Workshop Overview

Your manual is divided into two sections. Hands on exercises are located in the first section. PowerPoint slides of presentations can be found in the second half of the manual. The workshop is broken up into five modules. Each module covers a specific topic and may have one or more detailed presentations, short lightning talk presentations, demos and hands-on independent exercises. The table below references each module, presentation and exercise covered in this three-day workshop.

Module	Presentation Topic	Exercise Type
Module 1: **Introduction to GIS**	1-1 - Introduction to GIS Introduction to ArcGIS	Follow the Instructor Exercise 1a - Hands on
Module 2: **All about Data**	2-1 - Where to Find Data (Lightning Talk) 2-2 - Data Types 2-3 - Understanding Spatial Reference	Exercise 2a – Hands on Exercise 2b – Hands on
Module 3: **Working with Tables**	3-1 - Introduction to Tables 3-2 – Working with Tables 3-3 – Selections & Queries	Ex 3a - Hands on Ex 3b - Hands on Ex 3c - Hands on
Module 4: **Map Production**	4-1 – Layer Symbology 4-2 - Adding Text & Graphics 4-3 - Creating a Cartographic Output 4-4 - Data Driven Pages (Lightning Talk)	Ex 4a - Hands On Ex 4b - Hands on Ex 4c - Hands on Reference Exercise 6c
Module 5: **Data Manipulation**	5-1 - Georeferencing (Lightning Talk) 5-2 – Digitizing & Editing 5-3 - Working with ArcToolbox	Reference Exercise 6f Ex 5a - Hands on Ex 5b - Hands on
Module 6: **GIS Hodgepodge**	6-1 - Adding XY Coordinates to ArcMap 6-2 - Mind Over Metadata 6-3 - Google Earth (KML) 6-4 - ArcGIS Online	Reference Exercise 6a Reference Exercise 6b Reference Exercise 6e Reference Exercise 6d

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Table of Contents - Exercises

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PowerPoint presentations are located in the second half of this manual.

Exercise 1a: ArcMap Basics

This first hands-on exercise is designed to introduce you to ArcMap. You will open and explore a premade map document (.mxd), familiarize yourself with the graphical user interface (GUI) and interact with toolbars, tools, data layers, data frames and the Table of Contents. We will explore much of what you do in more detail in later exercises so don't get hung up on details.

Getting Started: Opening ArcMap

To start ArcMap, double click on the **ArcMap shortcut** on the desktop. If there is no shortcut, then you can access ArcMap by clicking on **Start>All Programs>ArcGIS>ArcMap 10.5.** It may take ArcMap a minute to open so be patient.

✧ Open a New Map

When the **Getting Started** window pops up, click on **New Maps** under the "**Open existing map or make new map using a template**" heading on the left.

Under **My Templates**, select **Blank Map**. Click **OK** at the bottom of the window to open a blank map in ArcMap.
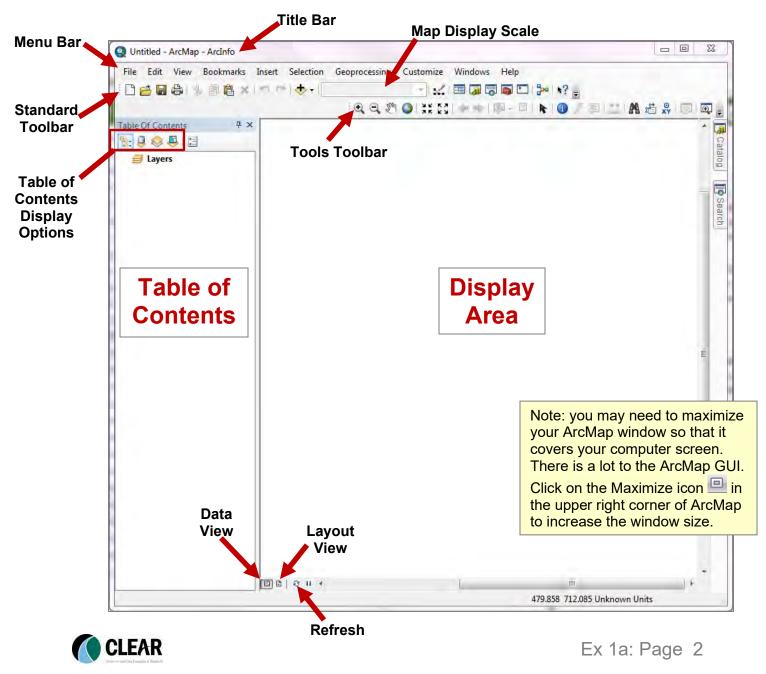
The ArcMap Interface

The ArcMap Graphical User Interface (GUI) will look something like what you see below. If it looks slightly different, it's because additional functionality (toolbars, etc.) may have been turned on or enabled by a previous user. When ArcMap is closed, it "remembers" these settings and restores them when it is reopened.

✵ Exploring the GUI

As you hold the mouse pointer over a button, a description of its function will appear in a small box below it. Take a few minutes to try out this technique. As you mouse over some of the icons and buttons, try to familiarize yourself with what each one does.
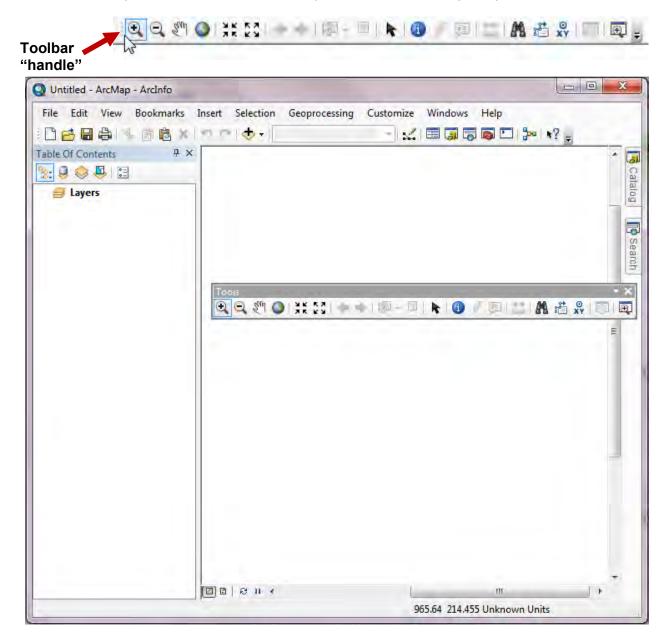
Some of the major "areas" of the ArcMap interface are labeled below.

Title Bar

Map Display Scale

Menu Bar

Standard Toolbar

Table of Contents Display Options

Tools Toolbar

Table of Contents

Display Area

Note: you may need to maximize your ArcMap window so that it covers your computer screen. There is a lot to the ArcMap GUI.

Click on the Maximize icon 🔲 in the upper right corner of ArcMap to increase the window size.

Data View

Layout View

Refresh

✻ Working with Toolbars

Toolbars in ArcMap are sets of tools that perform similar types of functions. The Tools toolbar includes tools for navigating around the map display and tools for performing basic query functions. All toolbars can be moved around the ArcMap interface and can be "floating" windows or docked to the left, right, top or bottom of the GUI. The position of toolbars can be manipulated by clicking on the "handle" on its far left side and dragging it to a new location.

- Try moving the **Tools toolbar** around the ArcMap window. You can even drag it to a location on your desktop that's completely off the ArcMap GUI, just try not to lose it!

Toolbar "handle"
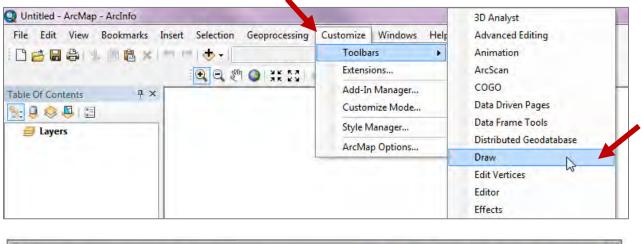
- After you have finished experimenting with new toolbar locations, move the **Tools toolbar** back to its original position.

- ArcMap has many toolbars that can easily be added or removed from the GUI. To add a toolbar, click on the **Customize** drop-down menu and then move the mouse to the **Toolbars** option. A list of available toolbars will appear. Examine the list and locate the toolbar titled **Draw**. Click on it to add it to the GUI.

- It will likely be added to the GUI as a floating toolbar. Click on the gray title bar and drag it to the bottom left corner of the ArcMap GUI, just above the status bar. This is a common docking position for the Draw toolbar.

- Repeat the process to add a few other toolbars to the ArcMap GUI. Try moving them around the interface and docking them in different positions. To remove a toolbar, uncheck the toolbar name under the **Customize>Toolbars** heading. If the toolbar is turned on it will have a check next to it. Once you are satisfied with the process, turn off all toolbars except the **Standard**, **Tools** and **Draw** toolbars.

Tip: You can access a shortcut to the toolbar list by right-clicking on any toolbar or grey areas of the ArcMap GUI. Give it a try!

Opening a Previously Created Map Document

Now that you are familiar with the ArcMap GUI, let's explore some GIS data. In this step, you will open a previously created ArcMap document (.mxd) that references several data sets including Connecticut towns and major waterways. Remember, an ArcMap document does not contain the data itself, but rather includes layers that point to data sets stored on your computer.
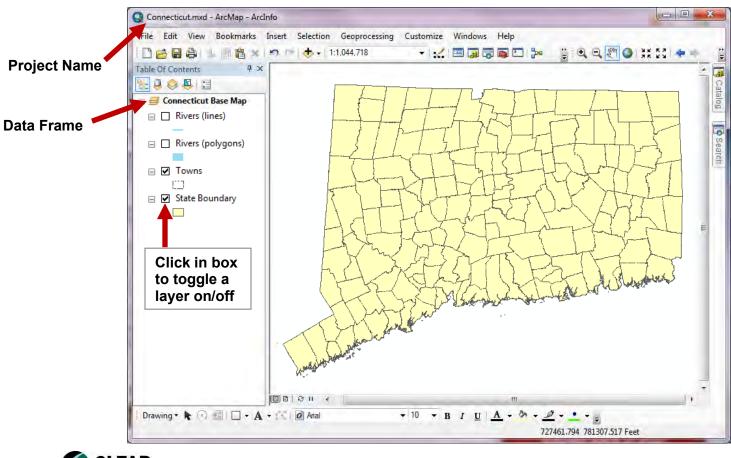
✤ Open a Project File (.mxd) within ArcMap

- In ArcMap, click on the **File** dropdown menu and select **Open** from the list of choices. This will open a window in which you are able to navigate to any location on your computer.

- Navigate to the following folder:

C:\GISEd10\Projects

⬆   ⬆   ⬆

Drive   Folder   Folder

Tip: In a pathname, folders are separated by backslashes. So to locate the project folder, first find your **C**: drive, then locate your **GISEd10** folder and finally click on the **Projects** folder.

- Select the map file named **Connecticut.mxd** and click the **Open** button. Double-clicking on the file name will also open it. If ArcMap asks you if you would like to save changes to your "**Untitled**" map, select **No**.

Project Name →

Data Frame →

Click in box to toggle a layer on/off

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The Map Document contains a single **Data Frame** named "**Connecticut Base Map**" that includes four data layers – **Rivers (lines), Rivers (polygons), Towns**, and **State Boundary**.
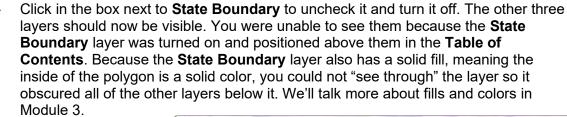
You can turn each layer on/off by clicking in the box next to the layer name. When there is a check in the box, the layer is turned "on" and will be displayed in the display area.

- Make **Rivers (lines)** and **Rivers (polygons)** visible by clicking in the box to the left of their names. All four layers should now be visible on the map.
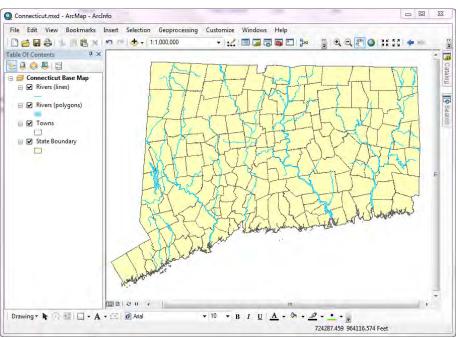
Note that ArcMap draws the layers from the bottom of the **Table of Contents** to the top. This means that the two Rivers layers are drawn on top of the Towns and State Boundary layers. You can change the drawing order by dragging a layer up or down to reposition it in the **Table of Contents**.

- Click on the **State Boundary** layer with the left mouse button and while holding the button down, drag the **State Boundary** layer up to the top of the layer list, just below the Connecticut Base Map **Data Frame** name. When you release the mouse button the **Display Area** will redraw.

What happens to your other three data layers?

- Click in the box next to **State Boundary** to uncheck it and turn it off. The other three layers should now be visible. You were unable to see them because the **State Boundary** layer was turned on and positioned above them in the **Table of Contents**. Because the **State Boundary** layer also has a solid fill, meaning the inside of the polygon is a solid color, you could not "see through" the layer so it obscured all of the other layers below it. We'll talk more about fills and colors in Module 3.

- Click in the box next to **State Boundary** to turn it back on.

- Now drag the **State Boundary** layer back to the bottom of the **Table of Contents** so that all of the other layers will be displayed on your map.
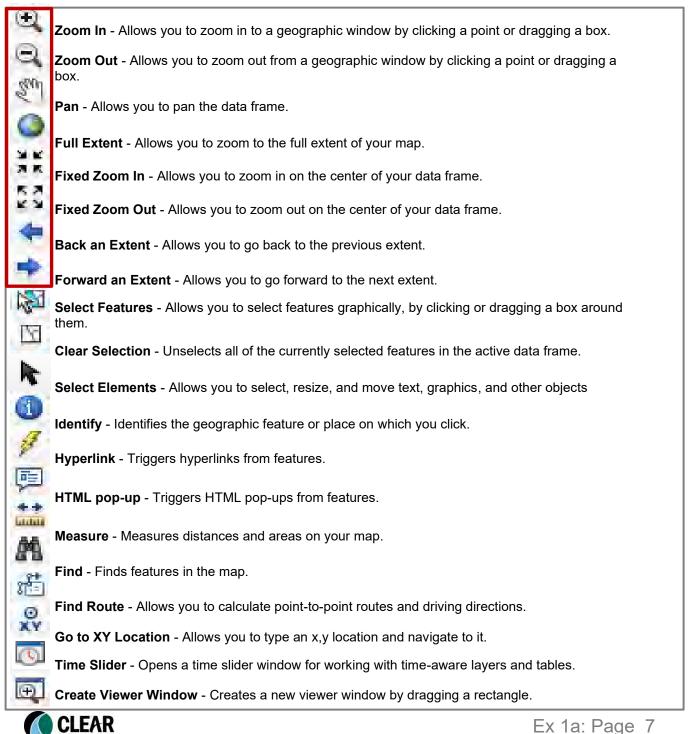
Using the Tools Toolbar to Navigate Within Data View

✴ The Tools Toolbar in Detail
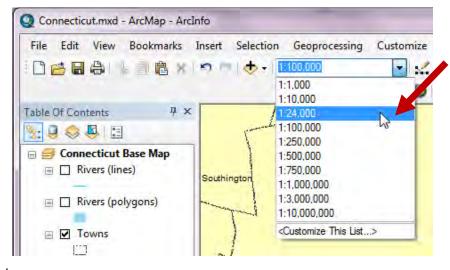
Let's start exploring some GIS data! The **Tools** Toolbar has eight tools to help navigate. It also has several other tools to help you with basic functions like selecting and identifying features, measuring distance and area, and finding XY coordinates on your map. Each tool is briefly described below.

Navigation Tools

Zoom In - Allows you to zoom in to a geographic window by clicking a point or dragging a box.

Zoom Out - Allows you to zoom out from a geographic window by clicking a point or dragging a box.

Pan - Allows you to pan the data frame.

Full Extent - Allows you to zoom to the full extent of your map.

Fixed Zoom In - Allows you to zoom in on the center of your data frame.

Fixed Zoom Out - Allows you to zoom out on the center of your data frame.

Back an Extent - Allows you to go back to the previous extent.

Forward an Extent - Allows you to go forward to the next extent.

Select Features - Allows you to select features graphically, by clicking or dragging a box around them.

Clear Selection - Unselects all of the currently selected features in the active data frame.

Select Elements - Allows you to select, resize, and move text, graphics, and other objects

Identify - Identifies the geographic feature or place on which you click.

Hyperlink - Triggers hyperlinks from features.

HTML pop-up - Triggers HTML pop-ups from features.

Measure - Measures distances and areas on your map.

Find - Finds features in the map.

Find Route - Allows you to calculate point-to-point routes and driving directions.

Go to XY Location - Allows you to type an x,y location and navigate to it.

Time Slider - Opens a time slider window for working with time-aware layers and tables.

Create Viewer Window - Creates a new viewer window by dragging a rectangle.

Take several minutes and try using each of the first 8 navigation tools on the **Tools Toolbar** to see how each one works. If you get stuck or lose your place, you can always click on the **Earth**
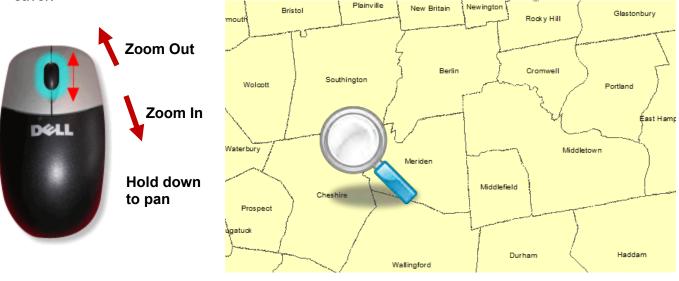
icon 🌐 on the toolbar. This is the **Full Extent** tool. It will restore the map display to its full extent. We'll get to some of the other tools in a minute.

- Go ahead and zoom way in. You will discover that the town names appear. These were set to turn on when the map scale gets to **1:250,000 or larger** and to turn off at smaller scales. You will learn how to set these type of scale dependencies in another exercise. For now, just get used to how they function.

- A map scale is the relationship between the distance on the map and the distance on the ground. You can explicitly set the display scale of your map by typing a value into the scale window on the **Standard Toolbar**. Try typing in something like "**1 inch = 1000ft**." You can also select from a set of predefined scales. This set of scales can be customized to include a user defined scale. Give it a try.

✺ Using the Mouse to Pan and Zoom

If your mouse has a scroll wheel, you can use it to zoom in and out and to pan around the display area. Rotate the wheel **forward** to **zoom out** and **backwards** to **zoom in.** Hold the wheel down and then move the mouse to pan around the display area. This can be a real time saver!

Zoom Out

Zoom In

Hold down to pan
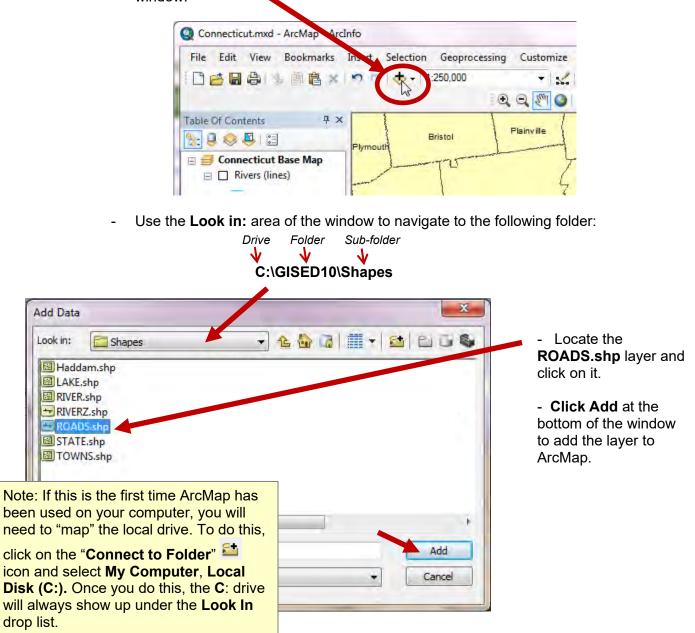
Adding Data to ArcMap

✦ Adding a Shapefile to ArcMap
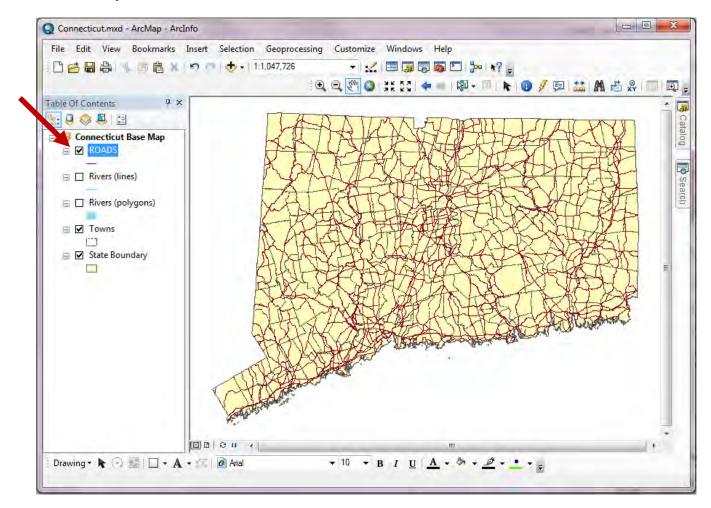
There are a number of ways to add geospatial data to an ArcMap session. In this step you will add a major highway layer to the **Table of Contents** using the **Add Data** button on the **Standard Toolbar**. The layer you add will reference a shapefile stored on disk.
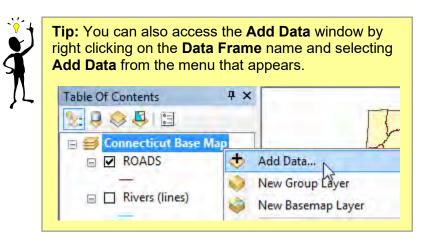
- Click on the **Add Data** button on the **Standard Toolbar**. This will open the **Add Data** window.

- Use the **Look in:** area of the window to navigate to the following folder:

Drive Folder Sub-folder

C:\GISED10\Shapes

- Locate the **ROADS.shp** layer and click on it.

- **Click Add** at the bottom of the window to add the layer to ArcMap.

Note: If this is the first time ArcMap has been used on your computer, you will need to "map" the local drive. To do this,

click on the "**Connect to Folder**" 📁⁺ icon and select **My Computer**, **Local Disk (C:).** Once you do this, the **C**: drive will always show up under the **Look In** drop list.

The **ROADS** layer will be added to ArcMap's **Table of Contents**. A randomly selected color will be assigned to the layer to symbolize the road features. You will learn how to create custom colors and symbols in Module 3.

Tip: You can also access the **Add Data** window by right clicking on the **Data Frame** name and selecting **Add Data** from the menu that appears.
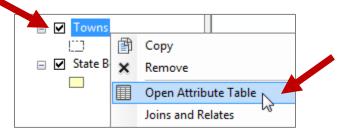
✤ Opening a Feature Attribute Table

Vector layers consist of points, lines or polygons. Generally, each feature in the layer has a corresponding record in a feature attribute table. In this step, you will learn how to access the feature attribute table for a vector layer in the Table of Contents.

- Right click on the **Towns** layer in the **Table of Contents** and click the **Open Attribute Table** menu item shown below.

- The **Towns** attribute table will open in a new window. For now, just take a look at the table. Notice it has **rows**, one for each feature, and **fields** (columns). Notice at the bottom of the table it says **Records (0 out of 169 selected)**. This indicates that there are 169 records in the attribute table – one for each feature in the data layer. Because this data layer contains all of the towns in Connecticut, there are 169 records in the table – one for each town.

- Close the attribute table by clicking on the **X** in the upper right hand corner of the window. We are moving on for now, but will spend a lot of time on tables in the next module!
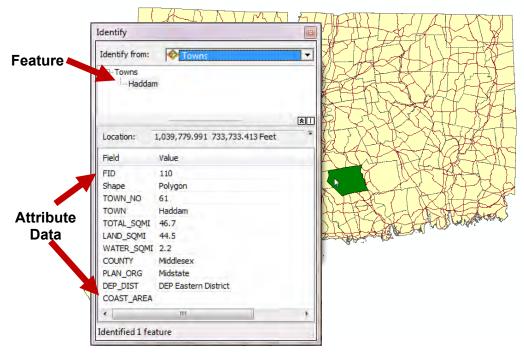
Using Basic Tools in ArcMap

✴ Using the Identify Tool

As you saw in the previous step, generally each feature in a data layer has a corresponding record in the layer's attribute table. The table record stores information about the map feature. In this step, you will use the **Identify Tool**, located on the **Tools Toolbar**, to access attribute data for a feature simply by clicking on the feature on the map.

- To view a feature's data record, click on the **Identify Tool** on the **Tools Toolbar**. When you move your cursor to the map, you will notice it has turned into a small **Identify icon**. Click on a feature on the map. This will open an **Identify window**. In the window, click the **Identify From** drop down arrow and select the **Towns** layer. There are other options available in this menu, but for now let's keep it simple.

- Click on any town on the map. Its attribute information will be displayed in the **Identify** results window. These are the same attributes that are stored in the layer's data table.

- Try holding down the **Shift** key while clicking on multiple towns on the map. Notice how you can view more than one feature's attributes in the **Identify** window by using this technique? Cool, right?

- When you are done exploring this tool, close the **Identify** window by click on the **X** in the upper right hand corner.

✦ Measure Features

The **Measure Tool** allows you to measure lines and areas on a map. You can use the tool to draw a freehand line or polygon and it will give you its length or area, or you can click directly on a map feature and get its measurement information. The **Measure Tool** is located on the **Tools Toolbar** in ArcMap.

