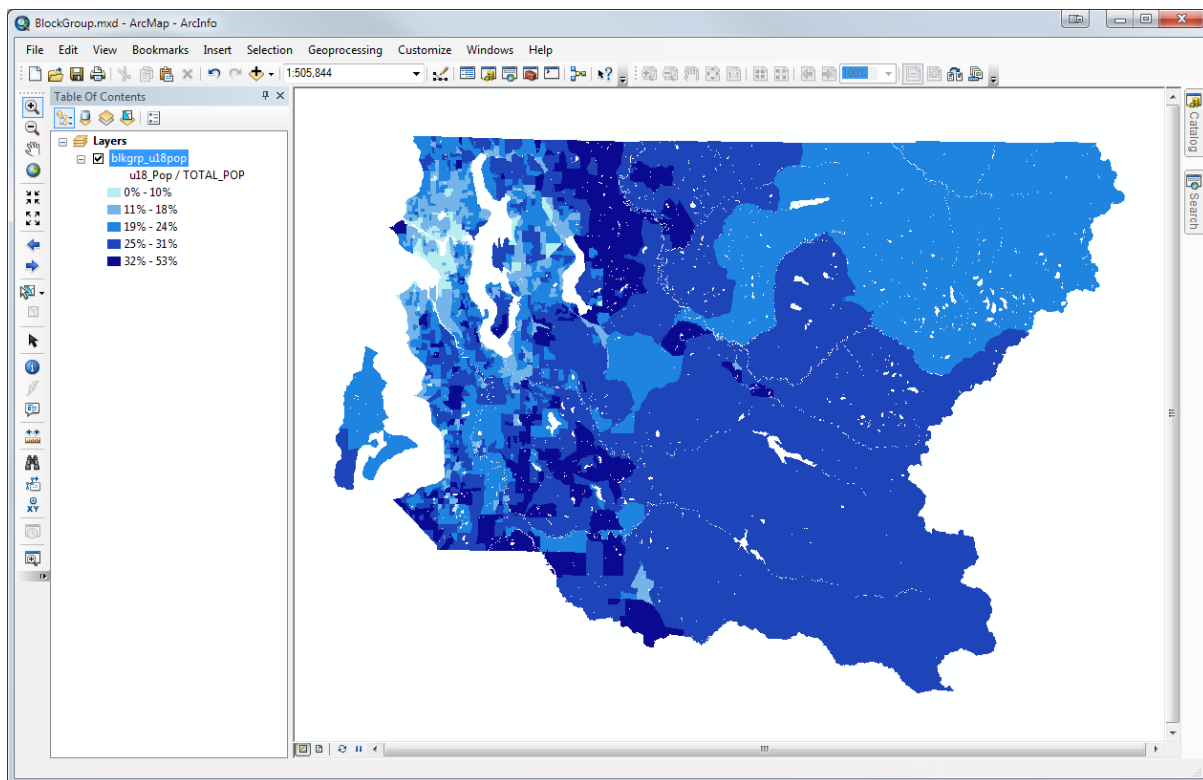
Symbolize and Map Percent Population under Age 18

1. In the table of contents, **double-click on “blkgrp_u18pop”** to bring up the layer properties.
2. Go to the **“Symbology” tab**. In the **“Show”** section, make sure **“Quantities > Graduated Colors”** is selected. Also confirm the Classification method is set to **“Natural Breaks”**.

As a review, the natural breaks classification method identifies breakpoints between values. Classes are based on natural groupings inherent in the data. ArcMap identifies break points by picking the class breaks that best group similar values and maximize the differences between classes. This method is good for mapping data values that are not evenly distributed as it tends to place clustered values in the same class.

3. For the **Value field**, scroll to the bottom of the list. **Select “u18_Pop”**, as population under age 18 is the subject matter for our map.
4. **Press “Apply”** to see the resulting map representing the count of individual under age 18 at the block group level. While this is may be a useful map for some purposes, it does not get at our interest of analyzing percentage of population under age 18.
5. Next, for the **Normalization field**, select **“TOTAL_POP”**. Remember our original King County GIS shapefile contained total block group population allowing us to create a normalized map.
6. **Press “Apply”** and notice the changes in the map. The distribution shifts dramatically as we change from mapping a simple count to a percentage measure.