- Click on the **Measure Tool** 🔃 on the **Tools Toolbar**. This will open the **Measure** dialog window. Take a minute to look over to tools included in the tool. Each tool is described below.

∿	**Measure Line** – Single click to complete the line.
⟁	**Measure an Area** - Double-click to complete the polygon. (This is unavailable if your data frame is not using a projected coordinate system.)
+	**Measure a Feature** - Click a feature to measure its length (line), perimeter and area (polygon or annotation), or X,Y location (point features). Polygon feature measurement is unavailable if your data frame is not using a projected coordinate system.
Σ	**Show Total** - Keep a sum of consecutive measurements.
▾	**Choose Units** - Set the distance and area measurement units. The measurement units are set to the map units by default.
✕	**Clear and Reset Results** - Clear and reset the measurement results.
▾	**Choose Measurement Type** - Set the measurement type for measuring line distances. Planar is the default when working in a projected coordinate system. Geodesic is the default when working in a geographic coordinate system.
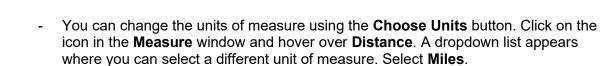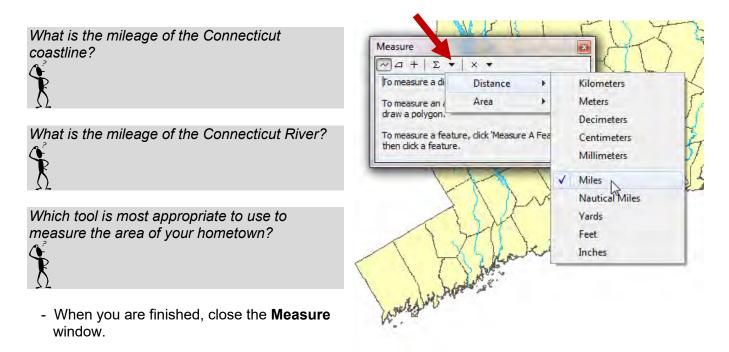
- Click on the **Full Extent** icon on the **Tools Toolbar** to zoom to the full extent of the **State Boundary** dataset in the **Display Area**.

- Make sure your two **Rivers** layers are turned on and displayed on the map.

- Click on the **Measure Line** icon on the far left and try measuring some distances in the **Data View**. After the first click which starts a line, each subsequent click marks the end of a line segment. Notice the line measurement for the segment and length change as you increase the length of your line. To end a line, double click. The segment and length values will remain in the **Measure** window until you clear the dialog using the **clear dialog** button.

What is the distance in feet along the coast of Connecticut from the Greenwich/NY border to the Stonington/RI border?

What is the distance in feet along the Connecticut River from Massachusetts to Long Island Sound?

- You can change the units of measure using the **Choose Units** button. Click on the icon in the **Measure** window and hover over **Distance**. A dropdown list appears where you can select a different unit of measure. Select **Miles**.

What is the mileage of the Connecticut coastline?

What is the mileage of the Connecticut River?

Which tool is most appropriate to use to measure the area of your hometown?

- When you are finished, close the **Measure** window.

⊕ Spatial Bookmarks

Spatial Bookmarks are references to specific geographic areas on your map. They can be accessed through the **Bookmarks** heading on the **Main Menu** in ArcMap. Bookmarks are created and saved in individual **Map Documents** so if you create a bookmark in Connecticut.mxd it will not be available in another **Map Document**. In this step, you will use **Spatial Bookmarks** that have been saved in the **Connecticut.mxd Map Document** to redraw the **Display Area** to the geographic extent of the bookmarks.
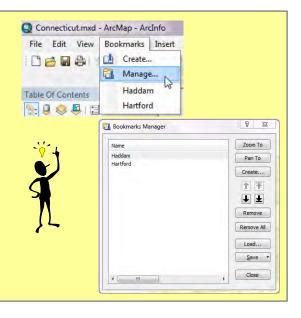
- Click on the **Full Extent** icon on the **Tools Toolbar** to display the entire state in the **Display Area**.

- Click on the **Bookmarks** drop-down menu. Notice there are two pre-created bookmarks listed here. Click on **Haddam**. The data frame will redraw to the geographic extent of the Haddam bookmark.

- Repeat the step above, however this time select the **Hartford** bookmark. This will redraw the map to the geographic extent of downtown Hartford.

More on Bookmarks: You can easily create your own bookmarks. First, navigate to an area of interest. From the **Bookmarks** menu, click **Create…** Enter "**my first bookmark**" as the name for the bookmark and click **OK**. Now pan to another area on the map. Return to the **Bookmarks** menu and click on the bookmark you just created. The **Display Area** will redraw to the saved geographic extent.

Spatial Bookmarks can also be saved as an ArcGIS Place file (.dat) and loaded into other Map Documents. To save or load a bookmark to/from a Place file, click on the Bookmarks heading and select Manage. In the Bookmarks Manager you can use the Load… and Save functions to use Bookmarks across multiple Map Documents.

Layer Properties and Data Frame Properties

Layers in an ArcMap Document are stored within a Data Frame. You can have multiple Data Frames in an ArcMap Document and many layers with each Data Frame. Both Data Frames and individual Data Layers have Properties. In this section, you will familiarize yourself with both Layer Properties and Data Frame Properties.

✴ Layer Properties

Layers are stored within one or more **Data Frames** in the **Table of Contents**. Each layer has properties associated with it that are controlled through the **Layer Properties** dialog window. All aspects of the layer's appearance and behavior can be controlled through these **Properties**. For example, you can define properties that include:

- How to draw the layer
- What data source the layer is based on
- Whether or not to label the layer and what those labels looks like
- Whether to specify scale-dependent display for the layer
- Attribute field properties

The **Layer Properties** dialog box will look different for different types of geographic data. For example, defining the symbology (how the data is drawn on your map) for vector data (a shapefile or feature class) will be different from a raster dataset. Below is a brief description of the tabs in the Layer Properties dialog box for vector data layers.

General	Used to record a layer description, set credits, and specify scale-dependent drawing properties.
Source	Allows you to view the extent of your data. You can view and change the source of your data.
Selection	Allows you to set how features in a specific layer are highlighted when they are selected. Selection property changes in a specific layer override the default Selection Options settings.
Display	Controls how your data is displayed as you move in the view. Options include making a layer transparent, adding MapTips and hyperlinks, and restoring excluded features.
Symbology	Provides options for assigning map symbols and rendering your data. Options include drawing all features with one symbol; using proportional symbols; using categories based on attribute values; the use of quantities, color ramps, or charts based on attributes; or the use of representation rules and symbols.
Fields	Used to set characteristics about attribute fields. You can also create field aliases, format numbers, and make fields invisible.
Definition Query	Allows you to specify that a subset of your features will be used in the layer.
Labels	Allows you to turn on a layer's labels, build label expressions, manage label classes, and set up the labeling options for label placement and symbology.
Joins and Relates	Allows you to join or relate attribute tables to the layer's feature attribute table.
Time	Used to specify the time properties of time aware layers.
HTML Popup	Used to specify how pop-ups are generated when you click a feature to display information about it.
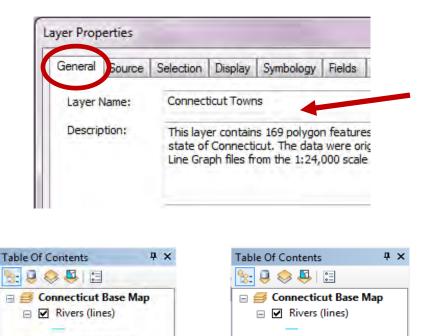
- In ArcMap, move your mouse over the **Towns** layer in the **Table of Contents** and right click. A menu of options will open. Click on the **Properties** menu item at the bottom of the list. This will open the **Layer Properties** window for the **Towns** layer.

- Click through the various tabs to see what type of information is available in each. Refer to the table on the previous page for more information about what functions each tab controls.

- Click the **General** tab and change the **Layer Name:** from "**Towns**" to "**Connecticut Towns**" and click **OK** at the bottom of the **Layer Properties** window. You will notice that the layer name in the **Table of Contents** has been updated.

There are many other items that can be changed through the Layer Properties that you will be introduced to in future exercises.

Tip: For a shortcut to the Layer Properties window, try double clicking on the layer name in the Table of Contents.
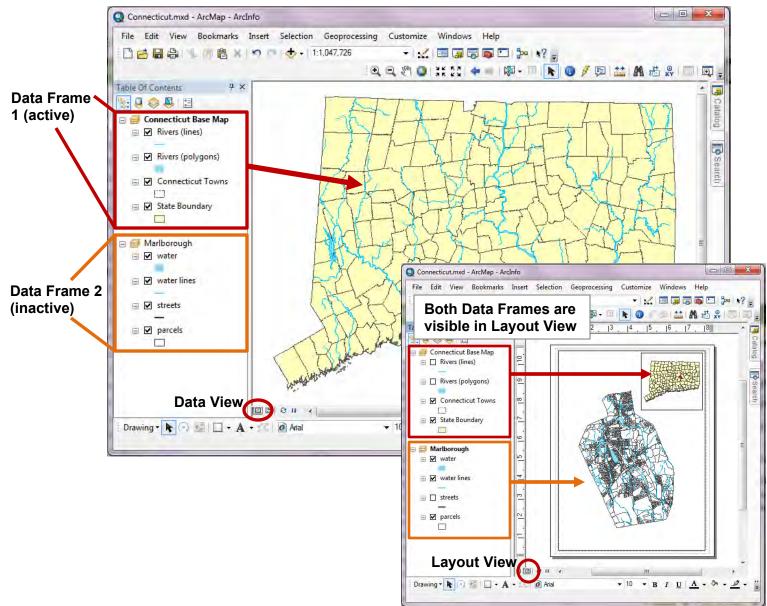
❋ Data Frames and Data Frame Properties

A **Data Frame** is a container for **Data Layers**. As we have learned, the **Data Layers** in a **Data Frame** are drawn in the order in which they are displayed, for example, the layer on the top of the list will be drawn above all others while the layer at the bottom of the list will be drawn below or under other layers above it. The drawing order can be changed by clicking on a **Data Layer** and dragging it to a new position in the **Data Frame**.

A **Map Document** can contain one or more **Data Frames**, however in **Data View** only one **Data Frame** can be "active" at a time. In **Layout View**, one **Data Frame** will be "active" however all of the **Data Frames** in the **Map Document** will be visible.

Like layers, **Data Frames** also have **Properties**. The **Data Frame Properties** window contains options for defining the content for displaying and working with the data the **Data Frame** contains.
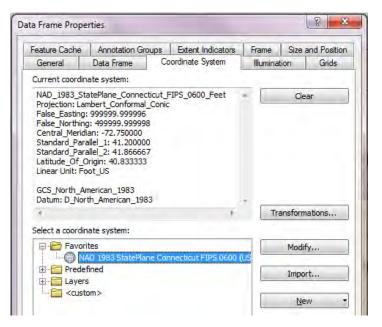
- In ArcMap, right click on the **Data Frame** name, "**Connecticut Base Map**" and select **Properties** from the menu that appears. This will open the **Data Frame Properties** window.

- Take a minute to review the content found on each tab in the **Data Frame Properties** window.

- One of the most important tabs is the **Coordinate System**. Typically the coordinate system of the **Data Frame** is determined by the first data set that is added to your map. You can review and set the **Data Frame's** coordinate system from the **Data Frame Properties**. This is an important function and one that we'll talk about in detail in another module. For now, just take a minute to explore some of these tabs.

- When you are done exploring, close the **Data Frame Properties** window.
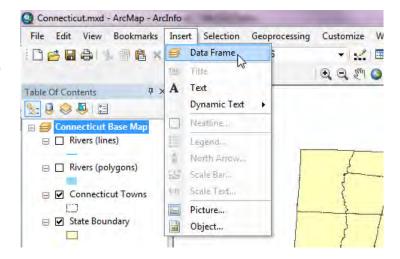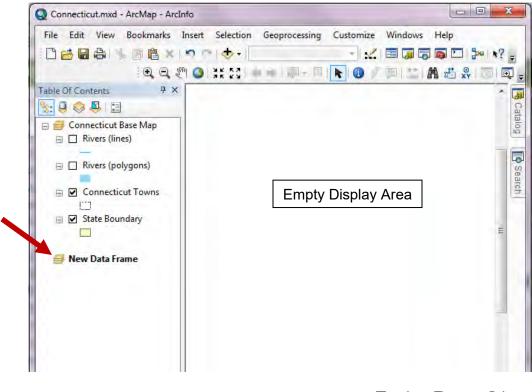
⊛ Insert a New Data Frame

In this step, you will add a second Data Frame to the Connecticut.mxd Map Document and add data to it from a geodatabase. You'll work more with geodatabases in the next exercise so try not to get hung up on the details of the file structure.

- In ArcMap, click on the **Insert** menu on the **Main Menu** and select **Data Frame**. This will create a new, empty Data Frame in the Table of Contents.
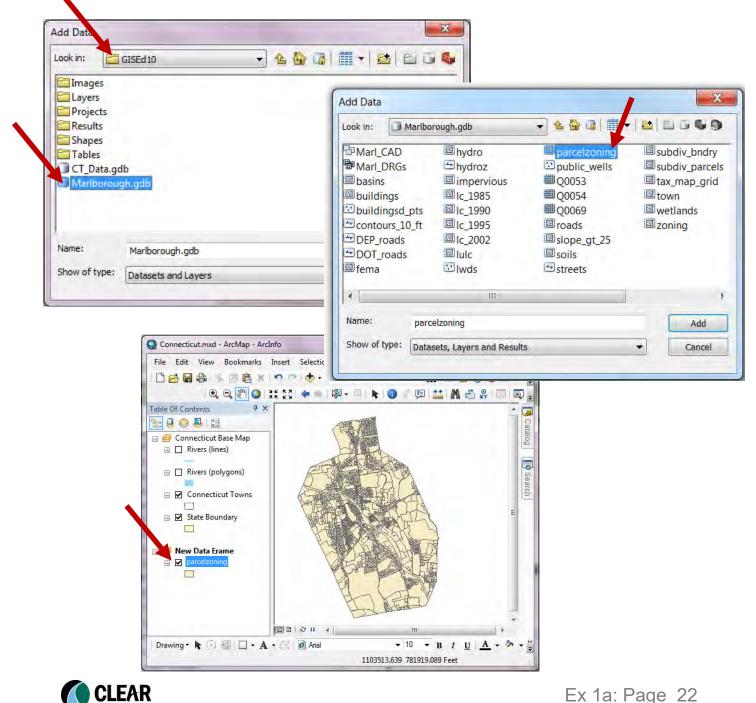
Notice its name, "**New Data Frame**" is in BOLD and your original **Data Frame**, "**Connecticut Base Map**" is no longer bold. Also notice that there is no longer map data being displayed in the **Display Area**. This is because by default, when you add a **Data Frame** to a **Map Document** it automatically becomes the "**active**" **Data Frame**. In **Data View**, only the contents of the "**active**" **Data Frame** will be displayed in the **Display Area**. In this case, our **Data Frame** is empty therefore the **Display Area** is also empty.

- Click on the **Add Data** ⊕ button on the **Standard Toolbar**.

- In the **Add Data** window, use the **Look In:** portion of the window to navigate to your **C:\GISEd10** folder.

- In the **GISEd10** folder, locate the item titled **Marlborough.gdb** and double click on it. This will open the "**Marlborough**" geodatabase and allow you to view its contents.

- Find the file titled "**parcelzoning**" and double-click on it to add it to the **New Data Frame**. You will now see the parcels data displayed in the **Display Area**.

- Right-click on **New Data Frame** and select **Properties** to open the **Data Frame Properties** window.

- In the **Data Frame Properties** window, click on the **General** tab and change the name from "**New Data Frame**" to "**Marlborough**" and click **OK** to close the window. You should see the name of the **Data Frame** is updated in the **Table of Contents**.

- Explore a little by clicking through some of the tabs in the **Data Frame** Properties window.

Save Your Work!

⊕ Save Your Map Project (.mxd)

Any time you make a significant change to your Map Document, you should save it. Unfortunately, ArcMap does not "auto save" and while it has improved greatly over previous releases of the software, it has been known to crash without warning. So, you'd be wise to follow the mantra "**save early and often**" when working on important projects!

- To save the changes you have made to the **Connecticut.mxd Map Document**, click on **File** on the **Main Menu** and select **Save** from the menu that appears.

  Alternatively, you can also save the **Map Document** by clicking on the **Save** icon 💾 on the **Standard Toolbar**.

Finding Help

ArcMap includes an extensive desktop and online help system. It really pays to get comfortable using it because even power users utilize ArcGIS Help on a regular basis. Below is an outline of three methods for finding help for ArcGIS topics.
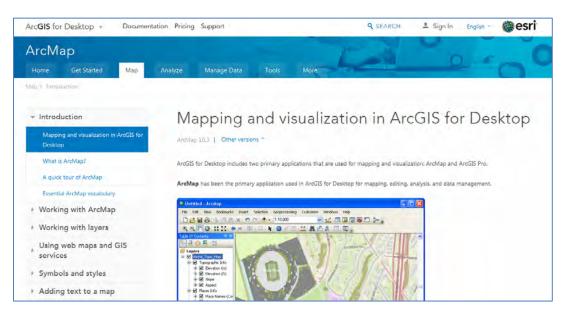
⊕ ArcGIS Desktop Help

Within ArcMap, you can access the desktop help library by clicking on Help from the Main Menu and selecting **ArcGIS Desktop Help**. This help library is installed with ArcGIS and is not updated regularly.

⊕ ArcGIS Desktop Web Help

Esri has created an online web resource for documentation of it's ArcGIS applications. The Web Help is the most complete, up to date and accessible source for help topics, demos and examples and discussion forums related to ArcGIS10.5. It can be accessed by clicking on **Help** from the **Main Menu** and selecting **ArcGIS Desktop Web Help**. The **Web Help** is an online tool and requires an internet connection.

Let's Review!

Congratulations on completing Exercise 1! This exercise was designed to introduce you to the ArcMap interface. A number of features were discussed including:

- ✓ **Toolbars:** all toolbars can be moved and arranged in the GUI. Toolbars can "float" as stand-alone windows, or can be docked within the ArcMap interface. All toolbars can be added or removed from the ArcMap GUI.

- ✓ **Opening a map document**: Map documents can be opened within ArcMap by clicking on the File drop-down menu. All ArcMap projects have an .mxd file extension.

- ✓ **Navigating within the data view:** spatial data can be navigated in the data view using the navigation tools on the Tools Toolbar.

- ✓ **Adding geospatial data:** the Add Data button allows you to navigate to folders where your geospatial data is located. Once you select a dataset, it will be added to the Table of Contents.

- ✓ **Exploring feature attributes:** All features in a layer have associated records within an attribute table. To open the attribute table for a layer, right click on a dataset in the Table of Contents and select open attribute table.

- ✓ **Identifying Features:** the Identify tool on the Tools Toolbar allows you to click on a feature and view its associated record in the attribute table.

- ✓ **Spatial Bookmarks:** a specific geographic area is referenced when you create a bookmark. Each time you click on the bookmark, the display will redraw to the specific geographic extent. Bookmarks are created under the View dropdown menu.

- ✓ **Measuring Features:** the measure tool on the Tools Toolbar lets you measure distances and areas of features.

- ✓ **Examining Layer Properties:** every layer in the Table of Contents has properties associated with it. These properties can be viewed and modified. To open the properties for a layer, right click on the layer in the Table of Contents and select Layer Properties.

- ✓ **Work with Data Frames**: every Data Frame in the Table of Contents has properties associated with it. Your project can have one or more Data Frames. Only one Data Frame can be "active" at a time.

- ✓ **ArcGIS HELP:** ArcMap includes an extensive Help system which can be accessed from the main menu.

This concludes Exercise 1a.

If you have finished and the class is still working on the exercise, go back and try of the tasks you just learned on your own. Explore and experiment, don't worry, you won't break it.

When you are done, **close ArcMap** by clicking on the **red X** in the top right corner of ArcMap.

Exercise 1a Answers

What happens to your other three data layers?

The other three data layers disappear on the map. This is because the State data layer has a solid color fill. The order in which layers are listed in the Table of Contents determines drawing order. Layers on the top will be drawn first and layers on the bottom will be drawn last. When the State data layer was moved from the bottom to the top, it was redrawn on top of the other layers, blocking them from being seen.

What is the distance in feet along the coast of Connecticut from the Greenwich/NY border to the Stonington/RI border?

Roughly 636,000 feet. Your answer should be in this ballpark, but may vary depending on how many clicks you made along the coastline.

What is the distance in feet along the Connecticut River from Massachusetts to Long Island Sound?

Roughly 310,000 feet. Your answer should be in the ballpark, but may vary depending on how many clicks you made along the river.

What is the mileage of the Connecticut coastline?

Roughly 122 miles.

What is the mileage of the Connecticut River?

Roughly 60 miles.

Which tool is most appropriate to use to measure the area of your hometown?

The measure a feature tool. This will allow you to click on your hometown and generate statistics including area. It is the most accurate method for calculating area using the measure tool.

What happens to your data frame when you change the background color?

The space behind your data, within the data frame will be changed to the color you specify.

What happens when you change the active data frame in Data View?

The data in the Display Area will change. Only one data frame can be active at a time. In Data View, the contents of the active data frame are drawn in the Display Area.

What happens when you click on the Layout View icon?

ArcMap switches over to Layout View. Layout View is where you format your map for printing and add cartographic elements like scale bars, legends and north arrows.

Exercise 2a: Working with Data

This exercise is designed to introduce you to different types of geospatial data including shapefiles, geodatabase files, raster datasets and more. You will become more familiar with ArcCatalog, an application within ArcGIS designed to help you organize and maintain your GIS data. Additionally, you will learn where to access some of Connecticut's public domain geospatial datasets and how to add an internet map service to a map document in ArcMap.
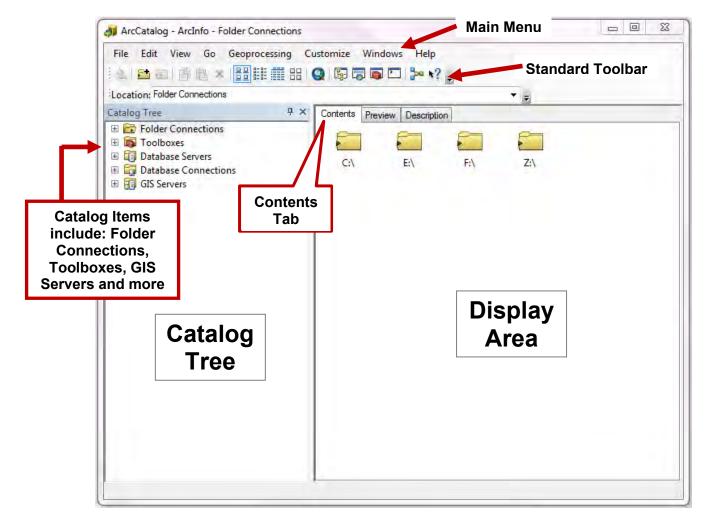
Getting Started: Opening ArcCatalog

To start ArcCatalog, double click on the **ArcCatalog shortcut** on the desktop. If there is no shortcut, then you can access ArcCatalog by clicking on **Start>All Programs>ArcGIS>ArcCatalog 10.5.**

✥ Exploring the ArcCatalog Interface
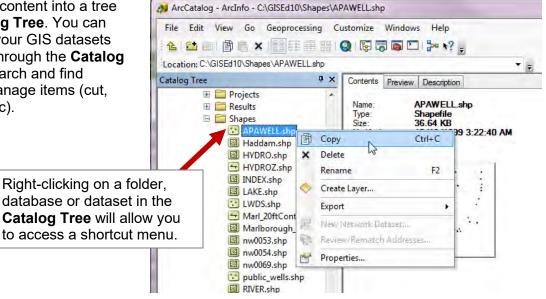
The ArcCatalog GUI will look something like what you see below. If it looks slightly different, it's because ArcCatalog "remembers" what windows, folders and toolbars were open the last time it was used and will return to that setup the next time it is opened. You've already seen this in the first Follow the Instructor hands-on so we won't spend much time on this now. Keep this for reference.
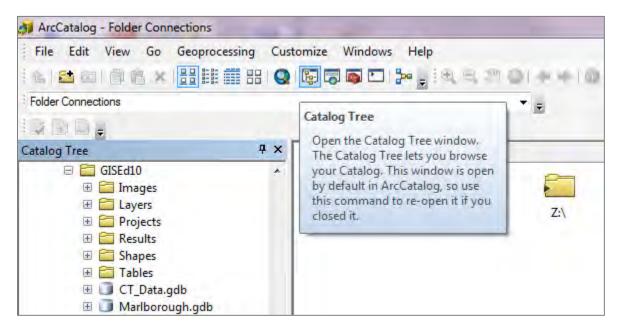
ArcCatalog organizes content into a tree view called the **Catalog Tree**. You can access and organize your GIS datasets and map documents through the **Catalog Tree**. You can also search and find datasets as well as manage items (cut, copy, paste, delete, etc).

Right-clicking on a folder, database or dataset in the **Catalog Tree** will allow you to access a shortcut menu.

- As with ArcMap, when you mouse over tool icons in the ArcCatalog GUI, a small box will appear that explains what the tool does. Spend a few minutes exploring the interface.
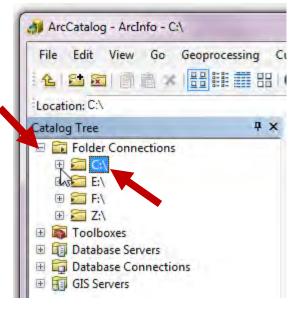
Navigating the Catalog Tree

✥ Locate the ArcGIS10 Folder

- Locate the **Folder Connections** folder in the **Catalog Tree**. This folder contains and displays all of your major drives on your computer. Click on the **+** symbol next to the **Folder Connections** folder to expand it and view its contents.