7. Next, fix the excessively complex label. **Left-Click on the "Label" heading and select "Format Labels"**. Change the **"Category" to "Percentage"**, and select the option **"This number represents a fraction."** Next, click on the **"Numeric Options"** button, then set the **"Rounding" to "Number of decimal places"**, and change the value to **"0"**. Click **"OK"**.
8. Finally, let's choose a different color ramp to symbolize our data. In order to insure consistency (and in case you are not a 'visual' person) you can switch the color ramp view to text-only. **Right-click the current color ramp in the drop down list and uncheck "Graphic View"**.
9. Scroll up the list and select **"Cyan-Light to Blue-Dark"**.
10. **Save your .mxd, and minimize ArcMap.**



On your own: Review the map-making concepts you learned in the last lesson, then create a formal map layout for your new data of percent population in King County under age 18, by block group.

Exercise 2 - Distribution of Bus Stops in King County, WA

In the next short exercise, we will investigate two different GIS analysis methods to explore the spatial distribution of bus stops in King County, WA. First, we will count the number of occurrences of one GIS point layer (bus stops) in each of the 1500+ polygons that make up the census block group layer for King County. This result will show us the distribution of bus stops by census block group. Second, we will derive a “density surface” from the bus stops point layer. This result will show us the density (bus stops per square mile) throughout a regularly spaced grid (raster data layer) covering all of King County. The exercise will conclude by comparing our results to road map and aerial imagery base data from online GIS services.

Download Bus Stops from WAGDA

1. **Open a web browser** and return to the King County GIS Portal website:
“<http://www5.kingcounty.gov/gisdataportal/>”. **Accept** the terms and conditions.
2. Find the text “**Bus Stops**” and locate the layer **Metro Transit Bus Stops (busstop)**. Click the **SHP download icon** for this layer. Choose to “Save File” and place it in
“C:\temp\csde_gis2_EPI\Downloads\”.. Minimize Firefox.
3. Open the **Windows File Explorer**, navigate to “C:\temp\csde_gis2_EPI\Data\” and make a new folder called “**BusStops**”.
4. **Extract all files** from the zip archive located at “C:\temp\csde_gis2_EPI\Downloads\busstop_SHP.zip” to “C:\temp\csde_gis2_EPI\Data\BusStops\”.

Count Bus Stops in Each Block Group

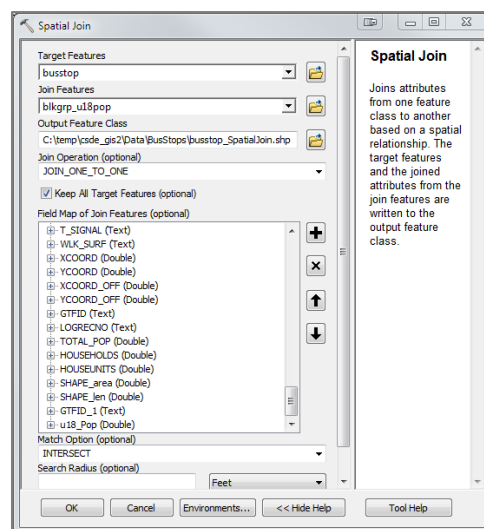
This rather simple calculation takes several steps to perform in a GIS:

- Create a new point shapefile, joining the spatial location of the original Bus Stop layer with the attributes of the corresponding Census Block Group the point is located within
- Calculate the frequency or count of Bus Stops based on each GTFID (unique Block Group ID) and place the results in a new data table
- Join the Bus Stop frequency table back to the Census Block Groups layer

This is an excellent example of the type of problem solving required to analyze data using GIS. As you can see, it is important to clearly understand the problem you are trying to solve before

you begin. Then, by using this GIS analysis tools you are familiar with and the data at your disposal, you must construct a step-by-step approach to solving your problem.