- You should see each of your hard drives displayed below. Note the image below has LOTS of drive connections. You will likely only have one – your **C:** drive. Click on the **+** symbol next to **C:** drive folder to expand its contents.

- You will see a number of different folders stored on your **C:** drive. Find the **GISEd10** folder and expand it by clicking on the **+** symbol.
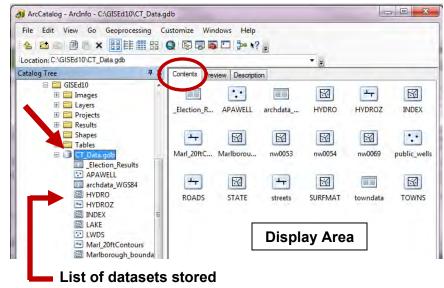
- You should now see all of the contents of the **GISEd10** folder in the **Catalog Tree**.

- Go ahead and take a peek inside some of the other folders in the **GISEd10** folder. Just click on the **+** symbol to expand and contract each folder.
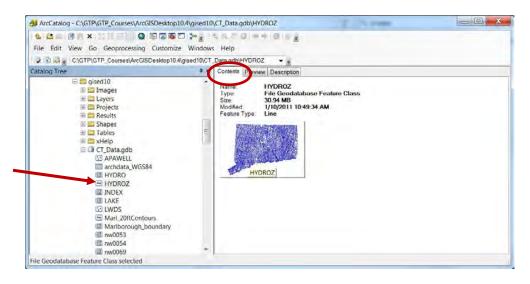
- Locate the **CT_Data.gdb** item in the **GISEd10** folder. This is a **File Geodatabase**. Click on the **+** symbol to the left of its name to view the contents of the geodatabase.

- Click on the name of the geodatabase in the **Catalog Tree** to highlight it. Notice that its contents are now also displayed on the **Contents Tab** in the **Display Area**.

Display Area

List of datasets stored in CT_Data.gdb

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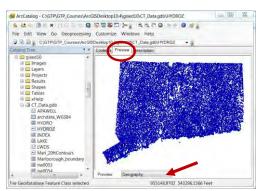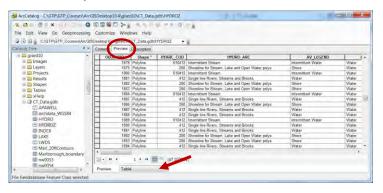
- Click on the **HYDROZ** feature class in the **CT_Data.gdb** geodatabase. The **Contents Tab** will give you an overview of the type of data the file is, add additional details about its size and modified data (these can be set up under the Customize>ArcCatalog Options tab).
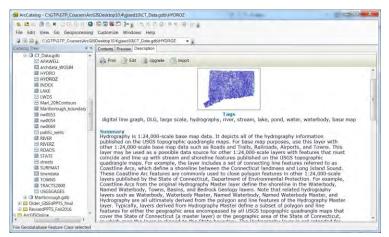
- Next click on the **Preview Tab**. This tab allows you to visualize the spatial data and preview the feature attributes. You can use the tools on the **Geography Toolbar** to explore the spatial data. The attribute **Table** is accessible from the **Preview menu** at the bottom of the window. Take a minute to explore the dataset.

- Click on the **Description Tab**. Here you can read, review and edit the **Metadata** for the HYDROZ layer. Metadata provides more information about a dataset to ensure that it is used appropriately.
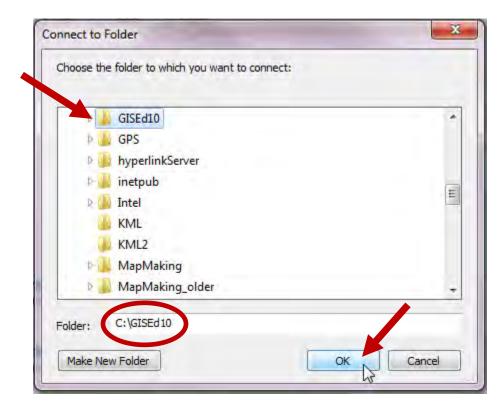
Modifying the Catalog Tree

� Connecting to a Folder

You can make it easy on yourself and avoid having to always navigate to folders containing geospatial data by creating a shortcut to the folder or folders and saving the shortcut as an entry in the Catalog Tree. By having these folders in the "top tier" of the Catalog Tree you will be able to quickly access them when accessing or saving data in ArcMap.

- Click on the **Connect to Folder** button on the **Standard Toolbar**. This will open the **Connect to Folder** window where you can navigate to any folder on the computer or network.

- In the **Connect to Folder** window, navigate to your **C:\GISEd10** folder. (You may have to expand your Local Disk (C:) folder to find the GISEd10 folder).

- Once you find it, click on it and be sure it says **C:\GISEd10** in the **Folder:** box at the bottom of the screen. Click **OK.**
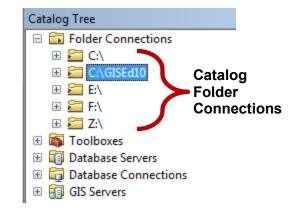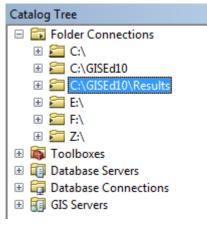
You will now be able see the **GISEd10** folder displayed in the **Catalog Tree** under **Folder Connections**. To view only the top level of the **Catalog Tree**, scroll to the top of the window and collapse the **C:** drive folder by clicking on the **–** symbol to the left of the drive name.

Click here to collapse the C drive folder

Catalog Folder Connections

- Repeat this process to add a folder connection to your **C:\GISEd10\Results** folder. This is where you will be storing the new datasets you create in this course so it will be helpful to be able to access the folder quickly in ArcMap and ArcCatalog.
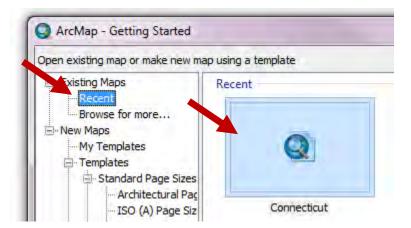
⊕ Launch ArcMap

- From the **Standard Toolbar** in ArcCatalog, click on the **Launch ArcMap** 🔍 icon. This will open ArcMap from within ArcCatalog.
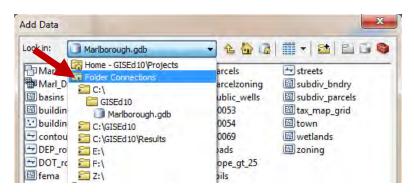
- When the **ArcMap – Getting Started** window appears, click on the **Connecticut** Map Document under **Recent** and click **Open**. This will open your **Connecticut.mxd** project from Exercise 1a.
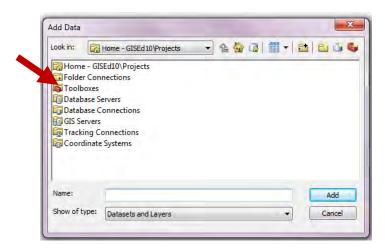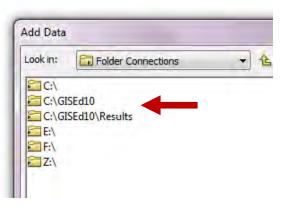
✻ Folder Connections in ArcMap

- Let's see how folder connections affect how you browse for data in ArcMap. Click on the **Add Data** button on the **Standard Toolbar**.

- The **Add Data** window will open. Click on the down arrow next to the Look In: option and select Folder Connections.

- The Folder Connections shows all of the folders that are present in the top level of your **Catalog Tree** in ArcCatalog, including the ones you just added. You should see your **GISEd10** folder and your **Results** folder. Cool shortcut, right?! Right!

- Click **Cancel** in the **Add Data** window to close it without adding any new content to the map.

> **Tip**: Did you notice the "Home" folder in your Add Data window? This is new at ArcGIS 10. The Home folder is automatically set by ArcMap. It is the folder where the current Map Document is stored. For this Map Document and all of the project files you will create in this course, the Home folder will be your GISEd10\Projects folder. Another great shortcut!
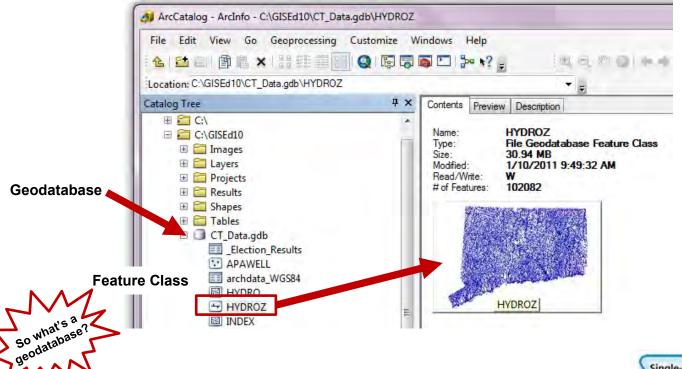
Exploring Data Types

There are many different types of data, spatial and non-spatial, that can be used in ArcGIS applications. In this step, you will use ArcCatalog to explore several different data types that will be used in this course.

✦ The File Geodatabase

- If you closed **ArcCatalog** in a previous step, open it again by clicking on the desktop icon or accessing the program through the **Start Menu**.

- In **ArcCatalog,** expand your **C:\GISEd10** folder in the **Catalog Tree**.

- Earlier in this exercise you explored a geodatabase **Feature Class, HYDROZ,** using the **Contents**, **Preview** and **Description** tab. **Feature Classes** are vector datasets stored within an ArcGIS geodatabase. Take a minute to check out some of the other feature classes in the **CT_Data.gdb** geodatabase in the **GISEd10** folder. Be sure to click on the **Feature Class** name in the **Catalog Tree** before clicking on the **Preview** or **Description** tabs.

At its most basic level, a geodatabase is a container for geographic datasets of various types (feature classes, tables, rasters, etc.) and is used primarily for storing, editing, and data management. There are different types of geodatabases, each varying in size and function. They can range from single user databases to larger workgroup or enterprise geodatabases that are accessed by many users. The type of geodatabase we will work with in this course is a **File Geodatabase**. A file geodatabase stores datasets in a folder of files on your computer. Each dataset is held as a file and can be up to 1 TB in size. File geodatabases can be used across all platforms and can be compressed and encrypted for read-only, secure use. See the ArcGIS Help for more information on different types of geodatabases.
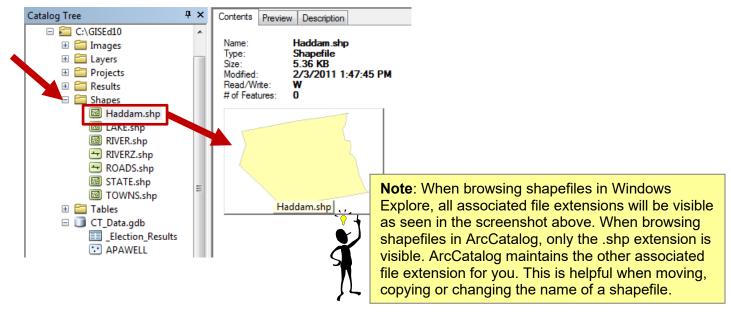
⊛ Working with Shapefiles

Like geodatabase feature classes, shapefiles are a vector data format for storing the geometric location and attribute information of geographic features. Unlike feature classes, however, shapefiles are not stored within a specific structure like a geodatabase. Shapefiles can be stored in any folder on your computer or network. Shapefiles are made up of several components which are stored in separate files. In order for a shapefile to function correctly, at least three files must exist (.shp, .dbf, .shx) and all of the component files must be stored in the same folder or workspace. Note that each component file must have the same prefix.

GISEd10/Shapes ➡️

Name	Date modified	Type
Haddam.dbf	2/3/2011 1:47 PM	DBF File
Haddam.prj	2/3/2011 1:47 PM	PRJ File
Haddam.sbn	2/3/2011 1:47 PM	SBN File
Haddam.sbx	2/3/2011 1:47 PM	Adobe Illustrator ...
Haddam.shp	2/3/2011 1:47 PM	SHP File
Haddam.shp.xml	2/3/2011 1:47 PM	XML Document
Haddam.shx	2/3/2011 1:47 PM	SHX File

The three **required** component files are the **.shp** file which stores the feature geometry, the **.dbf** file which stores attribute information and the **.shx** file which stores an index of the feature geometry. Additional files are ancillary and include components like coordinate system information (.**prj**) and metadata (.**xml**). These files are helpful, but not required to use and view a particular shapefile.
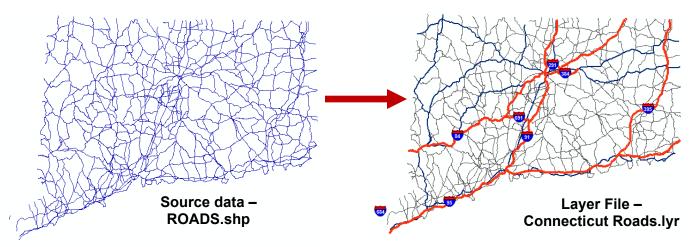
- In the **Catalog Tree**, locate the **C:\GISEd10\Shapes** folder. Click on the **+** symbol to the left of the folder to expand its contents. You will see a number of shapefiles stored in this folder. They all have the .shp file extension. Click on one of them in the **Catalog Tree** and preview the file in the **Preview Tab**. Notice that a shapefile looks and feels very similar to a feature class. That's because they are very similar, the biggest difference is the fact that feature classes are stored in geodatabases and shapefiles are stored directly in folders.

Catalog Tree 📌 ✕

- C:\GISEd10
  - ⊞ Images
  - ⊞ Layers
  - ⊞ Projects
  - ⊞ Results
  - ⊟ Shapes
    - Haddam.shp
    - LAKE.shp
    - RIVER.shp
    - RIVERZ.shp
    - ROADS.shp
    - STATE.shp
    - TOWNS.shp
  - ⊞ Tables
  - ⊟ CT_Data.gdb
    - _Election_Results
    - APAWELL

Contents | Preview | Description

Name: **Haddam.shp**
Type: **Shapefile**
Size: **5.36 KB**
Modified: **2/3/2011 1:47:45 PM**
Read/Write: **W**
# of Features: **0**

Haddam.shp

Note: When browsing shapefiles in Windows Explore, all associated file extensions will be visible as seen in the screenshot above. When browsing shapefiles in ArcCatalog, only the .shp extension is visible. ArcCatalog maintains the other associated file extension for you. This is helpful when moving, copying or changing the name of a shapefile.

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⊕ Layer Files

A layer file contains information about how a data set will be displayed in ArcMap. This includes the layer's symbology, labeling and display properties – all of the settings that can accessed through the Layer Properties window in ArcMap. You can create multiple layer files for a single data source (for example, ROADS.shp) – one only displaying major highways and others displaying only local roads or state roads. The layer files don't contain any actual geographic data, they simple "point to" or reference a particular dataset.

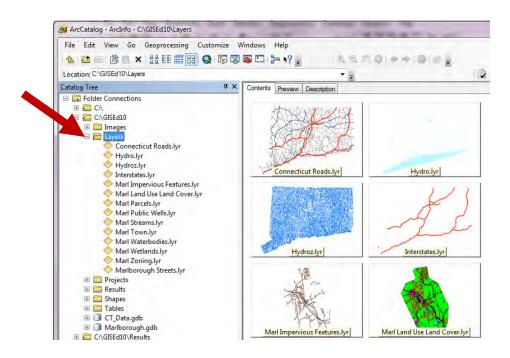**Source data –
ROADS.shp**

**Layer File –
Connecticut Roads.lyr**

- In ArcCatalog, locate the **C:\GISEd10\Layers** folder. Click on the **+** icon to the left of the **Layers** folder to expand its contents. Notice there are a number of files in the folder with the **.lyr** file extension. These are ArcGIS layer files. Each one contains information about how a dataset should be displayed within ArcMap. Each one references a source dataset stored on disk. Take a minute to explore some of these layer files. You can preview thumbnails of the datasets from the **Contents** tab or you can click on a layer file in the **Catalog Tree** and preview it from the **Preview Tab**. We'll work more with layer files in a later exercise.
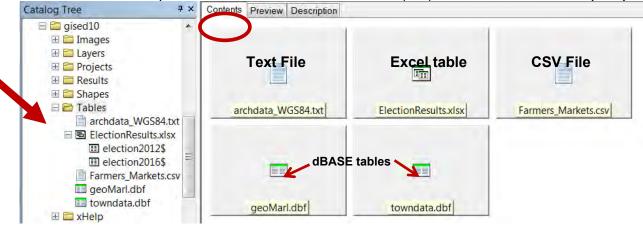
✥ Tabular Data

Tabular information is essential and is the backbone of geographic information, allowing you to visualize, query and analyze your data. Tabular data can be associated with a geographic dataset, such as a geodatabase feature class or shapefile, or it can be a stand-alone table, created in programs like Microsoft Excel or Access. Stand-alone tables can be joined to feature attribute tables using a common field. For example, if you have a GIS dataset of all 169 towns in Connecticut and a stand-alone table with information about each of those towns, you can append them using a common field, like town name. We will spend a lot of time on tables in the next exercise.

- Earlier in this exercise, you saw how you can preview the attribute table for a GIS dataset using the **Preview Tab** in **ArcCatalog**. You can use this technique to preview stand-alone tables as well. From the **Catalog Tree**, locate your **C:\GISEd10\Tables** folder and click on it to highlight it - if you are not already on it, click on the **Contents** tab to see the contents of the folder in the **Display Area**. Notice there are several files in this folder. Each are stand-alone tables of varying formats. The folder includes an **Excel** table (**.xlsx**), a **dBASE** table (**.dbf**) and two comma separated values files – one in **text file** (**.txt**) format and one in **CSV (.csv)**.
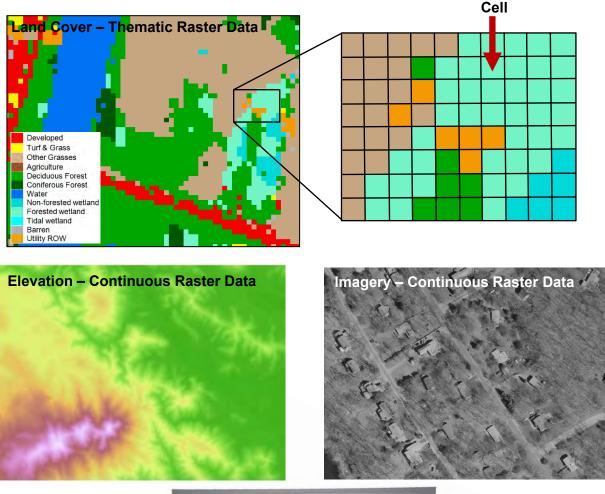

- Take a minute to click on each table type in the **Catalog Tree** and preview its contents using the **Preview Tab**. To view the table for the **ElectionResults.xlsx** file, first expand the file's contents by clicking the **+** symbol next to the file name and then select the **electiondata2012** or **electiondata2016** worksheet before previewing it from the **Preview Tab**.

✴ Raster Data

Unlike vector data (geodatabase feature classes and shapefiles), raster data is stored in a matrix of cells (or pixels) organized into rows and columns, where each cell contains a value representing information such as land cover type or temperature. Examples of raster datasets include aerial photographs, satellite imagery, digital pictures and scanned maps. Raster data can be thematic data, meaning each pixel represents a category of data such as land use or soil type, or raster data can be continuous data representing phenomena such as elevation, temperature or spectral data like satellite imagery.

Cell

Land Cover – Thematic Raster Data

Developed
Turf & Grass
Other Grasses
Agriculture
Deciduous Forest
Coniferous Forest
Water
Non-forested wetland
Forested wetland
Tidal wetland
Barren
Utility ROW

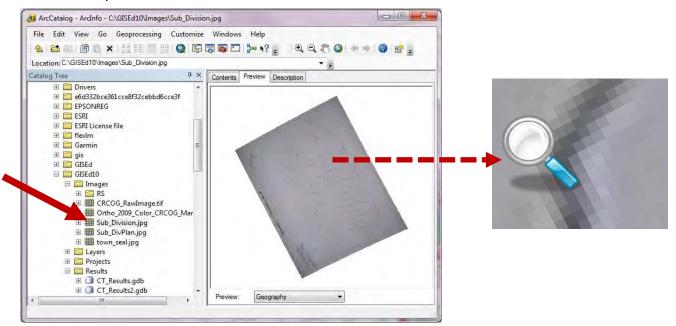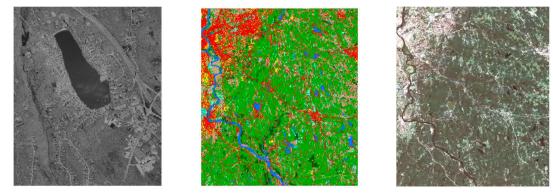Elevation – Continuous Raster Data

Imagery – Continuous Raster Data

Scanned Map

- Let's explore some raster data in ArcCatalog. Locate the **C:\GISEd10\Images** folder and click on the **+** symbol to the left of the folder to expand it. You should see a subfolder titled **RS** (for Remote Sensing) and several other raster files. Click on the **Sub_Division.jpg** and click on the **Preview Tab**. You should see the scanned subdivision map in the **Display Area** - use the navigation tools on the **Geography Toolbar** to pan and zoom in on the map. Notice when you zoom all the way in, the image becomes "pixelated"? Remember, rasters are files made up of lots of tiny cells or pixels.

- Expand the **RS** folder in the **Catalog Tree**. Click through each of the raster files inside the file and preview each one from the **Preview** tab.
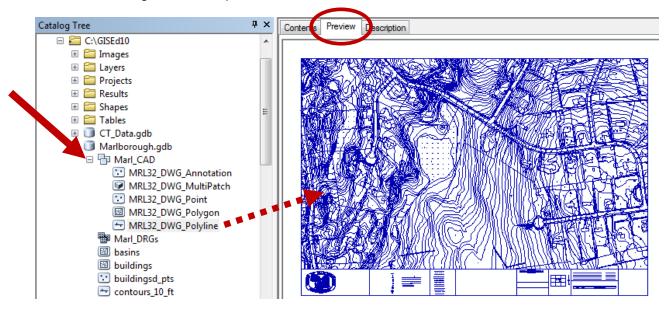

Is the lake.tif file a continuous raster or a thematic raster?

How about the landcover.img file?

✸ CAD Data

Computer-Aided Design (CAD) drawing files are digital representations of man-made designs or real world objects. They are primarily used by technical professionals that include engineering, architecture, surveying and construction disciplines. ArcGIS supports AutoCAD .dwg and .dxf files and MicroStation .dgn files. All of these file types are stored in file-based vector formats and organized into a geodatabase schema that includes five generic feature classes: annotation, multipatch, point, polygon and polyline. Let's take a look!

- In the **Catalog Tree**, locate the **Marlborough.gdb** geodatabase in your C:\GISEd10 folder. Click on the **+** symbol to expand the geodatabase and view its contents.

- Within the geodatabase, locate the **Marl_CAD** feature dataset. A geodatabase feature dataset is a collection of related feature classes that share a common coordinate system. The CAD files do not have to be in a feature dataset or even a geodatabase for that matter, however feature datasets are a good method for storing CAD data or similar datasets within a geodatabase.

- Expand the **Marl_CAD** feature dataset by clicking on the **+** symbol. You will see a number of CAD files that have been imported to the Marlborough geodatabase. Click through each and preview their contents from on the **Preview** tab.

We won't spend too much time working with CAD data in this course. If you are interested in learning more about how to effectively work with CAD data in ArcGIS, check out the ArcGIS for Desktop online help guide for more information. You can get to the Web Help from ArcMap or ArcCatalog directly from the Help dropdown menu.
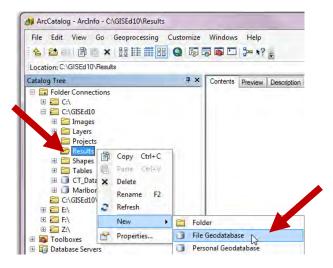
Working with File Geodatabases

As you have seen in previous steps in this exercise, a geodatabase is simply a sophisticated container for storing data. A file geodatabase stores the data it contains within a system of files and can be used simultaneously by several users, however only one user can edit a database at a time. All of the various data components in a file geodatabase are stored within a single folder, ending with the .**gdb** extension. This makes a geodatabase an effective way to share and distribute geospatial data. In this step of the exercise, you will learn how to create a new file geodatabase and import data into it from shapefiles.

✧ Creating a File Geodatabase

- From the **Catalog Tree**, locate your **C:\GISEd10\Results** folder. Right click on the **Results** folder and select **New>File Geodatabase.** A file geodatabase titled, "**New File Geodatabase.gdb**" will be added to your **Results** folder.

- By default the name of the geodatabase will be editable text (highlighted in blue), however if you clicked off of the geodatabase name, it will no longer be highlighted. If necessary, left-click on the geodatabase <u>name</u> once (name, not folder!) to highlight it in blue. Click on it again, you should now be able to edit the name of the geodatabase. Rename it to **CT_Results**.

Click once on geodatabase name   **Type in new name**   **Geodatabase name will be changed**

This geodatabase will serve as a repository for new and changed data that you will create during this course. In the next step, you will add data to the geodatabase by importing data from two shapefiles.

⊕ **Importing Data into a Geodatabase**

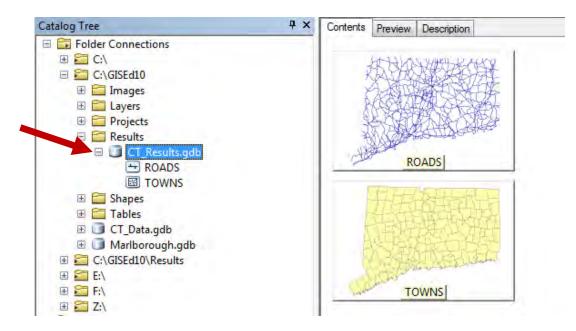- Right-click on **CT_Results.gdb** and select **Import > Feature Class (multiple).**

- In the window that appears, click on the **yellow folder** icon under **Input Features**. This is where you will select what files you would like to import.

- After you click on the folder, a window titled **Input Features** will appear. Using the browsing tools at the top of the window, navigate to your **C:\GISEd10\Shapes** folder.

- Several shapefiles are stored in the **Shapes** folder. Click on **TOWNS.shp** and click the **Add** button. This will add the shapefile to the **Feature Class to Geodatabase** window.

- Repeat the process to add a second shapefile, **ROADS.shp** to the **Feature Class to Geodatabase** window.

- Once both shapefiles have been added under the **Input Features** dialog box, your **Feature Class to Geodatabase** window will look like the graphic to the right.

- Click the **OK** button to import the two shapefiles into the **CT_Results.gdb**.

- The import process may take a minute so be patient if you don't see the new files in the geodatabase right away. As the computer processes your request, you will see a "work in progress" message scrolling along the bottom of the ArcCatalog window.

- After the two files are imported, you will see them in the **CT_Results.gdb**. Expand the **+** symbol next to the geodatabase name to view the contents. You should see both **ROADS** and **TOWNS**. These are the two new **Feature Classes** that you imported to the geodatabase from shapefiles. Take a minute to explore them. They should look very similar to the shapefiles which they were imported from.

Connecting to Web Enabled Data

Geospatial data is available for download from sources all over the Internet. However, very often, GIS data is published on the Internet through a GIS server as a map service that can be used to connect to data online instead of downloading data files and storing them locally on a hard drive or data disk. In this step of the exercise, you will learn how to connect to a GIS Server and add data to ArcMap through an Internet connection.

✦ Adding a Map Service to ArcMap

There are a number of useful sources of public domain geospatial data in Connecticut. These sources were highlighted in the previous Lightning Round Demo (check your slides for web links). In this step, you will visit one source (CT ECO) and add a map service to ArcMap.

- Open a web browser from the Start Menu (either Internet Explorer or Firefox) and enter **https://cteco.uconn.edu**. This will take you to the Connecticut Environmental Conditions Online (CT ECO) site.

CT ECO is a partnership between the University of Connecticut and the Connecticut Department of Energy & Environmental Protection. CT ECO is a website where users can browse map layers in interactive web maps, read information about particular datasets and connect to data layers and imagery in ArcMap through Map Services.

There is a lot of information and things to look at on the CT ECO page and you can spend a LOT of time exploring the site. For our purposes, however, let's just look at a few Map Services. Providing you have ArcGIS installed on your computer and an active Internet connection, Map Services allow you to connect to data over the web. This is particularly helpful for datasets that are very large or updated frequently and takes the burden off you to store and manage the data.

- **Open ArcMap** again by clicking on the **desktop icon**, launching it from **ArcCatalog**, or opening the program from the **Windows Start** menu.

- In the **ArcMap – Getting Started** window that opens after the program launches, open a **New Blank Map** by clicking on the **New Maps** link in the left panel and selecting **Blank Map** under **My Templates.**

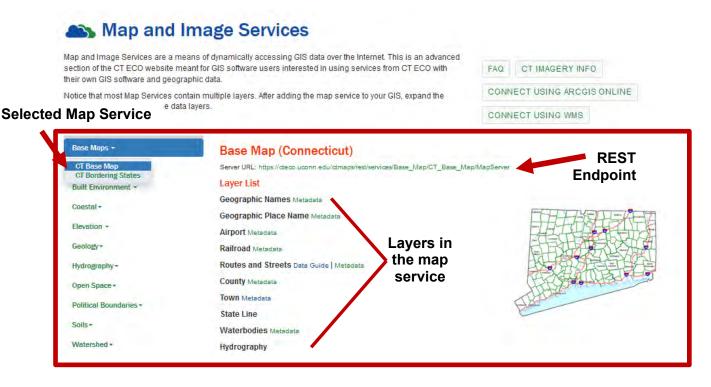- Click **OK** to open a blank, untitled map in **ArcMap**.

- Return to your web browser and the **CT ECO** website.

- In **CT ECO**, click on the Data heading under the title bar and click on **Map and Image Services** (see image below). This will take you to the **Map Services** directory (https://cteco.uconn.edu/map_services.htm).
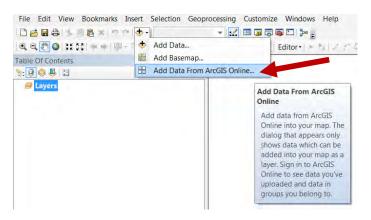

The Map Services directory provides links to a number of GIS map services. Each map service includes a number of layers.

- Browse the map services by clicking on each topic heading on the left side of the window. A list of related map services will appear under the heading. The image on the following page shows the layers in the "**Base Map**" map service.

Map and Image Services

Map and Image Services are a means of dynamically accessing GIS data over the Internet. This is an advanced section of the CT ECO website meant for GIS software users interested in using services from CT ECO with their own GIS software and geographic data.

Notice that most Map Services contain multiple layers. After adding the map service to your GIS, expand the ~~e data layers.~~

FAQ   CT IMAGERY INFO

CONNECT USING ARCGIS ONLINE

CONNECT USING WMS

Selected Map Service

Base Map (Connecticut)

Server URL: https://cteco.uconn.edu/ctmaps/rest/services/Base_Map/CT_Base_Map/MapServer

REST Endpoint

Layer List
Geographic Names Metadata
Geographic Place Name Metadata
Airport Metadata
Railroad Metadata
Routes and Streets Data Guide | Metadata
County Metadata
Town Metadata
State Line
Waterbodies Metadata
Hydrography

Layers in the map service

- If ArcMap is minimized on your desktop, maximize it so you can see the interface. You will add a CT ECO map service to your ArcMap project. Click on the **small black arrow** on the **Add Data** button. In the menu that appears, click on "Add Data From ArcGIS Online".

- In the ArcGIS Online window that appears, type **CT_ECO** into the search box. Press **Enter.** A long list of map services (the same one you just explored on the CT ECO website!) will be listed. Scroll to the bottom and find **Base Map (Connecticut)**. Click **Add**. The Base Map service will be added to your Table of Contents. Easy, right?!
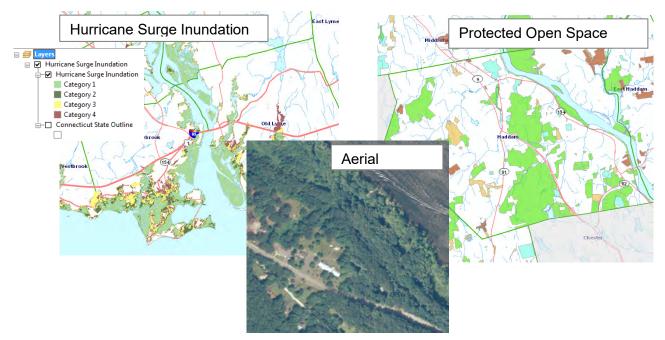

CLEAR

- To expand the layer list, click in the + next to **Base Map**. You should see some map data of the state drawn in the **Display Area**.

- Notice that **Base Map** has a number of sub-layers below it. Each one of the sub-layers includes additional sub-layers. Try expanding some of them so you can get an idea of what kind of data is included in the **Base Map** layer.

- Turn layers **on/off**. Do you notice that some of the layers are greyed out and the check boxes are inactive? This indicates that the layer has a scale threshold. You will need to zoom in on an area on the map in order to view that layer.

Zoom in to display these layers

- Pretty cool, right? Take some time to explore the **Base Map** map service and other map services available through **CT ECO**. Remember, to find a map service, return to **Add Data** button and select **Add Data From ArcGIS Online** and search for **CT_ECO**.

Hurricane Surge Inundation

Protected Open Space

Aerial

Adding Content from ArcGIS Online

✦ What is ArcGIS Online?

Esri, the company that developed the ArcGIS desktop software used in this training, has recently developed an online mapping and resource website called ArcGIS Online (also referred to as ArcGIS.com). Here you will find an extensive public map gallery, data and imagery services, content groups and mapping tools. If you're interested in learning more about ArcGIS Online, ask about CLEAR's training course!
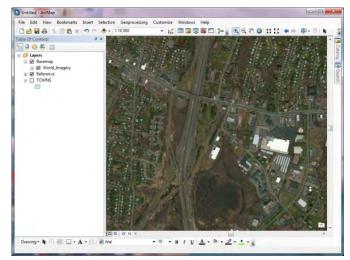
✦ Adding a Base Map from ArcGIS Online

- In ArcMap, remove any left-over CT ECO map services you may have in your **Table of Contents**. To remove a map service or layer, right-click on the layer or map service name in the **Table of Contents** and select **Remove**. You should now have an empty **Layers Data Frame.**

- Click on the small black down arrow to the right of the **Add Data** symbol. Click on the **Add Basemap** item.

- In the **Add Basemap** window that appears, select an Esri basemap and click **Add**.

- You may see a window pop up warning you that the **basemap** data source is in a different coordinate system than other layers in your map. Click **Close** to ignore the warning. If prompted, select **NO** to **Hardware Acceleration**.

- You will see a new basemap layer added to your **Table of Contents**.

- Take a minute to check out the map.

- If you have time to spare, explore some of the different **Basemaps** accessible from the **Add Data** button. Remember, you are connection to these basemaps over the
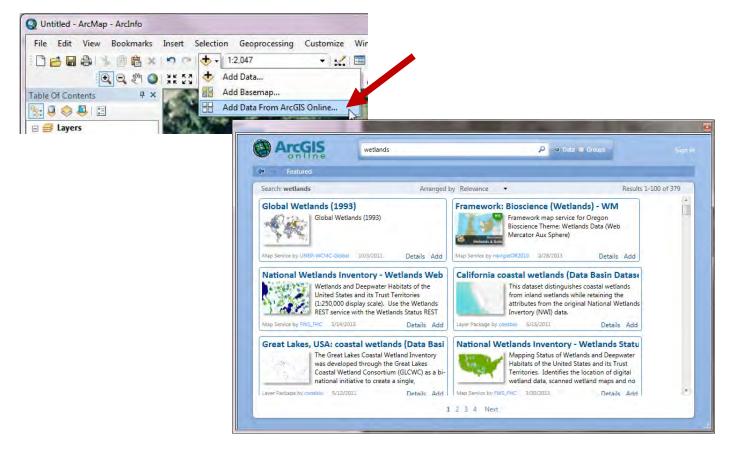
Internet so an Internet connection is required. Also, because the entire class is connecting to Map Services through a single wireless connection, the Map Services may be slow to load and draw so please be patient.

⊛ Adding Additional Data from ArcGIS Online

- As you saw in a previous step, there is a third option available to you from the **Add Data** dropdown list called **Add Data From ArcGIS Online.** Click on it. **ArcGIS Online** makes data available to ArcMap users in the form of online **Map Services**. These data range from the basemaps you added in the previous step to data submitted by various users all over the globe (including the CT ECO data you added in the previous step). If you or your "organization" have an ArcGIS Online account, you can also pull data into your map from your online account. Of course, ArcGIS Online requires an Internet connection. We'll talk more about ArcGIS Online in the Lightning Round.
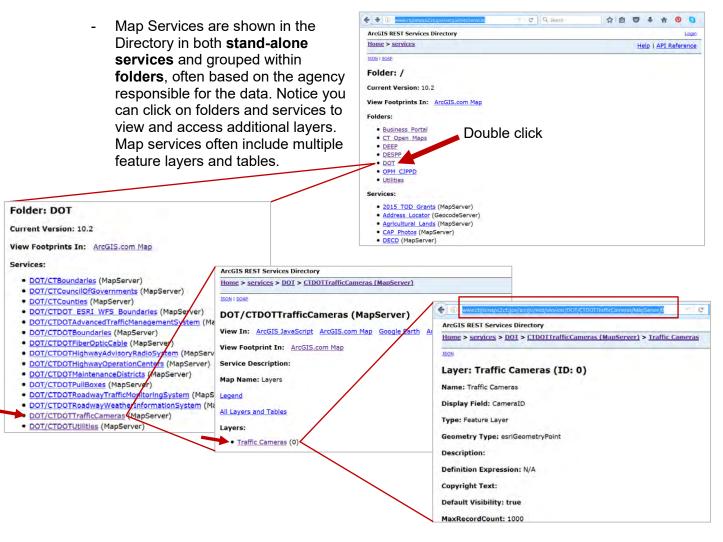
Add Data from a REST Endpoint

A common way to publish GIS data online is through an ArcGIS Server REST Services Directory. This is a fancy name for a webpage that provides access to users to connect to a dataset or group of datasets in a desktop GIS, web map, or mobile application using an Internet connection, web browser and URL. In this step of the exercise, you will add a GIS server to the Add Data directory in ArcMap and add GIS data layers from a REST endpoint.

✦ Explore a REST URL

The State of Connecticut Bureau of Enterprise Systems and Technology (BEST) has published some of the state's public domain spatial data through a REST Services Directory. Let's take a look at the BEST REST.

- Return to your web browser. Open a new tab and type in the following web URL: **https://www.ctgismaps2.ct.gov/arcgis/rest/services.** Be sure you do not make a typo.

- The web address will take you the **ArcGIS REST Services Directory** for CT BEST. It may not look like much, but this directory provides access to a ton of spatial data. Let's take a look.
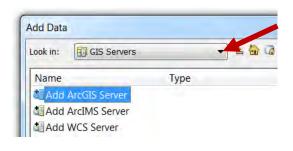
- Map Services are shown in the Directory in both **stand-alone services** and grouped within **folders**, often based on the agency responsible for the data. Notice you can click on folders and services to view and access additional layers. Map services often include multiple feature layers and tables.

Double click

⊕ Add a Server URL to ArcMap

In this step of the exercise, you will add a map service from the BEST GIS server to ArcMap.

- In ArcMap, click on the **Add Data** button. From the **Look in** text box at the top, click the **down arrow** and choose **GIS Servers**.

- In the list, click **Add ArcGIS Server** and click the **Add** button.

- In the window that appears, choose the "**Use GIS Services**" option.

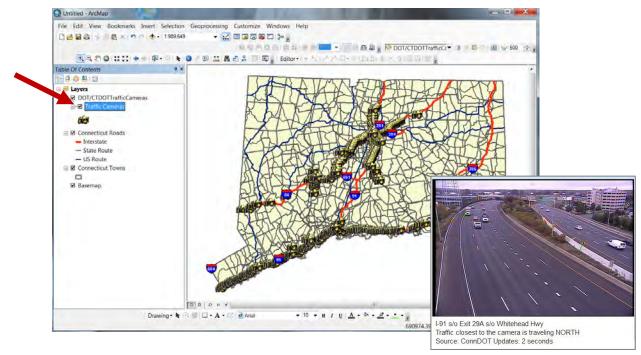- Type in the BEST REST Services Directory URL: **https://www.ctgismaps2.ct.gov/arcgis/rest/services** and click **Finish**.

- You will see the **BEST GIS Server** added to the list of **GIS Servers** your computer can now connect to.

- **Double-click** on the **server URL**. You should see a list of folders and Map Services appear. These are the same items that you explored through the REST URL in your web browser.

- **Double-click** on the **DOT folder**. Scroll through the available map services until you see **CTDOTTrafficCameras**. **Double-click** on it. The DOT Traffic Camera layer will be added to your Table of Contents. If you want to see real time images from the DOT traffic cameras, try using the **Identify** or **HTML tool** to click on a camera point. The images are available as hyperlinks stored in the TrafficLink field. The image will open in a web browser.

If you finished well ahead of your classmates, feel free to explore other map services that are available from the CT BEST GIS server. You may also try searching Google for other GIS REST Service Directories that you can add to ArcMap. A few others are listed below, but there are many more out there!

The USGS National Map Service Endpoints: https://viewer.nationalmap.gov/services/

The NOAA National Weather Service Endpoints: https://www.nws.noaa.gov/gis/services.html

Esri's ArcGIS Online Service Endpoints: https://services.arcgisonline.com/arcgis/rest/services

Various Federal Datasets: https://maps1.arcgisonline.com/ArcGIS/rest/services

Save Your Work!

✦ Save Your Map Project (.mxd)

Any time you make a significant change to your Map Document, you should save it. Unfortunately, ArcMap does not "auto save" and while it has improved greatly over previous releases of the software, it has been known to crash without warning. So, you'd be wise to follow the mantra "**save early and often**" when working on important projects!

- Now we're ready to save our map! To save the changes you have made, click on **File** on the **Main Menu** and select **Save As..** from the menu that appears. In the Save in: window, navigate to your **C:/GISEd10/Projects** folder. Name the file **Exercise2a.mxd** and click **Save**.

Let's Review!

Phew! Congratulations on completing Exercise 1b! This exercise was designed to introduce you to the ArcCatalog interface and gave you the chance to explore lots of different data types.

- ✓ **ArcCatalog:** ArcCatalog includes tools to browse and find geographic data; preview spatial data and attributes; to copy, delete, rename and move spatial datasets; to create, define, import and export geodatabase data models; and to create and view metadata.

- ✓ **Previewing geospatial datasets:** In ArcCatalog, the Preview tab gives you the option to view the geography or attribute table for any dataset. This allows you to browse through your datasets in an efficient manner.

- ✓ **Create direct connections to folders:** Creating a folder connection allows you to access file-based GIS data. You can connect to any folder, including folders on network drives. Once you've connected to a folder, you can browse the contents of the folder and any subfolders it may contain. Adding a folder connection to ArcCatalog can greatly increase the speed and efficiency of searching for data or adding a dataset to an ArcGIS application.

- ✓ **Using the Catalog tab in ArcMap:** the Catalog tab is available in ArcMap as a means of using and accessing ArcCatalog within the ArcMap application.

- ✓ **Exploring data types:** ArcGIS can processes a number of different types of data including shapefiles, file geodatabases, layer files, tabular data, raster data and CAD data. You will use all of these data types in this course.

- ✓ **CT's Public Domain Data:** there are many sources for accessing geospatial data for Connecticut. Some of the best sources are the CT DEEP, UCONN MAGIC, UCONN CLEAR and CT ECO.

- ✓ **Connecting to Map Services in ArcMap:** You can connect to online map services in ArcMap. This method is useful because it allows you to access the most up-to-date data without having to download large datasets to your computer. CT ECO is the primary source for geospatial map services in CT.

- ✓ **Connecting to ArcGIS Online Basemaps and Data:** ESRI's ArcGIS.com provides basemaps and data layers in the form of map services. These map services can be added to ArcMap from the Add Data button. All map services require an internet connection.

- ✓ **Connecting to Data through a REST Endpoint:** Many organizations publish public domain GIS data through a GIS server and make access to those data sets available through a REST URL. You can add a connection to a GIS Server through the Add Data button in ArcMap.

This concludes Exercise 2a.

If you have finished and the class is still working on the exercise, go back and try of the tasks you just learned on your own. Explore and experiment!

When you are done, close ArcMap by clicking on the red X in the top right corner of ArcMap.

CLEAR

Exercise 2b: Understanding Spatial Reference

This exercise is designed to the concepts of projections and spatial references within your GIS application. You will open a premade ArcMap document (.mxd), modify the spatial reference values for the layout view, define the spatial reference for a feature, and optionally modify the spatial reference for a feature. In each case noting how this affects display. This should go quick, about five minutes per section.

Getting Started:

- Open **ArcMap**. For detailed instructions, refer to Exercise 1a.

⊕ Open an Existing Map

When the **Getting Started** window pops up, click on **Existing Maps** under the "**Open existing map or make new map using a template**" heading on the left, then click on **Browse for more…** *Note: If the document was previously opened the following may be found under the **"Recent"** link.
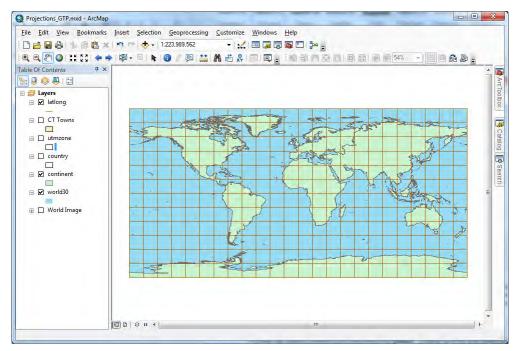
In the **Open ArcMap Document** window, navigate to the following folder **C:\GISEd10\Projects** and open the file **Projections_GTP.mxd.**

Once open, the ArcMap GUI will look something like what you see below. If it looks slightly different, it's because additional functionality (toolbars, etc.) may have been turned on or enabled by a previous user. When ArcMap is closed, it "remembers" these settings and restores them when it is reopened.

Changing the Spatial Reference of the Data Frame

If the project opened properly the image should display the world as a rectangular box. This is typical of how a map would look when displaying geographic coordinates in latitude and longitude directly onto a flat surface. To change the display to match a spatial reference of your choice you adjust the coordinate system for the **Data Frame**.   For this exercise you will modify the data frames spatial reference to use the UTM Zone 18N coordinate system.

- **Right-click** on **Layers** in the Table of Contents and select **Properties…** from the dropdown list. This will open the **Data Frame Properties** dialog.

- In the **Data Frame Properties** dialog select the **Coordinate Systems** tab

- From the displayed list click the (+) sign next to **Projected Coordinate Systems** to expand (open) this sub-list.

- Navigate down the list and click the (+) sign next to the **UTM** "folder"

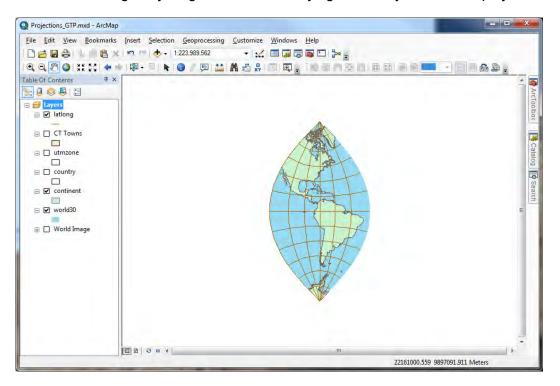- Navigate down this list and click the (+) sign next to **NAD 1983**

- Finally, navigate this list and select (left-click) **NAD 1983 UTM Zone 18N**. Zone 18N is the spatial reference that best represents UTM coordinates for Connecticut. Rhode Island uses Zone 19N. (Tip) BEFORE selecting OK in the next step, click the **Favorites** button ⭐ on the Coordinate System Dialog Window. Clicking this button will add the reference to you favorites list. Do this for any spatial reference you want quick access to in the future.

- **Click OK**. You may see a Warning dialog asking you to use Transformations. Just click **YES** to close this dialog (not NO, which would make more sense). This happens when two features have different datums. Transformation accuracy is not an issue for this demonstration, but it *is* important when editing data.

The data view should now match your selected coordinate system. If you selected the UTM Zone 18N your image should look like the map below. The feature layers, if they have defined projections, should adjust accordingly. Keep in mind changing the spatial reference for a data frame does not change anything within the underlying data, only how it is displayed.

With the data frame (view) in UTM Zone 18 move on to the next section - defining projections.

Define a Features Spatial Reference (Define Projection)

After you adjusted the map to a new spatial reference, if some of the layers do not show properly they may not have a spatial reference defined or their definition could be incorrect. In this section you will use the **Define Projection** tool to *tell* ArcMap what a features spatial reference is *supposed* to be (not to be confused with the Project tool where you are *changing* the projection values). When complete the feature should display in the proper location.

In the **Table of Contents** there is a feature called **CT Towns**. Prior to the class we deliberately removed its spatial reference, right now ArcGIS does not know where it should properly be located on the map. You are going to fix this.

To verify there is no projection, or see what it might be, do the following:

- **Right-click** on the **CT Towns** feature and select **Properties…** from the droplist.

- Select the **Source** tab on the **Layer Properties** dialog. The text within the Data Source box has a field called Coordinate System: - it should say <undefined>.
  * If it does show a coordinate system note what it is and let us know. I'll blame Cary.

- **Click OK** to close the **Layer Properties** dialog

Now let's see where ArcGIS *thinks* the feature should be:

- Turn on the **CT Towns** feature by clicking the check box next to it. You may see it appear on the map, or maybe not.

- **Right-click** on the **CT Towns** feature and select **Zoom to Layer** from the list. It should now zoom to the Towns feature.

- At the top of the ArcMap interface there should be a text box for changing the Map Scale. Type in the number 60,000,000 and hit Enter.
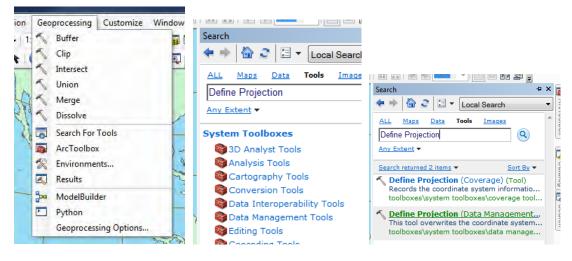

  This should give you a good scale to see where the feature actually is. Is the location correct? Or has has CT gone South?

Now *define* the projection to put the feature into its proper location:

- Select the **Geoprocessing** menu item at the top of the ArcMap interface, then select **Search for Tools** from the droplist. This opens a Search dialog (we'll explain more about tools in the next talk).

- In the Textbox type the words "Define Projection" and select Enter (or search).

- A list of options should be returned, select the choice called **Define Projection (Data Management)**. A **Define Projection** dialog box should appear (it may take a few seconds to load). There are two text boxes.

- In the **Input Dataset or Feature Class** textbox select the arrow at the right, then select **CT Towns** from the list.