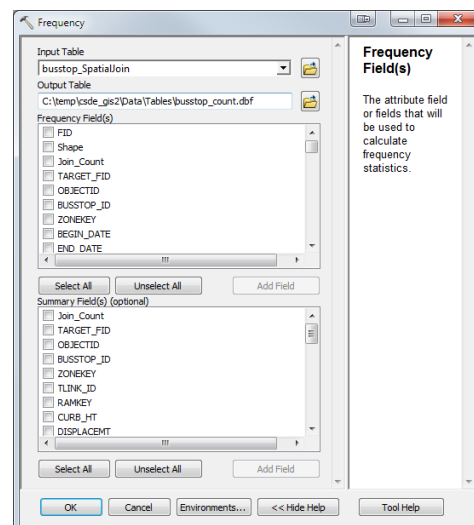
1. **Maximize ArcMap.** Use the **Add Data** Layer button to add the shapefile “C:\temp\csde_gis2_EPI\Data\BusStops\Busstop.shp” to your map.
2. You should now see all of the 8747 Bus Stops in the Seattle Metro transportation network. Feel free to change the point symbol to a more pleasing color. **Open the attribute table for the Bus Stops** to see what types of information this layer contains.
3. Our first task will be to create a new point shapefile at each Bus Stop location containing the attributes of the Census Block Group associated with the bust stop. This operation is known in ArcGIS as a “Spatial Join”. **Open ArcToolbox**, navigate to “**Analysis Tools>Overlay**” and double-click “**Spatial Join**”.



4. For the **Target Feature** select “**Busstop**”, and for the **Join Feature** select “**blkgrp_u18pop**”. Set the **output feature class** to, “C:\temp\csde_gis2_EPI\Data\BusStops\busstop_SpatialJoin.shp”. Notice the Field Map contains every attribute from both the Bus Stops and Block Groups layers. Leave all the features in the Field Map and click “**OK**”.
5. **When the processing finishes, click the “Close” button.** The new point layer appears in the table of contents, but looks exactly the same on the map as the old point layer. **Open the Attribute Table for the new layer** to see that each point now contains its original attributes, plus all attributes of the Census Block Group it falls within. Close the attribute table.

6. Now we will use the new point shapefile to calculate the number of bus stops in each Census Block group, using the GTFID field. In **ArcToolbox**, navigate to “**Analysis Tools>Statistics**” and double-click “**Frequency**.”

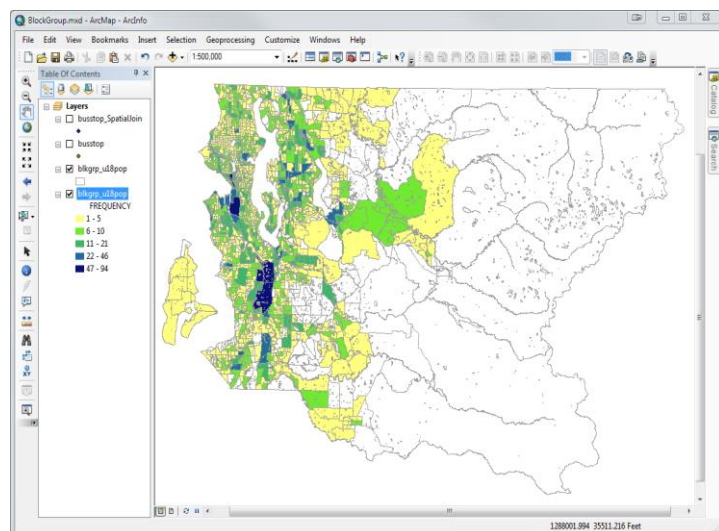
7. For the **Input Table**, select “**Busstop_SpatialJoin**”. Place the **output table** in “C:\temp\csde_gis2_EPI\Data\BusStops\” and



call it **"BusStop_Count.dbf"**. The **Frequency Field** is what we would like our count to be based on. In this case we want to use the ID for each Census Block Group. Scroll down to the bottom of the list and **select "GTFID"**. Click **"OK"** to begin.

Note: In this operation, we are using a geographic data layer (Busstop_SpatialJoin) to generate a simple table as an output. As you saw in the last exercise, the interaction between spatial and tabular data is quite common in GIS.