- Next, click the small icon next to the **Coordinate System** text box. This will bring up a **Spatial Reference Properties** dialog.

- Where it says "Type here to search" in the **Spatial Reference Properties** dialog, type Connecticut, then hit enter or click the search button. This reduces the selection list to spatial references recommended for CT.

- From the list below, open the following directory tree by clicking their plus (+) signs. **Projected Coordinate Systems ->State Plane ->NAD 1983 (US Feet)**

- Finally, select **NAD 1983 StatePlane Connecticut FIPS 0600 (US Feet)**

- **Click-OK** to close the Spatial Reference Properties dialog

- **Click-OK** on the Define Projection dialog to start the process. This can take a minute. When the tool is finished CT Towns will snap into its proper location. To verify, **right-click** on **CT Towns** in the Table of Contents and select **Zoom to Layer** from the droplist. The map *should* zoom into the towns and be at its proper location in the United States.

You now have CT Towns in one coordinate system and the Data Frame in another with all of the features displaying in their proper locations.

Optional: Change a Features Spatial Reference (Project)

Occasionally you will need to actually convert a data feature from one spatial reference to another. Not all GIS software can make use of spatial reference data to match one feature to the others, for example the old ArcView 3.0 and some free software. Also, working with multiple datasets together is always more accurate, and can display faster, if all features in a data frame are referenced to the same datum and coordinate system. To match these datasets you actually convert the data using the **Project** tool (not to be confused with Define Projection).

In theory, if you properly defined the projection in the previous section, the spatial reference for CT Towns is now set to CT State Plane Feet. Your goal in this section is to re-project these towns to a new feature set with a UTM Zone 18N coordinate system:

- Just like with define projection, select the **Geoprocessing** menu item at the top of the ArcMap interface, then select **Search for Tools** from the droplist.

- This time in the Textbox type the word "Project" and select Enter (or search).

- A list of options should be returned, select the choice called **Project (Data Management)**.

- A **Project** dialog box should appear. There are more text boxes and more options in this dialog than just the two when defining a projection. In the **Input Dataset or Feature Class** text box select the arrow at the right, then select **CT Towns** from the list. The second box, **Input Coordinate System**, *should* populate itself with the State Plane coordinate system you defined before, in this case **NAD_1983_StatePlane_Connecticut_FIPS_0600_Feet**. If it does not check with one of us before proceeding.

- Another box is for the **Output Dataset or Feature Class**. Select the folder next to this text box and navigate to **C:\GISEd10\Results**, then type the new name for your feature – in this case **CTTowns_UTM18.shp**, and click OK. This is what your new feature will be called. Tip: Adding a short piece of the coordinate system text to the filename can help later if you need to guess what the features spatial reference is when moving files around.

- Now click on the button to the right of the Output Coordinate System text box. As with define projection this will bring up a **Spatial Reference Properties** dialog.

- Where it says "Type here to search" in the **Spatial Reference Properties** dialog, type UTM, then hit enter or click the search button. This reduces the selection list to spatial references with UTM coordinates.

- From the list below, open the following directory tree by clicking their plus (+) signs. **Projected Coordinate Systems ->UTM ->NAD 1983**

- Finally, select **NAD 1983 UTM Zone 18N**

- **Click-OK** to close the Spatial Reference Properties dialog.

- Note: You can ignore the Geographic Transformation textbox, in this case both features are going to use the same datum (NAD1983) so no transformation is required.

- **Click-OK** on the **Project** dialog to start the process. This can take a minute. When the tool is finished **CTTowns_UTM18** should show up in the Table of Contents and draw on the map. Visually not much should change, ArcMap will simply redraw the feature into the correct location in the same spatial reference as the Data Frame. Behind the scenes however, you now have a new feature with physical coordinates (X, Y) in UTM Zone 18 meters. This could now be sent to someone who has a GIS software that cannot handle projections, displaying properly if their data is also in UTM Zone 18.

Bonus: Change the Spatial Reference of the Data Frame

Repeat section one, this time pick any projection(s) you want. To zoom to the full extent after adjusting the map **right-click** on **world30** in the Table of Contents and select **Zoom To Layer**.

Exercise 3a: Introduction to Tables

This exercise will introduce you to attribute tables and selections. Tabular information is the foundation of a GIS. It allows you to visualize, query, and analyze your data. It is important to remember that feature attribute tables contain data that are directly attached to map features. Tables are critically important in making geospatial data useful. In this exercise, you will explore:

- Table Field properties in both Layer Properties and Table Properties
- The Attribute Table including sorting rows and table layout
- Selections

Getting Started

- Open **ArcMap**. For detailed instructions, refer to Exercise 1a.
- Open a **New Map**. Remember, to click on **New Maps** and then a **Blank Map**.

✦ Add a Layer to ArcMap

In this step you will add the towns layer to the **Table of Contents** using the **Add Data** button. The towns layer is a feature class inside the **CT_Data** geodatabase.

- Click on the **Add Data** button on the **Standard Toolbar**. This will open the **Add Data** window.

- Use the **Look in:** area of the window to navigate to the following folder:
  C:\GISEd10\Results

TIP: Remember that geodatabases are containers for layers. Layers inside a geodatabase are called **Feature Classes**, not shapefiles.

CLEAR

Notice that the geodatabases have a different icon than the folders that contain data.

- Double-click on **CT_Results.gdb**. This is the geodatabase that you created in an earlier exercise.
- Locate the **TOWNS** layer and click on it.
- **Click Add** at the bottom of the window to add the layer to ArcMap.

The **TOWNS** layer will be added to ArcMap's **Table of Contents**. A randomly selected color will be assigned to the layer to symbolize the towns.
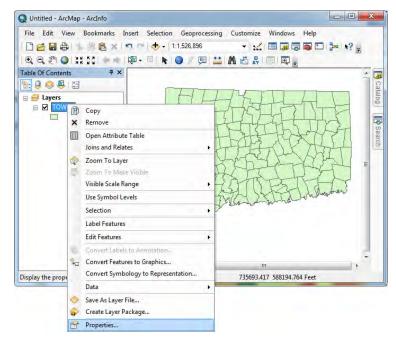
Field Properties

Field Properties contain options for how each field (column) is displayed in the table.

✺ Field Properties via Layer Properties

First you will look at the Field Properties that can be changed in the Layer Properties box.

- Right-click over **TOWNS** in the **Table of Contents** and select **Properties**.

- Click on the **Fields** tab. Notice that all fields have a checkmark meaning that they are visible (turned on).

- Un-check **COAST_AREA** to hide this field.
- Click on **PLAN_ORG** in the left column. It should be highlighted.
- On the right side, click in the **Alias** field and type in **Planning Org**. Hit the ENTER key on your keyboard. Notice that the name changes on the left side.

- If you like, use the arrows ⬆ ⬇ to **rearrange the order** of the fields in your table.

- Click on **TOWN**.
- On the right, change **Highlight** to **Yes**.
- Click **OK** to close **Layer Properties**.
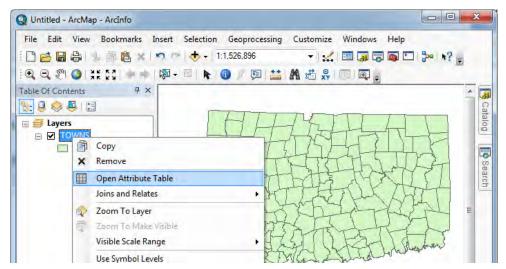
⊕ Field Properties via Table Properties

To open the Attribute Table of the **TOWNS** layer,

- Right-click over **TOWNS** and select **Open Attribute Table**.

CLEAR

The table should look like the graphic on the following page. Notice that the changes you just made in **Layer Properties** are evident. The **TOWN** field is highlighted in yellow, the Planning Organizations field says **Planning Org** and not PLAN_ORG and the **COAST_AREA** field is not visible.

These settings and others can also be changed within the **Field Properties** inside the table.

- Right-click over the yellow **TOWN** field and select **Properties**. Uncheck **Highlight field**. Notice that you could change the **Field Alias** and turn the field off (hide it) if you wanted.

- Click **OK** to close the **Field Properties** window. The town field is no longer yellow.

Explore the Attribute Table

The attribute table is similar to a spreadsheet in layout, but not function. It consists of rows, called records (usually with one record per layer feature), and columns. Each column contains values for a single data field. The field name (column) is in bold at the top of the column.

You will now locate and explore the various menus and options available inside a table.

❋ **Row Box Menu**

- Right-click over the row box next to a record at the very left of the table.
- Click on **Flash**. The record over which you right-clicked should flash in the map display.
- Try using **Zoom To**, **Pan To** and **Identify** to see how it changes your map display.

✧ Field Menu

SORT ON A SINGLE FIELD
- Right-click over the **TOWN** field name to display the field options.

TIP: The **Field Options** menu contains operations that work on the column or field ONLY.

- Choose **Sort Ascending**.

How does Sort Ascending change the field? What happens to the other fields?

SORT ON MULTIPLE FIELDS
- Right click on the **TOWNS** field again. This time choose **Advanced Sorting**.
- In the first **Sort by** field, choose **County**.
- In the second **Sort by** field, choose **TOTAL_SQMI**.
- Click **OK**.

- Notice in the table that the records are first sorted by county and then the total sq.mi.

What is the largest town in square miles in Hartford County?

What is the smallest town in square miles in Middlesex County?
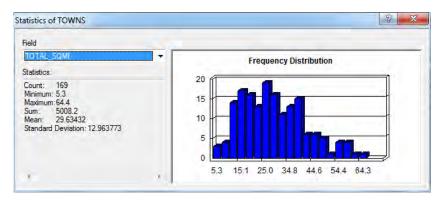
TIP: Sorting, especially when used with selecting (coming up), can be a powerful and simple way to answer questions using your GIS data.
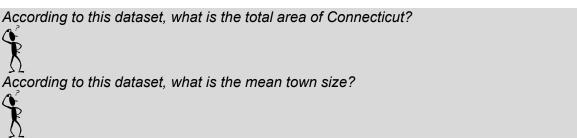
NOTE: Sorting a table does not permanently rearrange the records. If you were to close the table, remove the layer and then add it back into ArcMap and open the table, it would no longer be sorted.

STATISTICS

- Right-click over the **TOTAL_SQMI** field and choose **Statistics**. Descriptive statistics for the field values will be displayed, including sum (or total area of all towns), minimum and maximum values for total square miles, and mean.

According to this dataset, what is the total area of Connecticut?

According to this dataset, what is the mean town size?
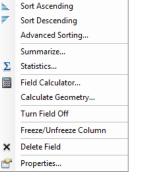
- Close the **TOWN Statistics** window when you are done.

We won't use these options now, just note that the field menu also includes
- **Summarize**
- **Field Calculator** and **Calculate Geometry** (we'll use these later)
- **Turn Field Off**
- **Freeze/Unfreeze Column**
- **Delete Field** (don't do this!)

Selections

There are many uses for and reasons to select features, including:
- To retrieve and examine attribute data
- To answer simple questions

- To create summary statistics
- To create a new feature class or shapefile
- To focus an analysis on appropriate features
- To select features based on spatial relationships with other layers

You will now explore a variety of ways to select features.

> **REMEMBER:** Attribute tables and features are connected. A selected feature is selected in BOTH the table and the map.
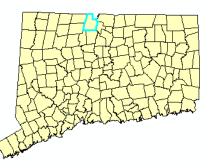
✥ Select Records in a Table

- Open the attribute table for **TOWNS** by right-clicking over the layer in the **Table of Contents** and selecting **Open Attribute Table**.
- Move the table so that you can see the **TOWNS** layer in your map.
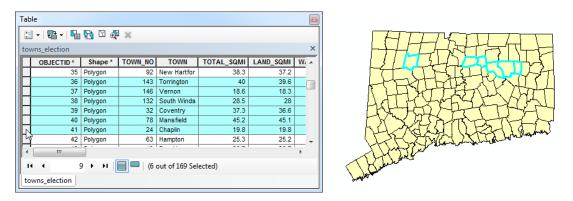
Row Box

- **Left-click over a row box** to select a record. If you cannot see the selected record on your map, click on the **Zoom to Full Extent** 🌐 icon on your **Tools Toolbar**.

- **Left-click** and **drag** to select multiple consecutive records.

- **Hold down the control key** and left click to select multiple, non-consecutive records.

Table

	OBJECTID *	Shape *	TOWN_NO	TOWN	TOTAL_SQMI	LAND_SQMI	W/
	1	Polygon	122	Salisbury	60.5	57.6	
	2	Polygon	100	North Canaa	19.6	19.6	
	3	Polygon	98	Norfolk	46.7	45.6	
	4	Polygon	29	Colebrook	33	32.8	
	5	Polygon	65	Hartland	34.5	33	
	6	Polygon	56	Granby	41.3	41.1	
	7	Polygon	139	Suffield	43.1	42.4	
	8	Polygon	49	Enfield	33.8	32.9	

9 (5 out of 169 Selected)

towns_election
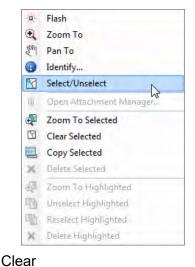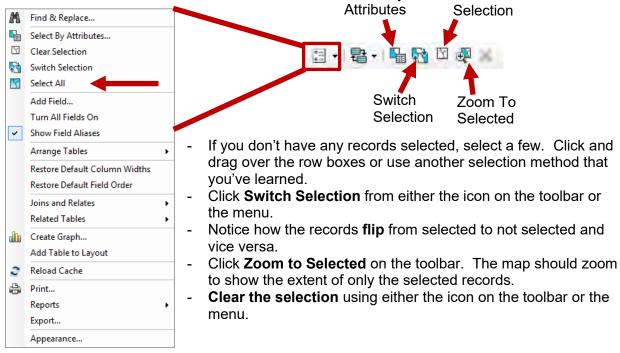
Row Box Menu

- Right-click over any row box to access the menu.
- Select or unselect a record or records using this menu.
- Try the **Flash** tool.
- Try the **Zoom to** tool.
- Try the **Pan To** tool.
- Select a few records and try the **Zoom to Selected**.
- When you are finished choose **Clear Selected**.

Table Selection Tools

Table Selection Tools can be accessed through the icons at the top of the table or through the Table Options Menu. Note that Select All is only available on the Menu and Zoom to Selection is only available on the toolbar.

Select by Attributes   Clear Selection

Switch Selection   Zoom To Selected

- If you don't have any records selected, select a few. Click and drag over the row boxes or use another selection method that you've learned.
- Click **Switch Selection** from either the icon on the toolbar or the menu.
- Notice how the records **flip** from selected to not selected and vice versa.
- Click **Zoom to Selected** on the toolbar. The map should zoom to show the extent of only the selected records.
- **Clear the selection** using either the icon on the toolbar or the menu.

Menu items (right panel):
- Flash
- Zoom To
- Pan To
- Identify...
- Select/Unselect
- Open Attachment Manager...
- Zoom To Selected
- Clear Selected
- Copy Selected
- Delete Selected
- Zoom To Highlighted
- Unselect Highlighted
- Reselect Highlighted
- Delete Highlighted

Menu items (left panel):
- Find & Replace...
- Select By Attributes...
- Clear Selection
- Switch Selection
- Select All
- Add Field...
- Turn All Fields On
- Show Field Aliases
- Arrange Tables
- Restore Default Column Widths
- Restore Default Field Order
- Joins and Relates
- Related Tables
- Create Graph...
- Add Table to Layout
- Reload Cache
- Print...
- Reports
- Export...
- Appearance...

CLEAR

> **NOTE:** The **Select By Attributes** option is available on both the toolbar and the menu within the table. We will use Select By Attributes soon.

- **Close** the table.

Save Your Work!

✤ **Save Your Map Project (.mxd)**

- To save the changes you have made, click on **File** on the **Main Menu** and select **Save** from the menu that appears. Name it **Exercise3.mxd** and be sure to save it in the Projects folder. You will use it for the next exercise so it is important that you remember to save the project!

Let's Review!

Congratulations on completing Exercise 3a! This exercise covered all of the basics of using feature attribute tables and stand alone tables in ArcMap. A number of important concepts were covered including:

✓ **Understanding feature attribute tables:** Feature attribute tables are tables that are directly linked to map features. Any changes made to the feature attribute table will also be reflected in the map.

✓ **Modifying table properties:** Table properties such as field name aliases, arrangement of fields, and visibility of fields (you can make a field "hidden") can be modified to make a table more "user-friendly".

✓ **Selections:**.There are basic tools to easily select records in a table.

This concludes Exercise 3a.

If you have finished and the class is still working on the exercise, move on to the extra credit below.

Extra Credit

Be sure your **Exercise3.mxd** is still open. If not, open it.

Try using the table to find

- The biggest town in Connecticut. _____

- The smallest town in Connecticut. _____

- The biggest town in each county

- and the smallest town in each county.

County	Biggest	Smallest

Exercise 3a Answers

How does Sort Ascending change the field? What happens to the other fields?
The records are re-ordered occurring to alphabetical order of town name. All other fields are rearranged along with the town field.

What is the largest town in Hartford County?
Glastonbury, 52.5 sq. miles.

What is the smallest town in Middlesex County?
Essex, 12.2 sq. miles.

According to this dataset, what is the total area of Connecticut?
5008.2 sq miles. Find this using Statistics for the TOWN field and looking at the Sum.

According to this dataset, what is the average town size?
29.6 sq. miles. Find this using Statistics for the TOWN field and looking at the Mean

Exercise 3b: Working with Tables

Exercise 3b takes moves beyond working on the table as a whole and introduces you to ways to add and change data in your table. It also shows you how to bring two tables together so that the information can be used together. In this exercise you will learn how to:

- Add a table field
- Calculate area in the new field
- Join tables
- Use the field calculator
- Create a new file with the joined information

Getting Started
- Open **ArcMap**. For detailed instructions, refer to Exercise 1a.

⊛ Open an Existing Map (.mxd)
- **Exercise3.mxd** will likely appear as a **Recent** document. If so, click on it to select it and click **Open.**
- If the **Exercise3.mxd** does not appear, in ArcMap, click on the **File** dropdown menu and select **Open** from the list of choices. This will open a window in which you are able to navigate to any location on your computer.

- Navigate to the following folder:

    C:\GISEd10\Projects

- Select the map file named **Exercise3.mxd** and click the **Open** button. Double-clicking on the file name will also open it.

Open the TOWNS table if it is not still open from the previous exercise.

- Right-click over **TOWNS** in the **Table of Contents** and select **Open Attribute Table**.

⊛ Table Options
The **Table Options menu** is opened by clicking on the **Table Options** icon 🔲 in the top left of the table window.

> **TIP:** The **Table Options** menu contains operations that work on the ENTIRE table.

TURN ALL FIELDS ON
- Click on the **Table Options icon** and select **Turn All Fields On**.

ADD FIELD

- Click on the **Table Options icon** and select **Add Field**.
- Type **acres** as the field name and choose **Float** as the type. Below is a table describing the different types of fields that can be added to a table.
- Click **OK**.   Notice that a new field, called **acres**, has been added to your table. Because this is a feature class table inside a geodatabase, the default values say **<Null>.**

Numeric Table Field Types

Field Type	Appropriate Use	Data Storage Size	Allowable Range
Short Integer	Whole **numbers**	2 bytes	-32,768 to 32,767
Long Integer	Whole numbers, especially large **numbers**	4 bytes	-2,147,483,648 to 2,147,483,647
Float	Single precision **numbers** with decimals	4 bytes	Approx. -3.4E38 to 1.2E38
Double	Double precision **numbers** with decimals	8 bytes	Approx. -2.2E308 to 1.8E308

Other Table Field Types

Field Type	Appropriate Use
Text	A text field represents a series of alphanumeric symbols. This can include street names, attribute properties, or other textual descriptions
Date	The date data type can store dates, times, or dates and times. The default format in which the information is presented is mm/dd/yyyy hh:mm:ss and a specification of AM or PM. When you enter date fields in the table, they will be converted to this format

CALCULATE GEOMETRY

You will now calculate area, in acres, in the column. Remember, each row in the table is associated with one feature. Here, the features are individual towns. The **Calculate Geometry** tool will do the calculation for each town. The **Calculate Geometry** function can be used to calculate **Area**, **Perimeter**, **X Coordinate of Centroid** or **Y Coordinate of Centroid**.

- Right-click over the new **acres** column and select **Calculate Geometry**.
- A warning box will show. It is telling you that you will be making an edit to the table outside of an edit session and you CANNOT UNDO your edits. Click **Yes**.

- Choose **Area** under **Property**.

- Select **Use coordinate system of the data source**.

- Specify **Acres US [ac]** as the Units.

- Click **OK**.

The acres field in your table should now be populated. For easier viewing of the town name and acres column together, it is helpful to freeze the field.
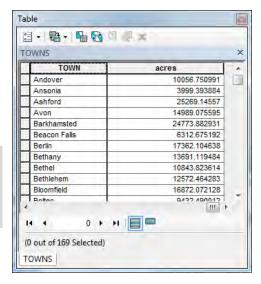
TIP: If it doesn't seem to have worked, check to see if any records are selected. If any records ARE selected, the calculation ONLY works on the selected ones.

FREEZE/UNFREEZE COLUMN
- Right-click over **TOWN** and choose **Freeze/Unfreeze**.
- Use the bottom scroll bar to move the **acres** column closer to the frozen **TOWN** column so you can see both fields near each other in the table.
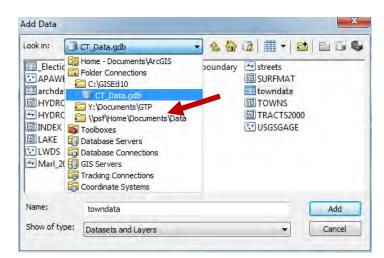
According to this dataset, what is the biggest town in Connecticut? The smallest?

⊕ **Add a Table to ArcMap and Open the Table**
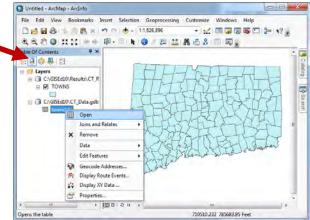
Leave the TOWNS table open for now. You will add the towndata table to your ArcMap document. The towndata table contains population information.

- Click on the **Add Data** button.
- Navigate to **C:\GISEd10**
- Double-click on **CT_Data.gdb**.
- Click on **towndata** and then click **Add**.

After adding the table in ArcMap, the **Table of Contents** will switch from **List By Drawing Order** to **List By Data Source**.

- Right-click over **towndata** and select **Open**.

- Because the **TOWNS** attribute table is already open, the **towndata** table is added to the **Table Window** as a tab at the bottom of the window. If your **TOWNS** attribute table isn't

open, right-click over **TOWNS** in the **Table of Contents** and choose **Open Attribute Table**.

- Take a minute to explore the table. It includes a **TOWN** field and various population fields. Notice how the **TOWN** field in **towndata** matches the **TOWN** field in the **TOWNS** feature class that you have been working with.

✪ Arranging the Table Window

If more than one table is opened, they can be arranged using tabs, side-by-side or top and bottom.

- Click on the **towndata** tab, **hold the click and drag your mouse** to the center of the table. A blue graphic (below) will appear.
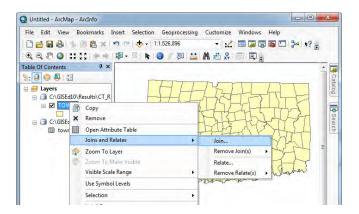
- While you are **still left clicking** (don't let go), move your mouse over one of the triangles and **release** your mouse.
- The **towndata** table will be arranged based on which triangle you selected.

- **Close** your tables.

Table Joins

In ArcMap you can join two tables together based on the values in a common field. When the common field values are equal, records are joined together. In this step you are going to join the **towndata** table to the **TOWNS** attribute table based on the values stored in the town name field which exists in both tables. Joins are useful when there is a one-to-one relationship between a layer attribute table and another table (i.e. there is one record for each town in each table) or when there is a many-to-one relationship. An example of a many-to-one relationship would be joining a town attribute table to a planning region database. There are 169 towns and each town is in only one planning region. Thus many towns will have the same value for their planning region.

✧ Join Two Tables

- Right-click over **TOWNS** in the **Table of Contents** and choose **Joins and Relates** and then **Join**.

TIP: For a one-to-many relationship, a relate is more appropriate than a join.

Fill out the **Join Data** box as follows:

- Choose to **Join attributes from a table**

- 1. Click on the down arrow to the right of the first field and select the field named **TOWN**.

- 2. Since there is only one data table in the **Table of Contents**, **towndata** will be entered automatically as the name of the table that will be joined. Note that you could click the open folder icon to specify a table that is located on disk and not already in the ArcMap project.

- 3. Since **towndata** has a field – **TOWN** – that's the same as the field specified in step 1, it automatically is entered into the form field in step 3. Otherwise, you would select the field from the drop-down list of fields.

- Choose to **Keep all records**.

- Click **OK**.

- If the **Create Index** box pops, click **Yes**. This will create an index so that ArcMap can sort through the table faster.

Tip: You can access the **Joins** on the **Table Options** menu inside a table or through the **Layer Properties** box on the **Joins and Relates** tab.

⊕ Examine Joined Tables

After you have joined the towndata table to the TOWNS attribute table, the fields and data from towndata will appear as part of the TOWNS attribute table.

- If you still have the Table window open, click on the TOWNS tab at the bottom to explore the joined table. If you closed the table, right-click over **TOWNS** in the Table of Contents and select **Open Attribute Table**.
- Explore the table.
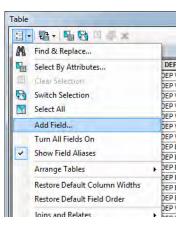
TOWNS Attribute Table Fields   **towndata** table fields

⊕ Field Calculator

Earlier in this exercise, you added a field and then used the Calculate Geometry tool to calculate area in acres. Calculate Geometry is extremely useful when you want to calculate area, perimeter or centroids. However, there will be many times where you want to do other calculations. The Field Calculator is the tool.

You will be adding a new field and using the Field Calculator to populate the field with population density.

- Be sure your **TOWNS** table is open. It should include the results of the join from the previous step, meaning that it contains both the **TOWN** attributes and the **towndata** table fields. If it is not open, open it now. If it does not contain all the fields, ask an instructor for help.
- On the **Table Options** menu, choose **Add Field**.
- Name the new field **PopDens2000**.
- Select **Float** for the data type. Remember that Float fields are for single precision numbers with decimals.
- Give the field an alias called **Population Density**.

CLEAR

- Click **OK**.
- The field should be added to the very right-hand side of the table.

Now it is time for the Field Calculator.

- Right-click over your new **Population Density** field and select **Field Calculator**. If you get a warning box, click yes to continue.

On the top left is the Fields: box which lists all the fields in the table.

On the top right is the Functions box which lists simple functions like addition and mulipllication as well as more advanced functions.

Tip: You can specify whether you want to see Field Names or **Field Aliases** by right-clicking in the Fields box.

At the bottom is a white box where you will create your formula.

- Notice that the first part of your equation, **TOWNS.PopDens2000=** is present based on the field over which you right-clicked.

TIP: The **period** in **TOWNS.PopDens2000** indicates that the **PopDens2000** field is joined to **TOWNS**. If you were doing a calculation in a table that did not have a join, there would be no dot.

- In the **Fields:** list, double-click on **Pop_2000** (or **towndata.POP_2000** if you did not change your fields to show aliases). It will be added to the formula box and will probably be written as **towndata.POP_2000**.
- Click on the **divide by** button. /
- In the **Fields:** box, double-click on **acres**.

- Your formula should look like this:

TOWNS.PopDens2000 =

[towndata.POP_2000] / [TOWNS.acres]

- Click **OK** and wait for ArcMap to perform the calculation. The **Population Density** field should now be populated with a number representing people per acre.
-
If it doesn't appear to work, make sure no records are selected. **If records are selected, the field calculator ONLY does the calculation on those fields!**

- Use the information to answer the following questions. Remember to use table tools you have already learned, such as sorting and statistics.

CAUTION: You can right-click and use the Field Calculator over any field, but it will OVERWRITE whatever is there and you cannot get it back.

What town in Connecticut has the highest population density?

What town in Connecticut has the lowest population density?

What is the mean population density for all towns in Connecticut?

How many towns have a population density over 10 people/acres? What are they?

Add an Excel File of Election Results

You are going to start by joining an Excel table containing results from the 2016 Presidential election to your town layer that already contains town population information. You will then use all this data to answer some questions.

In this step you will add an Excel table to the **Table of Contents** using the **Add Data** button. The **TOWNS** layer is referencing a feature class inside the **CT_Data** geodatabase.

- Click on the **Add Data** button on the **Standard Toolbar**. This will open the **Add Data** window.

- Use the **Look in:** area of the window to navigate to the following folder:

C:\GISEd10\Tables

- All excel files have an .xlsx file extension. Locate **ElectionResults.xlsx**.
- Double-click on **ElectionResults.xlsx**.

- Click on **election2016** and click **Add**.
- The **Table of Contents** will switch to the **List by Source** view if it's not already on it. You should see **election2016** in the Table of Contents**.**

- Right-click over **election2016** and select **Open**.
- Explore the election results. Notice there is a **Town** attribute along with attributes for **Clinton, Trump, Stein, Johnson** and **TotalVote**.

- **Close** the **election2016** table.
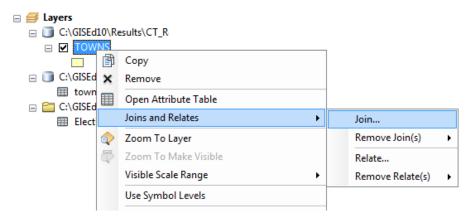
TIP:
- Field names **must start with a letter**.
- Field names **must contain only letters, numbers, and underscores**.
- Field names **must not exceed 64 characters**.

✦ Join Excel File to a Feature Class

- In the **Table of Contents**, right-click over **TOWNS**, select **Joins and Relates** and select **Join**.

- Complete the **Join Data** box so that you are

    - **Joining attributes from a table**

    - 1. Based on the field **TOWN**

    - 2. The table to be joined is **election2016$**

    - 3. And the field in the table to base the join on is **Town**.

    - Choose to **keep all records**.

- Click **OK**.

- Right-click over **TOWNS** in the **Table of Contents** and select **Open Attribute Table**.

- Explore the table and notice how there are attributes from **TOWNS, towndata** and **election2016**. The table on the following page organizes the fields by source.

ATTRIBUTES		
original **TOWN** layer	**Towndata** table	**2016 Election Results** table
TOWN	TOWN	TOWN
TOWN_NO	POP_1950	CLINTON
TOTAL_SQMI	POP_1960	TRUMP
LAND_SQMI	POP_1970	STEIN
COUNTY	POP_1980	JOHNSON
PLAN_ORG	POP_1990	
DEP_DIST	POP_2000	
COAST_AREA	PERCAPINC	
Acres	CRIMERAT98	

TIP: One **HUGE advantage of a join** is the ability to maintain updated data. The tables that are joined to a feature class or shapefile can be updated outside of ArcMap. Each time the ArcMap project is opened, the join is refreshed and the new information will be in both the joined table AND the map.

- **Close** the Table.

⊕ **Export as Feature Class**

Although joins have their benefits, there are many times when it is advantageous for the attributes from a join to become a permanent part of the feature class or shapefile. This is accomplished using Export.

- Right-click over **TOWNS** and select **Data** and then **Export Data**.

- Choose to Export **All Features** and to use the coordinate system of the **layer's data source**.
- For the **Output** features class, click on the yellow folder icon and navigate to

    C:\GISEd10\Results

- Change the **Save as Type** option to **File and Personal Geodatabase** feature classes.
- Double-click on **CT_Results.gdb**.
- Type **towns_election** into the **Name** field.
- Click **Save**.

- Click **OK** in the **Export Data** box.

The export will run and then ArcMap will ask you if you want to add the exported data to the map as a layer.

- Click **Yes**.
- A new layer, called **towns_election** will be added to the **Table of Contents**.
- Open its attribute table by right-clicking over **towns_election** and selecting **Open Attribute Table**.
- Verify that the table contains attributes from the original **TOWNS** file as well as the joined **towndata** table and the joined **2016 Election Results** table.
- **Close** the table.

NOTE: You may have noticed some other changes. In a single attribute table, each field must have a **unique name**. When you exported, there were multiple fields with the name TOWN. ArcMap adds underscores and numbers to these duplicate columns, such as TOWNS_12.

Because the new towns_election file is a feature class (meaning it's in a geodatabase), ArcMap adds and updates the **Shape_Length** field and **Shape_Area** field. Both of these are recorded in the unit of the coordinate system that has been assigned to the layer. To check the coordinate system, go to Layer Properties (right-click over the layer, select Layer Properties) and view the Source tab. All of the data used here is in Connecticut State Plane Feet and therefore the Shape_Length and Shape Area fields are in feet.

Save Your Work!

⊛ Save Your Map Project (.mxd)

- To save the changes you have made, click on **File** on the **Main Menu** and select **Save** from the menu that appears. It should already be called **Exercise3.mxd**. You will use it for the next exercise so it is important that you remember to save the project!

Let's Review!

Congratulations on completing Exercise 3b! This exercise covered adding or changing information in a table. A number of important concepts were covered including:

- ✓ **Add and Delete a Field.**
- ✓ **Calculate Geometry:** The calculate geometry tool provides shortcuts to calculating area, perimeter and x and y coordinates of the centroid in the table attributes.
- ✓ **Field Calculator:** The Field Calculator is a powerful tool for populating table fields with any type of information including mathematical equations. .
- ✓ **Table Joins:** As long as a common attribute exists, two or more tables can be jointed together and the resulting attribute information is available for display or use in other analyses

Exercise 3b Answers

How does Sort Ascending change the field? What happens to the other fields?
The records are re-ordered occurring to alphabetical order of town name. All other fields are rearranged along with the town field.

What is the largest town in Hartford County?
Glastonbury, 52.5 sq. miles.

What is the smallest town in Middlesex County?
Essex, 12.2 sq. miles.

According to this dataset, what is the total area of Connecticut?
5008.2 sq miles. Find this using Statistics for the TOWN field and looking at the Sum.

According to this dataset, what is the average town size?
29.6 sq. miles. Find this using Statistics for the TOTAL_SQMI field and looking at the Mean

According to this dataset, what is the biggest town in Connecticut? The smallest?
The biggest is New Milford at 40,883.67 acres. The smallest is Derby at 3471.81 acres.

What town in Connecticut has the highest population density? What is the density?
Bridgeport with 13.23 people per acre.

What town in Connecticut has the lowest population density? What is the density?
Union with .036 people per acre.

What is the mean population density for all towns in Connecticut?
1.37 people per acre.

How many towns have a population density over 10? What are they?
3 towns – Bridgeport, Hartford, New Haven

This concludes Exercise 3b.

If you have finished and the class is still working on the exercise, move on to the extra credit below.

Extra Credit

Be sure your **Exercise3.mxd** is still open. If not, open it.

✦ Advanced Calculations

Question: How does the population density in 1950 compare to the population density in 2000 for Connecticut's towns?

Which towns have changed the most?

Which towns have changed the least?

How much have they changed?

Do you see a geographic reason for the differences?

A suggested approach:
- Add a double field to your table to hold a 1950 Population density calculation.
- Use the Field Calculator to populate the field.
- Add another new field in your table that will hold the change in population density.
- Use the Field calculator to calculate change. This will be a subtraction, such as
  2000 Population Density – 1950 Population Density.
- Negative values indicate a decrease in population density and positive values indicate an increase.

Exercise 3c: Selections and Queries

Exercise 3c is designed to teach you how to conduct simple to complex queries of geospatial data. ArcMap provides a variety of methods to facilitate this process from clicking on a feature and retrieving attribute data to constructing complex logical questions that retrieve only a subset of data that meet specific search criteria. In this exercise you will learn how to:

- Select features using interactive selection tools, by attributes using queries, and by location
- Explore selectable layers and selection options
- Work with a definition query
- Create new feature classes by saving selected features

A point to remember as you work through this exercise is that operations performed on the cartographic data in the data frame also are reflected in the attribute table(s) of the layers you are working with. Whenever you select a layer feature you also are selecting its corresponding record in its attribute table. Remember the BIG PICTURE. In a GIS, many things are interconnected and there are often many ways to accomplish the same task.

Getting Started
- Open **ArcMap**. For detailed instructions, refer to Exercise 1a.
- Open **Exercise3.mxd** that you saved in the last exercise.

⊕ Selectable Layers

The selectable layers settings and selection options will influence the interactive selection and other methods that you will use next.

Only features in layers that are selectable can be selected. We want to be sure that **towns_election** is the only layer whose features can be selected.

- In the **Table of Contents**, choose **List by Selection** ⬇️.

- Click this icon ☑, called **Click to toggle selected**, to move layers from the Selectable list to the Not Selectable list and vice versa. For the purpose of this exercise, be sure **towns_election** is the only selectable layer.
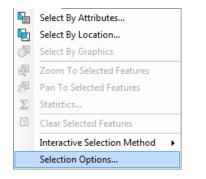
⊕ Selection Options

- Click on the **Selection** menu on the Main Menu at the top of the ArcMap interface and choose **Selection Options**.
- The **Selection Option** box contains a number of settings that influence how selection works and looks. Study the box for a moment. If you are so moved, change the selection color.
- **Close** the selection options box.

⊕ Interactive Features Selection

- Set up your ArcMap interface. Be sure you can see
    - the map of **towns_election**
    - the **Table of Contents** as **List By Selection**
    - the **attribute table** for **towns_election**

SELECT FEATURES TOOL
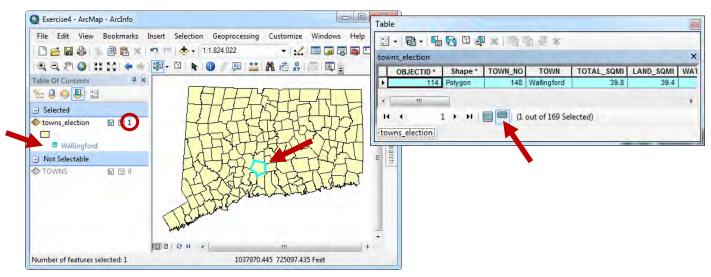
- Click on the **Select Features** icon on the **Tools Toolbar**   .

- Click anywhere on the **map**.
- Notice
    - how a town (or two) becomes selected
    - that the selected town is listed under "**selected**" in the **Table of Contents**
    - that the selected town is selected in the table (to see only selected features click on the   icon at the bottom of the table)
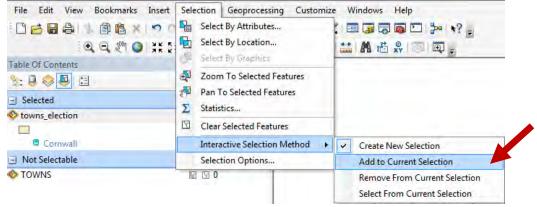
INTERACTIVE SELECTION METHOD

By default, the selection method is set to Create New Selection. This means that each time you clicked on a new town, a new selection was performed and whatever was previously selected was unselected. The **Interactive Selection Method** lets you choose between:

- Create New Selection
- Add to Current Selection
- Remove From Current Selection
- Select From Current Selection

- From the Main Menu's **Selection** dropdown, hover your mouse over **Interactive Selection Method** and select **Add to Current Selection**.
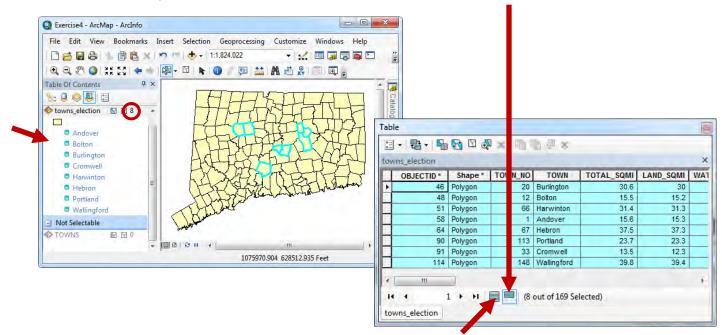
- Click on the **Select Features** icon.
- Click on the **map**.
- Notice
   - how towns are added to the selection each time you click
   - that the selected towns are listed under "**selected**" in the **Table of Contents**
   - that the number, here 8, in the **Table of Contents** shows how many features are selected
   - in the attribute table, that the towns are selected

- in the attribute table, it shows how many records are selected

  (8 out of 169 Selected)
.
- At the bottom of the table is the **Show Selected Records** button. Click it and notice that only the selected records are listed. Non-selected records are hidden from view.

- Click **Show all records** to show all records.
- If you have time, experiment with the other two interactive selection methods - **Remove from Current Selection** and **Select from Current Selection**.

⊕ Clear Selected Features

There are many ways and places to clear the selected features.

- **Choose one** of the methods below to clear the selected features.
  - In the table, click the **Clear Selection icon**
  - In the table, on the **Table Options menu**, choose **Clear Selection**
  - In the table, in the **Row Box menu** (right-click to open), choose **Clear Selection**
  - In the Table of Contents, click on the **Click to Clear Layer Display** icon
  - In the Table of Contents, **right-click over the layer name** and choose **Clear Selected Features**
  - On the **tools toolbar**, click the **Clear Selected Features** icon
  - On the **selection menu**, choose **Clear Selected Features**

✥ Select by Attributes Query Builder

Features can be found and selected based on their attribute values. For example, you can construct a question such as "Select all towns that had a 2000 population over 50,000." You can also build compound queries such as "Select all towns that had a 2000 population of over 50,000 and a 1998 crime rate of less than 50 per 1,000 people."
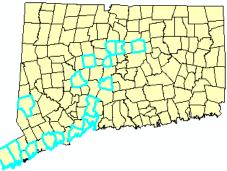
When you create a compound query you can use AND, NOT, OR and LIKE.

- On the **Selection** menu, choose **Select By Attributes**.

You will construct a query that first finds all the towns with a 2000 population greater than 50,000. Then we will add a second part that finds, of those towns, which had a crime rate in 1998 that was lower than 50/1000 people.

- Fill out the **Select By Attributes** box so that
    - (1) **towns_election** is the layer that is being queried.

    - (2) You are creating a **new selection**. This is another place where you can change the Interactive Selection Method.

    - (3) Double-click on **POP_2000** to add it to the query box below.

    - (4) Click on the **>** sign.

    - (5) In the box, type **50000**.

- Click **Apply**.

You should have 17 towns selected and the map should look like this.
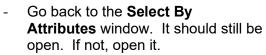
- Open the **attribute table** (right-click over **towns_election** in the **Table of Contents** and choose **Open Attribute Table**) if it's not already open.
- Verify that 17 records are selected.
- Click on the **Show Selected Records** button at the bottom of the table.
- Right-click over the **POP_2000** field and select **Sort Descending**.

Which town has the greatest population in 2000?

- Go back to the **Select By Attributes** window. It should still be open. If not, open it.
- 1. Click the **And** button to add "And" to the query.
- 2. Scroll down the field list and double click on **CRIMERAT98** to add it to the query.
- 3. Click the **<** button
- 4. Type in **50**.
- Click **OK**.

Seven towns should be selected.

Of the big towns in Connecticut (more than 50,000 people), which 7 have the lowest crime rate?

Let's try another. We want to know: **Which towns had over 80% of the voters vote for Hillary Clinton in the 2016 election?**

We could do this work in the attribute table by adding a new field and using the field calculator to populate the data. For now, we just want to show them on a map so a query is the perfect method.

- **Clear your selection**.
- From the **Selection** menu, choose **Select By Attributes**.
- If a query is still in the query box at the bottom, click the **Clear** button.
- Be sure you are still working on the **towns_election** layer and you are **creating a new selection**.
- Double-click **CLINTON** to add it to the query.
- Type in the divide symbol / .
- Double-click the **TotalVote** filed to add it to the query.
- Click the **>** button.
- Finally, type in **0.8.**

Your query should look like this:

```
SELECT * FROM towns_election WHERE:
Clinton/ TotalVote > 0.8
```

- Click **Apply**.

How many towns had more than 80% of the votes for Clinton? What towns were they?

If you have time, try asking and answering a similar question:
Which towns had over 60% of the voters vote for Trump?

TIP: The **Select By Attributes** window also includes buttons to **Save...** and **Load...** expressions. If you have a particularly complex expression or one that you might want to use repeatedly or in another ArcMap document, then saving and loading the expression would be a useful technique to employ. Also, when you save an expression it is saved as a file with an exp extension. This file could be used by another user, e-mailed to a colleague or shared in other ways.

- **Clear** any selected features.
- **Close** any windows or tables that might be open.

✤ Creating a Definition Query

So far, we have displayed our selection on the map but we have not used the map to make a selection. In this step, you will add the roads to your map, set a definition query so that only the major highways are visible, and use a highway to select towns around it.

ADD ROADS

- Click on the **Add Data** button.
- Use the **Look in:** area of the window to navigate to the following folder:

C:\GISEd10

- Double-click on the **CT_Data.gdb**.
- Click on **ROADS**.
- Click **Add**.
- The **ROADS** layer will be added to the **Table of Contents** and will be drawn in a default color in the **Display Area**.

By default, all the roads are visible. We are only interested in the major highways. There are several ways to "hide" the other roads. One handy way is to use a Definition Query.

> **TIP:** Creating a **definition query** allows you to display only a subset of the features in a layer based on the layer's attributes.

- If your **Table of Contents** is still displaying "List by Selection", change the view option to "**List by Drawing Order**".

- Right click over **ROADS** and select **Properties**.
- Click on the **Definition Query** tab in the **Layer Properties** window.

- Click on the **Query Builder** button.

You will use the ROUTECLASS attribute to select only interstate highways for display.
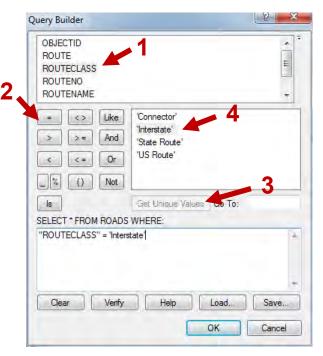
- (1) Double-click on **ROUTECLASS** to add it to the query at the bottom of the Query Builder window.

- (2) Click the **=** sign.

- (3) Click **Get Unique Values**. This will list all the values that exist in the ROUTECLASS attribute in the table.

- (4) Double-click **Interstate** to add it to the query.

- Click **OK**.

CAUTION: Although you may be tempted to type the query as it appears in the graphic, you may make an error in the syntax or punctuation. Use the steps above to ensure that your query will work.
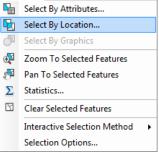
- Click **OK** to close the **Layer Properties** window.

⊕ Select by Location
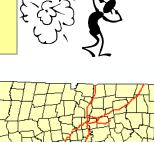
- Only the interstates should now be visible in your map.

In the next Module, you will learn how to change the color and symbols, called symbology. Now we want to find all the towns that have an interstate.

- From the **Selection** menu on the Main Menu, choose **Select By Location**.

- Choose to
  - o **select features from**
  - o **towns_election**
  - o with the **Source** layer **ROADS**
  - o Use the default **Spatial selection method** of **Target layer(s) features intersect the Source layer feature.**
- Click **OK.**

Select By Location
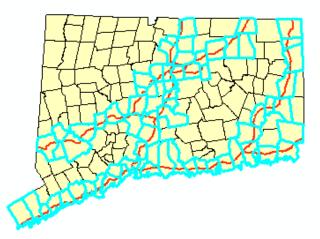
Select features from one or more target layers based on their location in relation to the features in the source layer.

Selection method:

select features from

select features from
add to the currently selected features in
remove from the currently selected features in
select from the currently selected features in

Target layer(s):

- ☐ ROADS
- ☑ towns_election
- ☐ TOWNS

☐ Only show selectable layers in this list

Source layer:

◈ ROADS

☐ Use selected features   (0 features selected)

Spatial selection method for target layer feature(s):

intersect the source layer feature

intersect the source layer feature
intersect (3d) the source layer feature
are within a distance of the source layer feature
are within a distance of (3d) the source layer feature
contain the source layer feature
completely contain the source layer feature
contain (Clementini) the source layer feature
are within the source layer feature
are completely within the source layer feature
are within (Clementini) the source layer feature
are identical to the source layer feature
touch the boundary of the source layer feature
share a line segment with the source layer feature
are crossed by the outline of the source layer feature

Notice how all the towns that contain an interstate are selected. If you have time, experiment with other selection methods.

⊕ Export Selected Features

It is often beneficial to create a new layer that consists only of a subset of features. Here, we want to create a layer than contains only towns that have a major interstate.

- If necessary, in the **Table of Contents**, go back to **List By Drawing Order**.

- Right-click over **towns_election** and select **Data** then select **Export Data**.
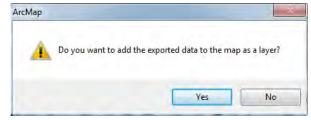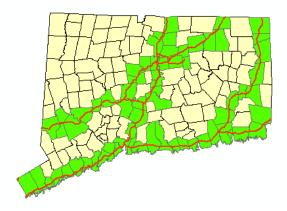
- Choose to **Export: Selected features**
- Click on the yellow folder to set the **Output feature class**.
- Choose to save the file as a **File and Personal Geodatabase feature class** in the **CT_Results.gdb**. Name the dataset **towns_with_interstates.**

- When ArcMap asks if you want to add the exported data to the map as a layer, select **Yes**.

- Your new layer, **towns_with_interstates**, is added to the display. Try turning off all the other layers.

Tips on constructing query expressions

When using **Select By Attributes** it is important to be able to build correct expressions. The following is a list and a brief definition of the operators that you can use in selection expressions.

=	equals
>	greater than
<	less than
<>	not equal to
>=	greater than or equal to
<=	less than or equal to
( )	parentheses to enclose parts of expressions; these are evaluated first
and	both expressions MUST be true
or	only one of the expressions needs to be true
not	excludes
like	use with wildcards to perform partial string searches
_	one character wildcard for coverages and shapefiles
%	any number of wildcard characters for coverages or shapefiles
?	one character wildcard for geodatabases
*	any number of wildcard characters for geodatabases

Field names for shapefiles are always enclosed in double quotes " ".
Field names for geodatabases are enclosed in square brackets [ ].
Text strings are always enclosed in single quotes ' '.

Examples of some typical expressions for the **TOWNS shapefile**:

"County" = 'Hartford'   finds all towns in Hartford County

"County" = 'Hartford' or "County" = 'New London'   finds all the towns in both Hartford and New London Counties

"County" LIKE 'New%'   finds all towns in New Haven and New London Counties

"COUNTY" = 'Hartford' AND "TOTAL_SQMI" > 25   finds all towns in Hartford County that are larger than 25 square miles in area

Save Your Work!

✳ Save Your Map Project (.mxd)

- To save the changes you have made, click on **File** on the **Main Menu** and select **Save** from the menu that appears.

Let's Review!

Congratulations on completing Exercise 3c! In this exercise you learned how to create both simple and complex queries of geospatial data. Queries are used to answer questions about your data and to select out desired features of a dataset based on attributes or location. In this exercise you learned how to:

✓ **Change selection options:** Selectable Layers and Selection Options influence which layers can be selected and how.

✓ **Select features based on attributes:** Layer features can be found and selected based on their attribute values. Simple or compound queries can be created using one or more attribute values. The Query Builder allows you to construct a query without any knowledge of SQL (Structured Query Language).