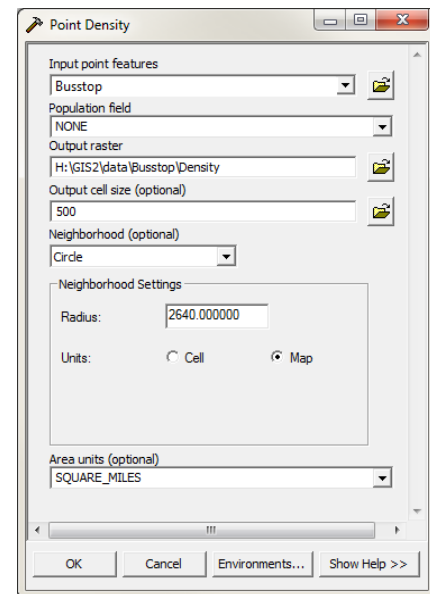
8. **After closing the processing window, go to the "Source" tab in ArcMap's table of contents area. Open the table for "Busstop_Count" to see your results. The spatial join and frequency operations have created a table summarizing the total number of Bus Stops in each of our Census Block Groups (as represented by GTFID). Return to the "Display" tab.**
9. Finally, we will update our map to show the results. **Right-click on "blkgrp_u18pop" and select "Joins and Relates>Join"**. Use **"GTFID" as joining field for both datasets** and select **"Busstop_Count" as the join table**. Click **"OK"** and then **"Yes"** to create an Index.
10. **Turn off both point layers.**
11. Open the **Layer Properties for "blkgrp_u18pop"**. Using the **"Quantities>Graduated colors"** method, set the **Value field to "FREQUENCY"**. Set the **Normalization to "none"**. Click **"OK"** to draw the map.
12. As many Block Groups in King County do not have any metro bus stops, you will likely see large holes in the new map. The map would be more appealing if all block groups were still visible.
13. **Right-click on the layer "blkgrp_nowater" and select "Copy". Then, from the main menu, select "Edit>Paste"**.
14. **Change the symbology for the top Block Group layer to "Feature > Single symbol" and set the symbol to a hollow fill with a light grey outline color.**
15. **Save your mxd.**



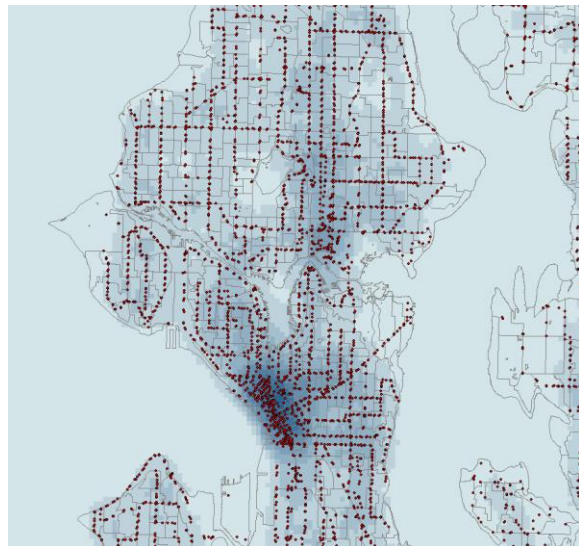
Derive Density Surface of Bus Stops in King County

1. Turn off the bottom block group layer, which uses colors to symbolize bus stop counts.
2. In **Arctoolbox**, navigate to **“Spatial Analyst Tools>Density”** and double-click **“Point Density.”**
3. Enter the following parameters into the Point Density Tool, then click **“OK”**:

- **Input Point Feature**, select **“Busstop”**
- **Population Field**, select **“NONE”**
- **Output raster**, set as **“C:\temp\csde_gis2_EPI\data\Busstop\Density”**
- **Output cell size (optional)**, type in **“500”** (feet)
- **Neighborhood (optional)**, leave as **“Circle”**
- **Radius**, type in **“2640”** (feet, or one-half mile, assumed to be a fair walking distance to get to a bus stop)
- **Units**, select **“Map”**
- **Area units (optional)**, leave as **“SQUARE_MILES”**