✓ **Create a definition query:** Definition queries allow you to work with a subset of a dataset without having to create a new data layer or without having to permanently delete features. When a definition query is established for a layer, ArcMap will only display features with attributes that apply to the defined query expression, however all attributes will be retained in the underlying data.

✓ **Select features based on location:** Layer features can be found and selected based on their spatial relationships to all or selected features in another layer.

✓ **Create a new feature class or shapefile:** Once you have selected features using any of the techniques covered in this exercise, you can export them to a new shapefile. If you select Export Selected Features only when you export the data, only the features that are currently selected will get exported to the new dataset.

This concludes Exercise 3c.

If you have finished and the class is still working on the exercise, move on to the extra credit below.

Extra Credit
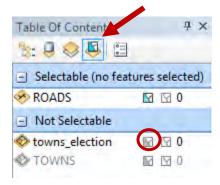
Be sure your **Exercise3.mxd** is still open. If not, open it.

✧ Select By Location Using Selected Features

SET SELECTABLE LAYERS

- In the Table of Contents, click to view **List By Selection**.
- Be sure no features are selected (Clear selection if necessary).
- Click on the **Click to toggle selected** icon next to **towns_election** to make it not selectable. Only ROADS should be selectable.

SELECT AN INTERSTATE

- Click on the **Select Features** icon [icon].
- Click on Interstate 91. It is the north-south highway cutting through the middle of the state. In the Table of Contents, notice that one record is selected.

SELECT BY LOCATION DIALOG

- On the Selection menu, choose **Select By Location**.

- Choose to
  - ○ **select features from**
  - ○ **towns_election**
  - ○ with the Source layer **ROADS**
  - ○ be sure **Use selected features** is checked
  - ○ Use the default **Spatial selection method** of **Target layer(s) features intersect the Source layer feature.**
- Click **Apply.**
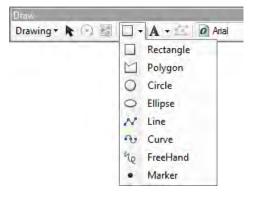
- Notice how the map changes. Experiment with different **Spatial selection methods**.

⊕ Select By Graphics

- Open the **Drawing** toolbar.
- Choose to **draw a shape**, such as a rectangle or circle, or a line on your map.
- Be sure the **graphic is selected**. Selected graphics have small squares on the edges. Below, the circle graphic is selected and the square graphic is not.
- On the **Selection** menu, choose **Select By Graphics**.
- Experiment with Select By Graphics.

Exercise 3c Answers

Which town has the greatest population in 2000?
Bridgeport with 139,529 people

Of the big towns in Connecticut (more than 50,000 people), which 7 have the lowest crime rate?
Greenwich, Bristol, West Hartford, Fairfield, Hamden, Stamford, Milford

How many towns had more than 80% of the votes for Clinton? What towns were they?
4 towns – Bloomfield, Bridgeport, Hartford, New Haven

Which towns had over 60% of the voters vote for Trump?
12 towns – Beacon Falls, Bethlehem, Hartland, Harwinton, Oxford, Plymouth, Prospect, Sterling, Thomaston, Voluntown, Watertown, Wolcott

✧ Create Graph

- Open the attribute table of **TOWNS**.
- On the table menu, select **Create Graph**.
- Explore the graphing options and create a graph that successfully and clearly shows something about the data in the table.

Exercise 4a: Symbology

Most of the time, you will want to modify the default colors and styles that ArcMap uses to display cartographic data. This exercise is designed to provide a basic introduction to symbolization operations. In this session you will work with Layer Properties to learn how to create a variety of symbols and how to save this information as a layer file. Layer files store symbols assigned to features and/or feature classes. The techniques learned in this exercise also will facilitate the preparation of data for printing or publication. In this exercise, you will:

- Set the Map Document Properties
- Change single symbols for points, lines and polygons
- Make thematic maps of points (wells), lines (roads) and polygons (towns)
- Classify numeric data to show voting trends
- Create and open a layer (.lyr) file

Getting Started: Opening ArcMap

- Open **ArcMap**. For detailed instructions, refer to Exercise 1a.
- Open a **New Map**. Remember, to click on **New Maps** and then a **Blank Map**.

Set Up Your Map Document

✦ Save Your Map

- On the **File** menu, select **Save As** OR click the **Save** icon 💾 .
- Name the file **Exercise4a** and save it in the **Projects** folder.
- Click **Save**.

✦ Set Map Document Properties

Click on the **File** drop-down menu and click **Map Document Properties.** A window will open in which you can enter information about the map document that you are about to create. You can use the Map Document Properties box below as a guide.

- Fill out the text fields in the window including **Title**, **Summary**, **Description**, **Author** and **Credits**.
- Set the **Default Geodatabase**. Click on the folder icon and navigate to the **Results** folder and the **CT_Results.gdb**.
- Click **Add**.
- For now, don't bother clicking **Make Thumbnail**. Make Thumbnail will take a static snapshot of the map at that moment. Because it is still an empty map, there is no point in creating a thumbnail.
- Click **OK**.

Default Geodatabase:
The default geodatabase is simply the geodatabase that you'll be working with the most as you work with the mxd. There are several advantages to specifying a default geodatabase:

- It is easy to get to. Simply click the **Go To Default Geodatabase** button in any dialog in which you access or save data, or at the top of the Catalog window.
- In certain dialogs, the default geodatabase is shown with this icon CT_Results.gdb. In the Catalog window's tree the default geodatabase's name is also shown in bold.

Later we will talk about geoprocessing tools that require certain settings. If a default geodatabase has been set, some settings are done automatically.

Store relative path names:
If this box is checked, **pathnames are stored as incomplete paths that are relative to the current location of this document on disk**. This setting makes it easier to share or move the map document and its data because ArcGIS will resolve the paths to the data relative to the document's current location in the file system, rather than by full paths that include a drive letter or machine name.

Store full path names:
If this box is not checked, pathnames are stored in the document as **full pathnames** (also called 'absolute' or 'complete' pathnames). The paths will contain a disk letter or machine name. **This is the default option.**

⊛ Add Layers to ArcMap

- Click on the **Add Data** button on the **Standard Toolbar**. This will open the **Add Data** window.
- Click on the **Go to Default geodatabase** icon. This will take you straight inside **CT_Results.gdb** because you set it as the default geodatabase in the last section. .

TIP: Remember that geodatabases are containers for layers. Layers inside a geodatabase are called **Feature Classes**.

- Double click on the **towns_election** layer to add it to your map. If you don't have this layer, talk to an instructor. To refresh your memory, this layer originated as just towns, then you joined population data (towndata.dbf) and election data (2008_Election_Results.xls) to it, then exported it as a new feature class called **towns_election** in the **CT_Results.gdb**.
- **Click Add** at the bottom of the window to add the layer to ArcMap.

The **towns_election** layer will be added to ArcMap's **Table of Contents**. A randomly selected color will be assigned to the layer to symbolize the towns.

You will now add roads and wells to your document.
- Click on the **Add Data** button.

- Use the **Look in:** area of the window to navigate to **C:\GISEd10\Shapes.**
- Double-click on the **APAWELL.shp** file.
- It should be added to the Table of Contents in your map document.

- Click on the **Add Data** button.
- Use the **Look in:** area of the window to navigate to **C:\GISEd10\Shapes.**
- Click on the **ROADS.shp** file. Hold down the **CTRL** key and then click on **STATE.shp**.
- Click **Add**.
- Both should be added to your map document.
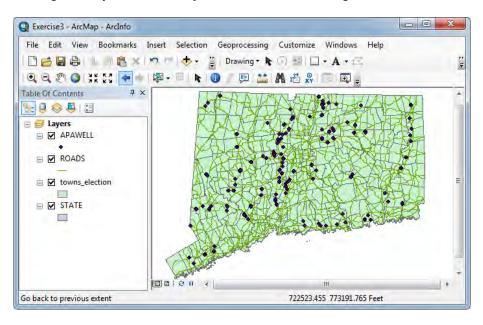
> **TIP:** There are several ways you can add data to a map document.
> 1. Use the **Add Data button**.
> 2. Right click on the **Data Frame name** and select **Add Data**.
> 3. Use the **File** menu and select **Add Data**.
> 4. **Drag** the datasets, one at a time or as a set, from **ArcCatalog** into **ArcMap**.

- Order your layers in the **Table of Contents** so that **APAWELL** is on the top of the list followed by **ROADS, towns_election,** and **STATE**.

Each layer is added using single a symbol with a default color. Beautiful! Yours will probably look different from the map below because your default colors may vary. Now, we will work with each layer to change the symbols so they are clear and meaningful.
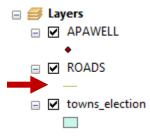
Changing a Layer's Symbol

To change the color and/or pattern of all features within a layer, click on the layer's symbol that is beneath the layer name in the Table of Contents.
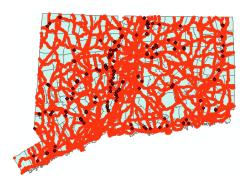
✪ Line Symbol Selector
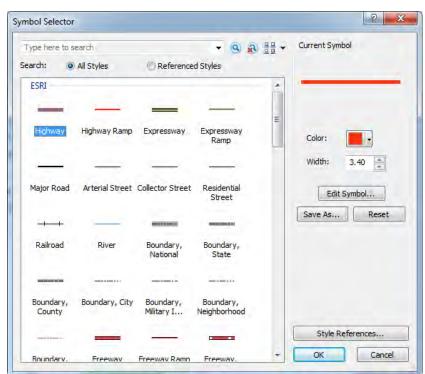
Change the **ROADS** layer to fat red lines.

- Click on the symbol below the layer **ROADS** in the **Table of Contents**.
- A **Symbol Selector** window will open that displays many different line patterns and colors. Click on the fat red line, labeled Highway, and then click **OK**.

The **ROADS** layer will redraw using the line symbol you selected. WOW. Repeat the process and try different predefined symbols.

✪ Polygon Symbol Selector

Use the same steps above to change the color and pattern of polygons in your town election layer.

- Click on the **towns_election** layer's symbol to open the **Symbol Selector**.

- You can use one of the many **predefined symbols** for polygons. OR,
  o access many additional **colors** to fill polygons
  o specify a **width** for polygon outlines as well as choose
  o a color for the **outlines**.
- Experiment with the **Symbol Selector** and create your own fill and outline colors and outline widths.

Note that when you click on the fill or outline color buttons that a window opens providing you with many predefined colors. However, at the bottom is the **More Colors…** choice. Clicking it will open a **Color Selector** window that gives you complete control over the color to use.

RGB stands for **Red, Green, Blue**. The RBG values are added together to create any color of the rainbow. You can use the slider bars or type in a known RGB value to get an exact color.

- Click on the small arrow next to RGB and select HSV. **HSV** stands for **Hue, Saturation and Value**. HSV is the easiest to use to adjust colors.
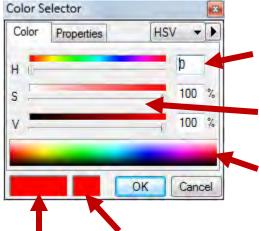
TIP: Hue is the gradation of color that allows it to be called red, yellow, green, etc. **Saturation** is a measure of the vividness of the color. As a color becomes less saturated, it tends towards gray. **Value** is measure of how much light is reflected from an object relative to white.

With the **Color Selector** you can adjust colors to be whatever you need. You can type in values from 0 to 360 for Hue and 0 to 100 for **Saturation** and **Value**.

The **slider bars** have colors above them to indicate the resulting color that will be created as you reposition the pointer beneath any of the three sliders.

You also can click within the **rainbow box** of colors at the bottom to get close to a specific color and then adjust it with the sliders.

New Color   Starting Color

- After you have selected a color, click **OK** to return to the **Symbol Selector**.
- Click **OK** on the **Symbol Selector** to apply the changes to the **towns_election** layer.

⊕ Point Symbol Selector

Change the symbols for the **APAWELLS** layer.

- Click on the symbol below **APAWELLS**.
- On the **Symbol Selector** click the button named **Style References**. This will open a list symbol groups that can be checked on and used.
- Scroll down and check the box next to **Environmental**.
- Click **OK**.

Notice that the new category, called **Environmental**, is visible along with the symbols it contains. Symbol Reference groups are listed in alphabetical order.

- Many of the symbols have large sizes so you may want to set the **Size** to **8 points**; otherwise the display may become cluttered with symbols that are too large.
- You also can change the symbol **Color** as you did above.
- When done selecting and setting the symbol, click **OK**.

By now you should have a feel for how you can use the Symbol Selector to modify all features in a layer. However, uniformly changing the symbolization may make a more attractive display but it doesn't tell you anything about the underlying data. And, let's face it, that's the power of the GIS. That's what you will look at next.

Making Thematic Maps

Thematic maps use different symbols to visually differentiate ranges of attribute values or among attribute classes. In this step you will symbolize the **APAWELLS**, **towns_election,** **STATE** and **ROADS** layers to highlight different feature classes.

- Turn off (uncheck) the **towns_election** and **ROADS** layers.

- Change the **STATE** layer symbol to a light yellow. This will serve as the background for the **APAWELLS** layer. Do this simply by clicking on the symbol beneath **STATE** and changing the **Fill Color**.
- Open the **APAWELLS** attribute table by right clicking on the **APAWELLS** layer name and selecting **Open Attribute Table**.
- Inspect the column named **WELLSTATUS** and note that there are two values – **Active** and **Inactive**.

You will assign different symbols to visually discriminate between the two classes. You will use a unique value classification which is appropriate when the number of classes is relatively small - say 10 or fewer.

- Close the **APAWELLS** attribute table.
- Right click on the **APAWELLS** layer and select **Properties.**   Alternatively, you can double click on the layer name to open the **Layer Properties** window.
- Click the **Symbology** tab.

By default, ArcMap assigns a **Single symbol** to all features in each layer.

Note that other options exist for assigning symbols – **Categories**, **Quantities**, **Charts** and **Multiple Attributes**. Since the **APAWELLS** layer has only two classes for wells, you will use the **Unique values** choice under the **Categories** option.

✤ Symbolizing Point Categories

- Click on **Categories** on the left side of the Symbology window.
- Select **WELLSTATUS** from the list called **Value Field** (see image on following page for reference).

- Click the **Add All Values** button.
- Change the **Label** fields under the **WELLSTATUS** heading to **Active Wells** and **Inactive Wells** by typing them. What is entered here will appear in the ArcMap **Table of Contents** as well as the legend in a layout (next exercise).
- Since all wells are assigned to either the active or inactive class, there will not be any other values. **Uncheck the box** next to **<all other values>** so it will not appear in the legend in the **Table of Contents**.

- **Double-click** on the symbol next to **ACTIVE** to open the **Symbol Selector**.
- **Choose a symbol** to represent active wells. You may want to add more predefined symbols by clicking on the **Style References..** button and then checking on more categories. You can also use the **Search** window at the top of the **Symbol Selector** to search for a keyword such as "well."
- **Double-click** on the symbol next to **INACTIVE** to open the **Symbol Selector**.
- Choose a symbol to represent inactive wells.

- Before applying the symbols, change the name of the layer from APAWELLS to **Public Wells** by clicking on the **General tab** and entering the new layer name.

- Click **OK** to apply the new symbols and layer name.

✺ Symbolizing Line Categories
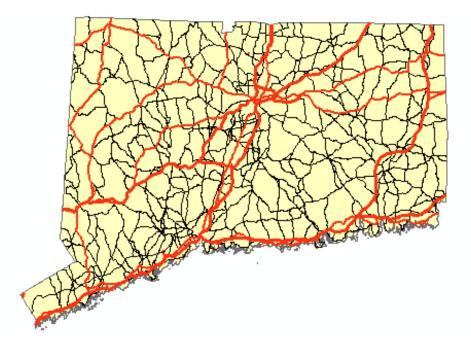
- Turn on the **ROADS** layer by checking the box next to the layer name in the **Table of Contents**.
- Right click on the **ROADS** layer and select **Properties.** Alternatively, you can double click on the layer name to open the **Layer Properties** window.
- Click the **Symbology** tab.
- Click on **Categories**.
- Select **ROUTECLASS** from the list called **Value Field**.
- Click the **Add All Values** button.

Notice that four values exist in the **ROUTECLASS** attribute: **Connector**, **Interstate**, **State Route** and **US Route**.

- Click on the colored line next to **Interstate**.
- Select a **predefined symbol** or create your own symbol to represent Interstates. You may want to turn off **Style References**, such as **Environmental**, or add **Style References**, such as **Transportation**.
- Click **OK** to close the **Symbol Selector** box.

- Click on a colored line next to another road type (Connector, State Route or US Route) and pick a symbol for that road type.
- Uncheck the **<all other values>** class.
- Repeat for all road classes until you have a properly symbolized road layer.

✦ **Symbolizing Polygon Categories**

Another example of a unique value classification is to use symbols to create a county or planning region map from the towns layer. You will recall that the **TOWNS** layer, which was the origin of the **towns_election** data you are using here, has attributes that define the county that each town belongs to.
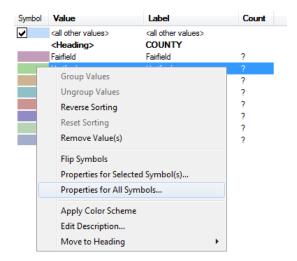
To make a county map:
- Turn off all layers except the **towns_election** layer.
- Double click on **towns_election** to open its **Layer Properties** window.
- Click the **Symbology** tab.
- Click on **Categories** then click on **Unique Values**.
- In the **Value Field** select **COUNTY**.
- Click the **Add All Values** button. This will add all the unique values in the field **COUNTY**. (Note: if there are misspelled county names they will be listed as unique values. This is a common problem with attribute data.)
- If you desire, change the **Color Ramp** by clicking on the current Color Ramp and choosing a different one from the list.
- Click **OK** to apply the symbols.
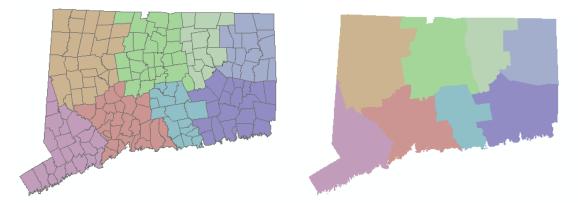
View the resulting map. Notice that the eight counties are each displayed using a unique color and that each town is outlined. If you want to display just the counties you would have to turn the outlines off for the towns.

TIP: To get rid of the outlines for all the towns while keeping county colors:
- Open the **Layer Properties**
- Right-click over one of the colors and select **Properties for All Symbols**
- Change the **Outline Color** to **No Color**.
- Click **OK**.

Extra Credit:

*How would you symbolize the **towns_election** data so that is a single-symbol statewide layer, similar to the **STATE** layer that you used as a background for the wells in the **Symbolizing Point Categories** section?*

Classifying Numeric Data

In the previous step you symbolized categorical data. The **APAWELLS** points had just two values for **WELLSTATUS**; the **ROADS** lines had four values for **ROUTECLASS** and the **towns_election** polygons had eight values for **counties**. In all cases, the values described unique, non-overlapping categories or groups. They did not represent a measured value that could be grouped, ranked, etc.

In this step you will classify and symbolize numeric data – data that measure some variable such as population, per capita income, percent of people completing high school, number of registered voters, square footage of buildings, assessed value of residential buildings, etc. While these data are unique, they are too numerous to be displayed in a meaningful way until they have been grouped and the group is assigned a symbol.

- In your map document, turn off all layers.
- Click on the **Add Data** button and then the **Go to Default geodatabase** icon. This will take you straight inside **CT_Results.gdb** because you set it as the default geodatabase in the last section. .
- Double-click on **towns_election** to add it to your project.

Yes, you already had a **towns_election** layer in your map but we don't want to lose the symbology you already created. Adding another copy of the same shapefile or feature class allows there to be more than one way to symbolize the same source data in the same data frame.

- Right click on the newly added **towns_election** layer and select **Properties.** Alternatively, you can double click on the layer name to open the **Layer Properties** window.
- Click the **Symbology** tab.
- On the left side of the window, click on **Quantities** and select **Graduated colors**.
- Select **Clinton** in the **Value Field** and **TotalVote** as the **Normalization Field**. When you normalize data, you divide it by the **Normalization:** field. Using these settings will create a map that displays the fraction – as a decimal value – of the percent of the voters that voted for Clinton in each town.

TIP: Normalization is the process of dividing one numeric attribute value by another in order to minimize differences in values. Normalizing the values in your classification field can show how your data relates to the values of another field which can make the data easier to read and understand.

The following options are available:
- Normalize by any attribute in the table. Usually attributes that contain totals or total area are used.
- <None> - No normalization will be applied
- <PERCENT OF TOTAL> - Normalize the Value field by its percentage of the total.
- <LOG> - Normalize the Value field by its log value.
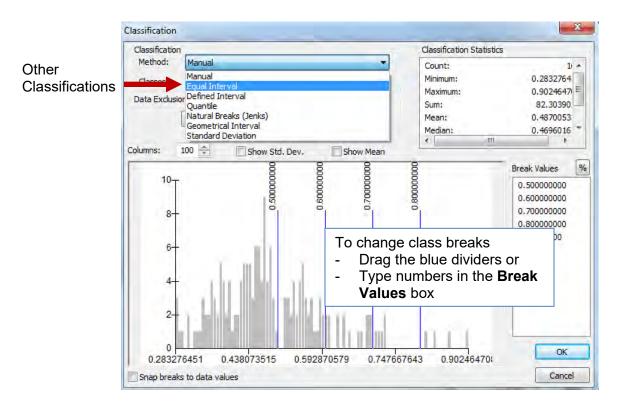
By default ArcMap will create five classes using **Natural Breaks** as the **Classification Method**. This method groups data such that the differences between groups are great while the differences within groups are small or at least smaller.

- Click the **Classify** button to open the **Classification** window.
- Change the **Classification Method** to **Equal Interval**.
- Change the **Break Values** so they occur at **0.5, 0.6, 0.7, 0.8** and **1.0**. You can drag the blue lines or type the values in under **Break Values** (see image on following page). Notice how the **Classification Method** changes from **Equal Interval** to **Manual** when you make these changes.

Other Classifications

To change class breaks
- Drag the blue dividers or
- Type numbers in the **Break Values** box
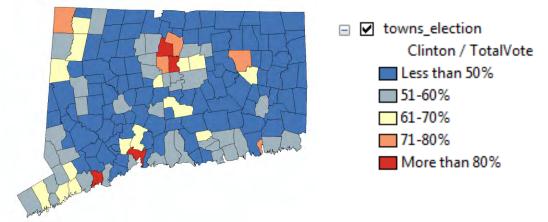
- Click **OK** to close the **Classification** window.
- On the **Layer Properties Symbology** tab, click on the color ramp to choose a new color ramp.
- Change the **Labels** to be more meaningful. The decimal values represent percent so change the labels to read percent.
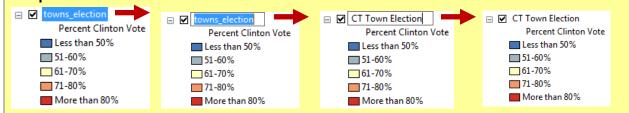
- Click on the **General** Tab in **Layer Properties**.
- Change the **Layer Name:** to **CT Town Election Results**.
- Click **OK** to close the **Layer Properties**.

☐ ☑ towns_election
Clinton / TotalVote
■ Less than 50%
☐ 51-60%
☐ 61-70%
■ 71-80%
■ More than 80%

What does the new layer symbology tell you about the 2016 election results?

TIP: Change the Text in the Table of Contents by clicking once on the text to select it and a second time to make it editable. **Note:** Changing the layer name in the **Table of Contents** also changes it in the **General** tab of **Layer Properties**. Changing the labels next to the color swatches in the **Table of Contents** also changes the labels on the **Symbology** tab of **Layer Properties**.

Save Symbology in a Layer (.lyr) File

Setting up symbols can be a time consuming process. Fortunately, ArcMap allows you to save and reuse symbols that you have created for a layer. Symbology is saved in a special "layer" file (not to be confused with a geospatial data layer in the Table of Contents) that contains instructions to ArcMap about how to display features in the dataset. Layer files also include the pathname to the geospatial dataset that is to be symbolized. The value of layer files is twofold – they conveniently store symbology information and they can be used to add symbolized geospatial data to ArcMap.

You will create a **Layer** File of the **towns_election** layer displayed so that it shows how much of the total vote was for Clinton.

- Right-click on the **CT Town Election Results (see TIP box above for notes on how to rename layer)** layer in the **Table of Contents**. It doesn't matter what the layer name is.
- Select **Save As Layer File**…
- In the **Save Layer** window, navigate to **C:\GISEd10\Results** folder and save the layer file as **ClintonVote2016.lyr**. Click **Save**.

Let's take a look at how the Layer file works.

- In the **Table of Contents**, right-click over **CT Town Election Results** and select **Remove** to remove the data layer from the project.

- Click on the **Add Data** button.
- Navigate to the **C:\GISEd10\Results** folder and select the layer file **ClintonVote2016.lyr**.
- Click **Add** to add it to the **Table of Contents**.
- The **towns_election** dataset will be added to the project, but instead of default symbology, each town will be drawn based on the symbology you defined and saved to the **.lyr** file.

TIP: Layer files cannot be saved inside geodatabases. Bummer.

REMEMBER! The **.lyr file does NOT contain the data itself**! It simply points to the dataset, in this case, the **towns_election** feature class, and contains instructions for how the features in that dataset should be displayed on the map. A .lyr file will not function without an associated dataset (.shp or geodatabase feature class).

.lyr files always have to point back to the "source" dataset!

Save Your Work!

✴ Save Your Map Project (.mxd)

- To save the changes you have made, click on **File** on the **Main Menu** and select **Save** from the menu that appears. Save it as **Exercise4a.mxd** in the **Projects** folder. Since we already saved it once, you can overwrite the existing Exercise3a.mxd.