4. Your results will display a coarse grid showing the density of bus stops per square mile, with darker colors indicating higher density (see legend). Zoom in to the downtown Seattle/University area. **Turn on** your **“Busstop” point** layer to compare the actual Bus Stop locations to your new density surface. *Why do the densest areas not necessarily correspond to the actual dense clusters of bus stops? ..think about half mile buffer...*



5. When you are finished, **remove** the **“Busstop” point** layers.

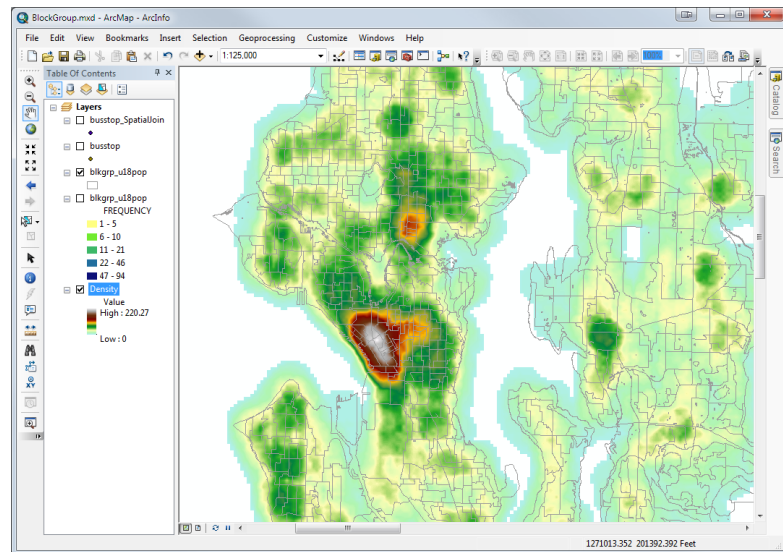
6. Now let's take a moment to improve the display of our density surface. **Open the Layer Properties for "Density."** When prompted "Unique histogram does not exist. Do you want to compute unique values?" **click the "Yes" button.** Go to the **"Symbology" tab.**
7. Perform each of the following steps one-at-a-time, followed by clicking the "Apply" button, and examine the results:

- Leave the symbolizing method in the Show: column as "Classified" and **change the color ramp to the multi-colored elevation profile** (light blue on left to white on right). Notice how it is now easier to pick out clusters, and differentiate density classes.



- Change the symbolizing method in the **Show: column** to **"Stretched"**, and **select the same multi-colored elevation profile.** Set the **Stretch Type** to **"None."**
- **Check "Display Background Value:"** to remove all cells which have a value of 0 bus stops per square mile.

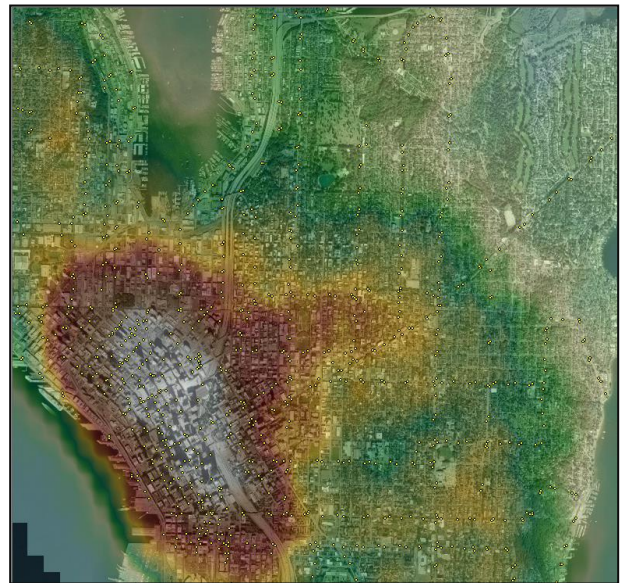
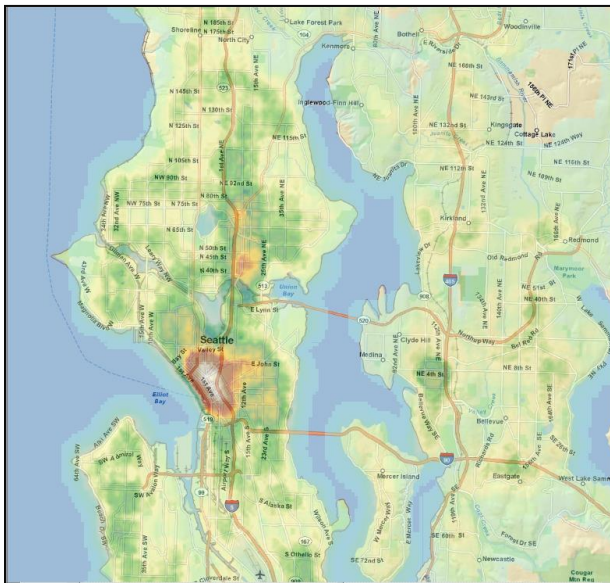
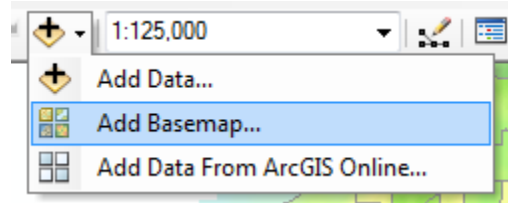
- **Change to the Display Tab, and change the Resample during display using: option to "Bilinear Interpolation (for continuous data)."** This will run a smoothing filter over the dataset as it is displayed.



- On the Display Tab, **set Transparency to 60% and close the Layer Properties.**
8. In the layer list, **move the new "Density" layer above both "blockgroup_u18pop" layers.** **Turn on** the top colored **blockgroup layer** and **compare** your density surface results to your Block Group count results. **Save your project.**

Road Map and Aerial Imagery Base Data from Online Services

1. Next, we'll use an online web mapping service to display aerial photography and road map base layers, adding additional context to bus stop results.
2. In ArcMap, click the small down arrow next to the add data button. Then select **Add Basemap...** This will open up an window showing you a variety of free basemaps you can use in your ArcGIS Project.
3. Click on the **"Imagery"** icon to add this basemap service to your project.
4. Note the Coordinate System Warning, then click **"Close"** to dismiss.
5. Turn each layer on and off as well as zoom in/out to see the multi-scaled nature of this service. Arrange the layers showing the results of the bus stop analysis and change their transparency to compare them to the Imagery Layers.
6. **Remove the Imagery Layer** and then **Save your project**.



NOTE: While there are data (lots of it) driving the *Visual* presentation now on your map, the Basemap services do not allow you to access the raw data for performing your own *Analysis*.

Exercise 3 – Buffered Distance to Hospitals/Medical Facilities

In this short exercise, we will use another common GIS analysis tool, Buffering, to explore the distance between Census Block Groups and hospitals in King County, WA. To meet this goal, we will create a set of distance buffers around hospital locations, and then compare the block group layer to these buffers.

Download Hospital Data from WAGDA

1. **Open a web browser** and return to the King County GIS Portal website: **“http://www5.kingcounty.gov/gisdataportal/”**. **Accept** the terms and conditions.
2. Find the text **“Hospitals”** and locate the layer **Medical Facilities including Hospitals (medical_facilities)**. Click the **SHP download icon** for this layer. Choose to **“Save File”** and place it in **“C:\temp\csde_gis2_EPI\Downloads\”**.. Minimize Firefox.
3. Open the **Windows File Explorer**, navigate to **“C:\temp\csde_gis2_EPI\Data\”** and make a new folder called **“Hospitals”**.
4. **Extract all files** from the zip archive located at **“C:\temp\csde_gis2_EPI\Downloads\medical_facilities_SHP.zip”** to the folder **“C:\temp\csde_gis2_EPI\Data\Hospitals\”**.

Create Hospital Buffer Rings

As with our last exercise, this analysis is easiest to understand as a series of steps:

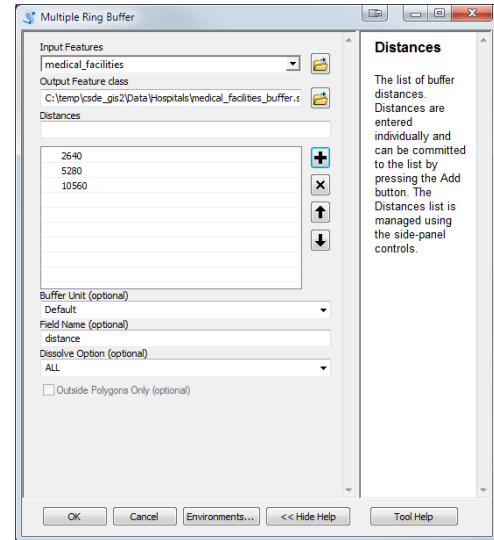
- Create a new polygon shapefile, containing buffered rings at a set of fixed distances (2640, 5280, and 10,560 feet) from every hospital in our point shapefile
- Spatially compare the location of these buffered rings to our Census Block Group shapefile. Create a new shapefile containing the results of this comparison

It is helpful to keep this stepwise approach to solving problems using GIS in mind as you continue to explore ArcGIS with your own data.

1. **Maximize or Start ArcMap**. Begin by **removing the outline “blkgrp_nowater” layer**.
2. Use the **Add Data** Layer button to add the shapefile **“C:\temp\csde_gis2_EPI\Data\Hospitals\ medical_facilities.shp”** to your map.
3. You should now see the 154 Hospitals/Medical Facilities in the Seattle Metro area. Feel free to change the point symbol to a something more appropriate. **Open the attribute table for the hospitals** to see what types of information this layer contains.

4. Our first task will be to create a new polygon shapefile, which contains a set of buffered distances or “rings” from each hospital point location. **Open ArcToolbox**, navigate to **“Analysis Tools>Proximity”** and **double-click “Multiple Ring Buffer”**.

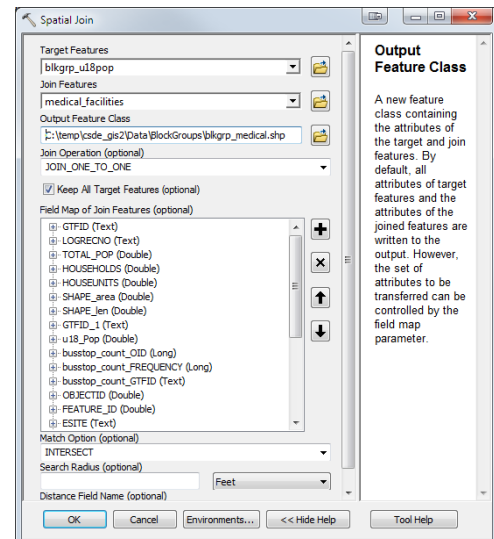
5. For the **Input Features** select **“medical_facilities”** and **Set the Output Feature Class to “C:\temp\csde_gis2_EPI\Data\Hospitals\medical_facilities_buffer.shp”**. For the **Distances** field, first type in **“2640”** (Feet or ½ mile) and press the **Plus key**. Repeat this process, **adding “5280” and “10560”**. Click **“OK”**.



6. This process will take a few seconds to perform. **When the buffer is complete**, click the **“Close”** button. The new polygon layer appears in your table of contents, and the distance buffers are drawn on the map. Inspect the map to visually check the output.

7. Now we will use the new polygon buffers to update our census block group layer, indicating which block groups have a hospital within ½ mile, 1 mile, or 2 miles. Again, we will use the Spatial Join function. In **ArcToolbox**, navigate to **“Analysis Tools>Overlay”** and **double-click “Spatial Join”**.

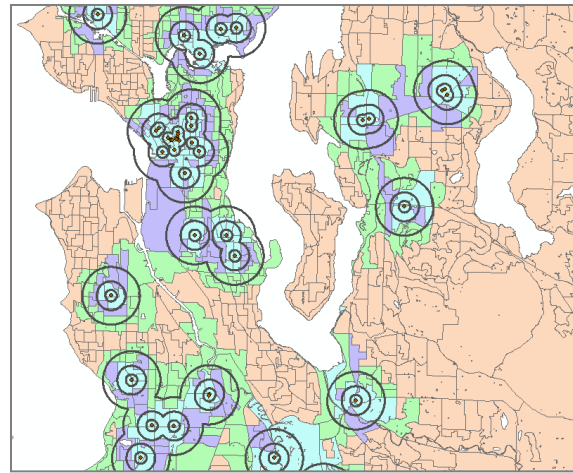
8. For the **Target Features** select **“blkgrp_u18pop”** and for the **Join Feature** select **“medcial_facilities_buffer”**. Set the **Output Feature Class** to **“C:\temp\csde_gis2_EPI\Data\BlockGroups\ blkgrp_medical.shp”**. Accept all other default options. Click **“OK”**.



9. The new will layer will appear in the table of contents and on the map. Open the **Layer Properties** for **“blkgrp_hospital”**. On the **Symbology** tab, select the **“Categories>Unique Values”** symbol type. Set the **Value Field** to **“distance”**. Finally, click the button **“Add All Values”**. Select **“OK”**.

10. To better understand the result of our analysis, we will compare the buffer rings to our new block group layer. First, **move “medical_facilities_buffer” up in the table of contents above “blkgrp_medical”**.

11. This looks better; however the colored buffer rings now obscure the block group layer. **Open the Layer Properties for “hospitals_MultipleRingBuffer”**. On the **“Symbology”** tab set the **Show:** type to **“Features>Single symbol”**. Change the symbol to **No Fill Color**, with a **Dark Grey Outline Color**, and an **Outline Width of 2.00**.



12. Look at individual block group polygons to explore how the Spatial Join operation actually attributes a buffer ring distance to each polygon. Can you see potential issues with this method?

On your own: Explore the difference between the Buffer method for calculating distance from hospitals and the results generated by using the Near tool. You can find the Near tool in the toolbox under **“Analysis Tools>Proximity>Near”**. To run the tool, set the **Input Features: blkgrp_medical** and **Near Features: medical_facilities**. Accept all other default values and click OK. The Near tool will calculate an exact distance between each block group centroid and the closest hospital point. After the tool has run, open the attribute table for blkgrp_medical and find the NEAR_DIST field. Try making a map with this new variable. HINT: set the classification method to **“Quantiles”** in order to see more detail near the tightly clustered blockgroups around the hospitals/medical facilities in Seattle.

Export Results as Table

While this map makes a great visual product, don't forget that map creation isn't the only reason for using GIS. The result of the last exercise contains a new census block group variable, which indicates distance to the nearest hospital. This new piece of data could be used for any number of additional forms of analysis. Think of GIS as just another tool, helping you to ask more spatially oriented research questions.

1. At any time, the tabular data from a GIS data layer can be output for use in another software package. **Open the Attribute Table for “blkgrp_medical”**. At the far right of the table notice the new variable, **“distance”**, derived from the buffer rings.

2. Click the “Options” button and select “Export”. Set the **Output table:** location to “C:\temp\csde_gis2_EPI\Data\Tables\blkgrp_medcial_final.dbf”.
 3. Select “No” to not add the table to ArcMap. **Save your .mxd.**
 4. Start Microsoft Excel and open your saved table at “C:\temp\csde_gis2_EPI\Data\Tables\blkgrp_medical_final.dbf”.
 5. Keep in mind these two additional exporting options for geographic data sets:
 - a. **Subsets** (using selection tools): Any time you have a selection of features active in ArcMap, you may choose to export a copy of your layer containing only the selected features. Do this by right-clicking on the layer name and selecting “Data->Export”.
 - b. **Incorporating Joined Datasets:** After performing an attribute or spatial join in ArcMap, you may export a copy of the layer you have joined data TO and it will contain, in its own attribute table, all of the information from any joined table(s). Do this by right-clicking on the layer name you data joined TO and select “Data->Export”.
-