Let's Review!

Congratulations on completing Exercise 4a! This exercise was designed to introduce you to tables in ArcMap. A number of topics were discussed including.

This exercise covered all of the basics of symbology in ArcMap. A number of important concepts were covered including:

- ✓ **Single symbols**: When your data is symbolized with a single symbol, all features are drawn with the same symbology properties. The symbol selector can be used to change features such as size, color, pattern, or symbol**.**
- ✓ **Categorical symbols:** Categorical data have values that describe unique non-overlapping groups of attributes. Different symbols can be used to display a set of features with the same attribute value in a layer.
- ✓ **Numeric symbols**: When data is represented as a measured amount that can be grouped or ranked, you can symbolize it using a quantitative measure. There are several methods for doing this: graduated colors, graduated symbols, proportional symbols, dot densities, and charts.
- ✓ **Layer files**: Symbology for a layer, including labels, can be saved in a layer file. Layer files contain instructions about how to display features in a dataset. They include the pathname to the geospatial dataset that is to be symbolized, they do not include the data itself.

This concludes Exercise 4a. You can keep the exercise open, you will use it in Exercise 4b.

If you have finished and the class is still working on the exercise, move on to the extra credit below.

Extra Credit

- Your **Exercisera.mxd** project file should still be open, if not, open it in ArcMap.
- Resave the project to your **C:/GISEd10/Projects** folder as **Ex4a_EC.mxd.**

✿ Choose Your Own Adventure

Pick one or more of the following processes to experiment with additional symbology tasks. You will be using the **towns_election** layer for most of the symbology experiments. It is beneficial to have multiple copies of this layer in your mxd so that it can be displayed many different ways. Choose one:

- Click on the **Add Data** button and then the **Go to Default geodatabase** icon 🗺 . .
- Double-click on **towns_election** to add it to your project.

    OR

- Right-click over **towns_election** (which is likely called **CT Town Election Results**) in the **Table of Contents** and select **Copy**.
- On the **Edit** menu, select **Paste**. A second layer, with the same symbology, will be added to the Table of Contents. You can now change the symbology of the copy.

- **Repeat** so you have several copies in the Table of Contents.

Categories: Unique Values, Many Fields
Try using the **Counties** and **Coastal Area** attributes of **towns_election**.
Or experiment with two other attributes that have discrete data values.

*What does **Unique Values, Many Fields** do? How might you color the classes to make them useful?*

Quantities: Graduated Symbols
Try using one of the population attributes of **towns_election.**

Try changing
- the Symbols and their colors
- the Background
- Normalization field

Quantities: Proportional Symbols
 Try using one of the **population** attributes of **towns_election.**

*How are **Graduated Symbols** and **Proportional Symbols** different?*

Try changing
- the Symbol Background

- the min and max values
- the Appearance Compensation
- Normalization field.

Quantities: Dot Density

Try comparing two attributes of the **towns_election** layer. Comparisons could be:

- **Clinton** Vote and **Trump** Vote
- **1950 Population** and **2000 Population**
- **Total Vote** and **Population 2000**

Features
Categories
Quantities
    Graduated colors
    Graduated symbols
    Proportional symbols
    Dot density
Charts
Multiple Attributes

How does a dot density map help display information?

Charts: Pies, Bar/Column, Stacked

Use the attributes from the **town_election** file to experiment with the three types of chart symbols – **pie**, **bar/column** and **stacked**.

Features
Categories
Quantities
Charts
    Pie
    Bar/Column
    Stacked
Multiple Attributes

Features
Categories
Quantities
Charts
    Pie
    Bar/Column
    Stacked
Multiple Attributes

Features
Categories
Quantities
Charts
    Pie
    Bar/Column
    Stacked
Multiple Attributes

Try changing
- the input fields
- the Symbols
- Color Scheme
- Normalization
- chart Properties

What is the most useful combination of chart type and input data that you can come up with given the attributes in **town_election**?
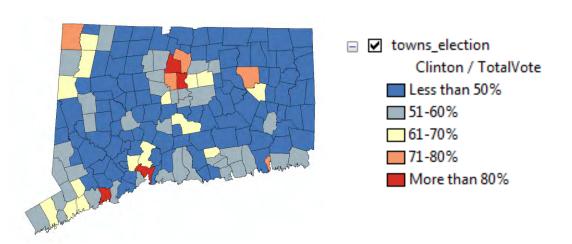
Exercise 4a Answers

One way is to display all towns as a single symbol AND make sure that symbols does not have an outline. If an outline is visible, it will outline every town (each record in the table) and not just the state.

If you are interested in an outline of just the state border, a geoprocessing tool called Dissolve is the way to go. You will learn about it in the ArcTools section of this class.
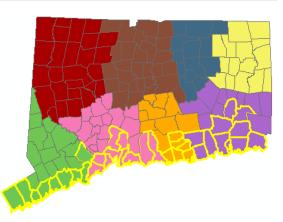
- More towns in Connecticut fell in the 51-60% category than any other category.
- The big cities (New Haven, Bridgeport, Hartford, New London) heavily favored Clinton.
- Towns in the Housatonic River Valley were less favorable for Clinton, and therefore, likely favored Trump.

This is just a sampling. There are many more interesting observations.

*What does **Unique Values, Many Fields** do? How might you color the classes to make them useful?*

It allows you to symbolize first on one attribute then further categorize the first attribute by a second. There are many potential combinations where this could be used. This example shows the Counties symbolized first, then the Coastal Area. The same fill color was used for each county, whether it was inside or outside the Coastal Area. A different outline was used for the Coastal Areas to separate them from the inland areas.

*How are **Graduated Symbols** and **Proportional Symbols** different?*

With graduated symbols, the quantitative values for a field are grouped into ordered classes. Within a class, all features are drawn with the same symbol.

With proportional symbols, data is not classified. Each symbols is sized to portray the value of the selected attribute.

Exercise 4b: Labels, Graphics and Annotation
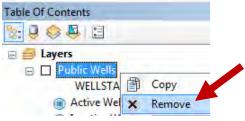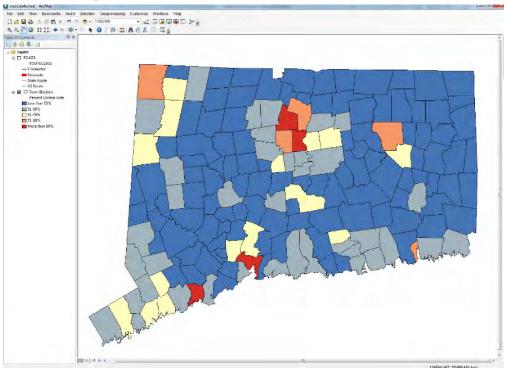
In the last exercise you were exposed to some of the basic techniques on how to customize map symbols and make thematic displays of attribute data. This exercise will focus on how you can use text to add valuable information to a map display. You will learn how to create labels from attribute data, how to place labels relative to map features, how to add freeform text to a map display and how to convert labels into geodatabase annotation.

Getting Started: Label Basics

✲ Set Up Your Map

- You will start this exercise where you left off in Exercise 4a. If you have closed the exercise, start a new ArcMap session and open your **Exercise4a.mxd**.

- Make sure the **CT Town Election Results** layer is turned on in your **Table of Contents.** This is the layer that you symbolized in **Exercise 4a** to show the percent of the total voting population that voted for Clinton in the 2016 election. If you removed this layer from your map, you can add it from your **C:\GISEd10\Results** folder.

- Remove the **Public Wells** and **STATE** layers from the **Table of Contents** by right-clicking on the layer name and selecting **Remove**. The only layers you should have in the **Table of Contents** are **ROADS** and **CT Town Election Results**. If you have others, remove them. Save 🖫 your map as **Exercise4a.mxd** in your **C:/GISEd10/Projects** folder.

❋ The Labels Tab
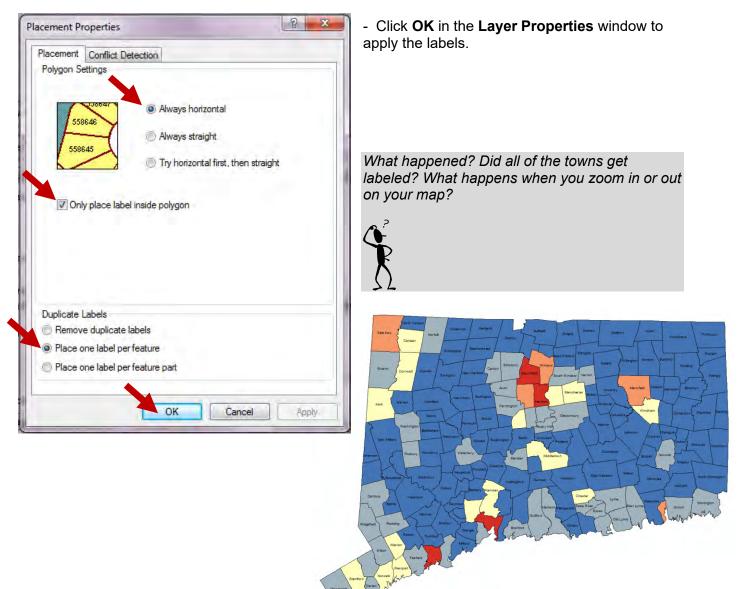
Labels are properties of a layer and can be formatted through the **Layer Properties** tab. In this step, you will set up basic labels for each of the 169 towns in the CT Town Election Results layer.

-   Right click on the **CT Town Election Results** layer and select **Properties** from the menu that appears to open the **Layer Properties** window.

-   Click on the **Labels** tab. This is where you will define the labels for the layer.

-   On the **Labels** tab, check the box next to "**Label features in this layer.**" Leave the Method set to "**Label all the features the same way**". This will ensure that all of your town labels are formatted the same.

-   Under **Text String**, be sure the **Label Field** is set to **TOWN**. This is the field in the attribute table that will determine the label text. Whatever appears in the TOWN field for a record (in this case, it will be the town name) is what you will see on your map.

-   Leave the **Text Symbol** properties as the default **Arial, size 8**. Under Other Options, click **Placement Properties…**

- In the **Placement Properties** window, change the settings so that the polygon labels are **Always horizontal** and check the box next to "**Only place label inside polygon.**" Under **Duplicate Labels**, select **Place one label per feature** to ensure that towns are only labeled once. Click **OK** to return to the **Layer Properties** window.

- Click **OK** in the **Layer Properties** window to apply the labels.

What happened? Did all of the towns get labeled? What happens when you zoom in or out on your map?

✪ Setting a Scale Range

You can specify the range of map scales at which labels will be drawn on your map. If you are zoomed out beyond the minimum scale, the labels will not appear on your map until you zoom in farther.

- Double click on **CT Town Election Results** to open its **Layer Properties**.

- Click on the **Labels** tab again.

- Click on the **Scale Range** button at the bottom of the window under **Other Options**.

- A window titled **Scale Range** will open. Click on the radio button next to: "**Don't show labels when zoomed:**"

- Click on the down arrow next to **Out beyond**: and select **1:500,000** as your minimum scale.

- Click **OK** to close the **Scale Range** window. Click **OK** to apply the change and close the **Layer Properties** window.

- Click the **Zoom to Full Extent** 🌐 icon on the **Tools Toolbar**. Notice your labels disappear.

- Click on the **Fixed Zoom In** ⚏ button on the **Tools Toolbar** several times until your labels appear. What is the scale now? _____

- When you have finished, return to the **Layer Properties** for **CT Town Election Results**. Click on the **Labels** tab and click on the **Scale Range** button at the bottom of the window.

- When the **Scale Range** window opens, click the radio button next to "**Use the same scale range as the feature layer**" to return to your original scale range. Click **OK** to close the window. Click **OK** to close the **Layer Properties**.

⊕ Using a Label Expression

Label Expressions allow you to label your features with values from more than one field in the layer's attribute table. In this step, you will label each town with the town name and the total number of votes for Hillary Clinton using a label expression.

- Double click on **CT Town Election Results** in the **Table of Contents** to open the **Labels** tab under **Layer Properties** window again.
- Click on the **Expression** button in the **Text String** box.

- In the **Fields** box in the **Label Expression** window, scroll down until you find the **CLINTON** field. Click on it to highlight the field and then click the Append button. This should add it to the **Expression** box at the bottom of the window.

- Click **OK** in the **Label Expression** window and **OK** in the **Layer Properties** window to apply the changes to your map.

You should now see two values in the text string for each town, the first part is from the TOWN (town name) field and the second is the value stored in the Clinton field (total votes for Clinton).

Interesting, but probably only slightly helpful. If someone was reading your map, how would they know what the numbers represent? What if you wanted to create two lines of text rather than have both fields side by side? Glad you asked, let's find out how to clean up these labels!

✤ Formatting a Label Expression

In this step, you will create a "stacked label" so that text appears on two lines and you will add text to the label expression to add context to the labels.

- Open the **CT Town Election Results, Layer Properties** window again and return to the **Labels** tab.
- Click on the **Expression** button to open the **Label Expression** window. You should see the label expression as it was set up in the previous step of this exercise.
- In the **Expression**, add the text "**vbnewline &**" in between the first **ampersand (&)** and the first set of quotations. It should look like the image below.

[TOWN] & vbnewline & "Total Votes for Clinton: " & [Clinton] |

- In between the double quotes, add this line of text: "**Total votes for Clinton:** ". Be sure to include a space after the semicolon. The final expression should look like this:

Expression

Write the expression in the language of the selected parser. ☐ Advanced

[TOWN] & vbnewline & "Total Votes for Clinton: " & [Clinton] |

- After you have completed your expression, click the **Verify** button. This will check your expression to be sure you entered is valid. It will also show you a sample of the label. If you get an error, go back to the expression and check for typos.

Expression Verification

This expression is valid.

Sample Text String

Salisbury
Total Votes for Clinton: 1671

Sample Label

Salisbury
Total Votes for Clinton: 1671

OK

- Click **OK** to close the **Expression Verification** window. Click **OK** again in the **Label Expression** window to return to the **Layer Properties**. Before we apply these labels, let's make a final adjustment to our **Placement Properties**.

- Click on the **Placement Properties** button in the **Layer Properties**. When the **Placement Properties** window opens, uncheck the box next to "**Only place label inside polygon.**" This will allow the labels to spill over the sides of the town boundaries when zoomed out to larger extents.

☐ Only place label inside polygon
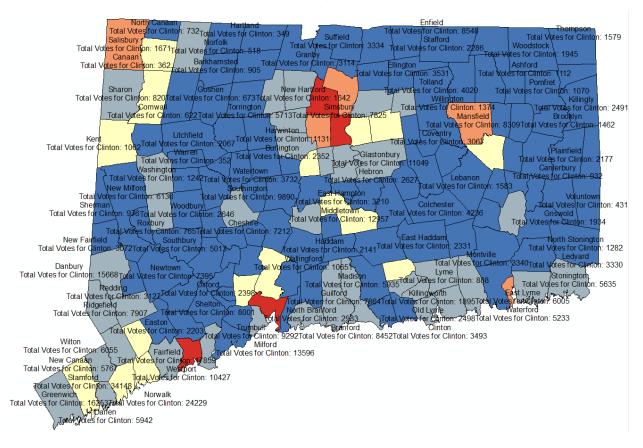
- Click **OK** to close the **Placement Properties** window and **OK** again to close the **Layer Properties** window.

Zoom to the **Full Extent** of your map so you can see the entire state.

What do your labels look like now? How about the map, is it legible? What happens when you zoom in?
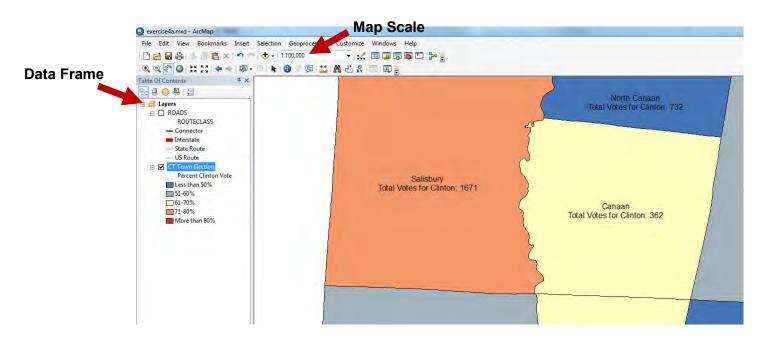
✥ Applying a Reference Scale

When you create labels and apply them to a map, they will stay the same size when you zoom in/out, which as you saw in the preview step, can cause problems. To avoid this, you can set a Reference Scale. Reference Scales are properties of Data Frames. If you have multiple Data Frames in your project, each can have a different Reference Scale. Think of the Reference Scale as the data view's display scale at which the text is appropriately sized relative to the cartographic features. After the Reference Scale has been set you can zoom in/out and the text in the data view will scale up/down along with the cartographic features.

- The easiest way to set a **Reference Scale** is to zoom in on your map to a scale in which your labels are appropriately sized and then set the **Reference Scale**. Use your **zoom tools** to zoom in on a portion of the state. As you zoom in, your labels will begin to fit within the town boundaries.

- When you have found a scale where the labels fit correctly within the towns they are labeling, right click on the data frame **Layers** and mouse over **Reference <u>S</u>cale** and then click on **Set Reference Scale** on the pop-up menu.

- Now zoom in or out and note that the text changes size along with the features.

- To return the display to the reference scale, right click on the data frame **Layers** and mouse over **Reference <u>S</u>cale** and then click on **<u>Z</u>oom to Reference Scale** on the pop-up menu.

- You also can clear the reference scale and then reset it to a different scale if needed.

Advanced Labels: Label Classes
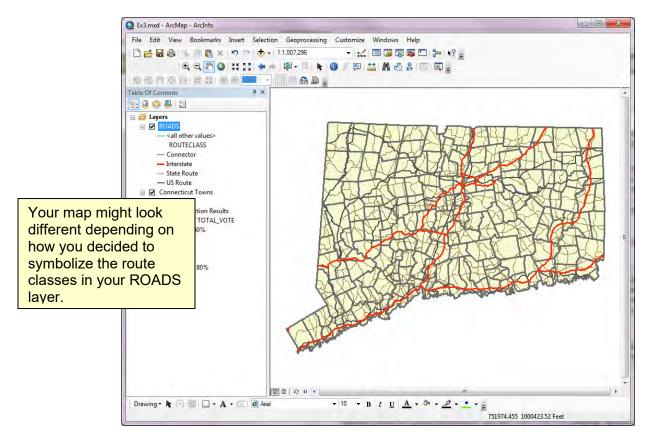
Label Classes allow you to specify different labeling properties for features within the same layer. For example, in a layer of city points, you may want to label the cities with larger populations with a larger font size than smaller cities. In addition, features in different label classes can be symbolized differently. For example, in this step of the exercise, you will create

label classes for the ROADS layer. Each road type (highway, state route, US route) will be symbolized differently and will be labeled with a different highway shield to represent the route type.

- **Clear the Reference Scale**. Right-click on the **Layers** data frame name and hover your mouse over **Reference Scale** and select **Clear Reference Scale**.

- Turn off the **CT Town Election Results** layer in the **Table of Contents**.

- Click the **Add Data** button on the **Standard Toolbar** and navigate to your **C:/GISEd10/Layers** folder and add **Connecticut Towns** to your map.

- Turn on the **ROADS** layer in your **Table of Contents** and zoom to **Full Extent**. You should see all 169 towns in the state on your map and all of the major roads in Connecticut as you symbolized them in Exercise3a.

- If you would like to change the symbology for any of the route classes, do so now.

Your map might look different depending on how you decided to symbolize the route classes in your ROADS layer.

⊕ Create a Label Class

- In the **Table of Contents**, double click on **ROADS** to open its **Layer Properties** window. Click the **Labels** tab.

- Check the box in the upper left hand corner next to **"Label features in this layer"**.

- Change the **Method** to "**Define classes of features and label each class differently.**"

- Under **Class**, click the **Add…** button.

- In the window that opens, name the new class **Interstates** and click **OK**.

- Notice that **Interstates** is now the active class. You can change the active class by clicking on the black dropdown arrow. Click on the arrow and select **Default** - with **Default** as your active class, click on the **Delete** button. This will delete the Default class. Interstates should now be the only class available from the dropdown list.

- Click on the **SQL Query** button. Here you will define the SQL Query to identify the Interstate route class for your new Interstates label class.

- In the **SQL Query** window, double click on **"ROUTECLASS."** This will add it to the query box at the bottom of the window.

- Next click on the **Get Unique Values** button. The unique **ROUTECLASS** values will be added to the box in the middle of the window.

- Click on the "**=**" button to add it to the query box.

- Finally, double click on **"Interstate"** value to add it to the query box.

- Your **SQL Query** should read, **"ROUTECLASS" = 'Interstate'** and the **SQL Query** window should look like the graphic below.

- Click **Verify** to make sure you have no typos in your SQL Query. If you get an error, go back and recreate your statement. If your expression was successfully verified, click **OK** to return to the **Layer Properties** window.

- In the **Layer Properties** window, change the **Label Field** to **ROUTENO**.
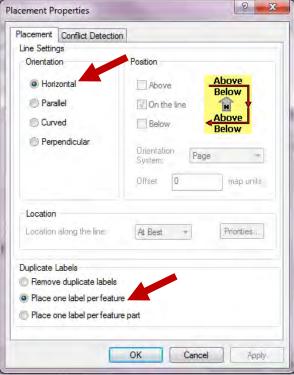
Text String

Label Field: ROUTENO | Expression...

Text Symbol

AaBbYyZz | Arial | 8

B *I* U | Symbol....

- Click on the **Symbol** button under **Text Symbol.** This will open the Symbol Selector.

- Scroll all the way down to the bottom of the **Symbol Selector** until you find the **U.S. Interstate HWY** symbol. It will look like the red, white and blue highway shield we are all familiar with. Click on it and then click **OK** at the bottom of the window.
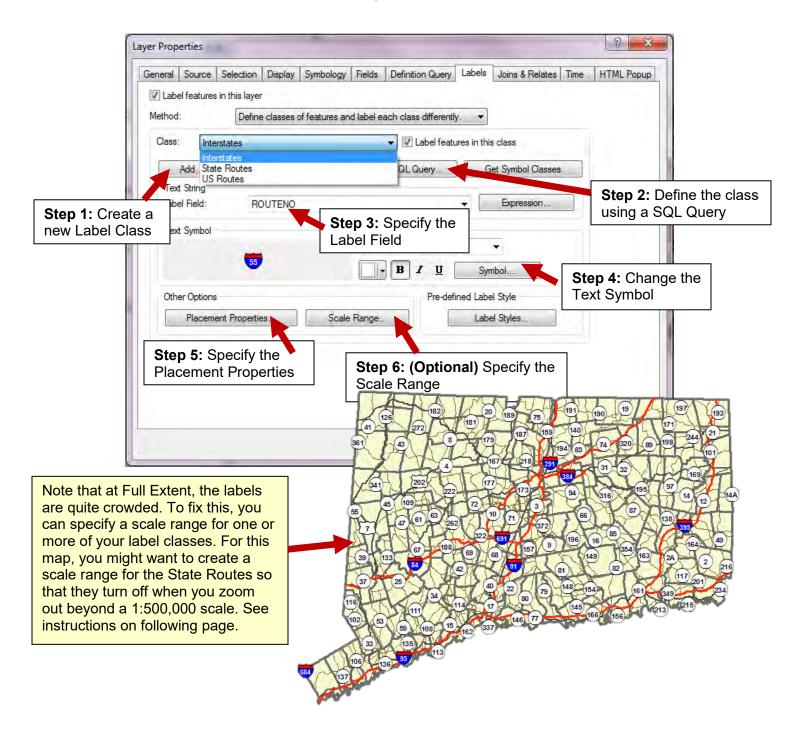
- The last thing we want to do before applying the Label Class is to specify the Placement Properties. Click on the **Placement Properties** button under **Other Options**.

- In the **Placement Properties** window, set the **Orientation** to **Horizontal**. At the bottom of the window, under **Duplicate Labels**, select the radio button next to **Place one label per feature.**

- Click **OK** to close the **Placement Properties** window.

- Click **Apply** in the **Layer Properties** window to apply the new label class. Move the **Layer Properties** window aside so you can see the changes to your map. You should see highway shields on all of the major interstate highways. Cool! Now let's create label classes for the other routes.

- You are going to repeat the process and create two additional Label Classes, one title **"State Routes"** and another called **"US Routes".** Refer to the previous steps to

create and define these two labels classes. Be sure to use the SQL Statement, **"ROUTECLASS" = 'State Route'** for your **State Routes** Label Class and **"ROUTECLASS" = 'US Route'** for your **US Routes** Label Class. The **Label Field** for both should be **ROUTENO**. You will find appropriate highway shield symbols in the **Symbol Selector** for both Label Classes. If you have questions or find yourself stuck, refer back to the previous pages or ask an instructor for help.

Step 1: Create a new Label Class

Step 2: Define the class using a SQL Query

Step 3: Specify the Label Field

Step 4: Change the Text Symbol

Step 5: Specify the Placement Properties

Step 6: (Optional) Specify the Scale Range

Note that at Full Extent, the labels are quite crowded. To fix this, you can specify a scale range for one or more of your label classes. For this map, you might want to create a scale range for the State Routes so that they turn off when you zoom out beyond a 1:500,000 scale. See instructions on following page.

✵ **Specify a Label Scale Range**

-   You may find that with all of your **ROADS** features labeled and your map zoomed to Full Extent, things look a bit crowded on your map. You can address this by specifying a **Scale Range** for one or more of your **Label Classes**.

-   Double click on the **ROADS** layer in the **Table of Contents** to open the **Layer Properties** window again. Click on the **Labels** tab.

-   Change the **Class** to **State Routes** and click on the **Scale Range** button at the bottom of the window.
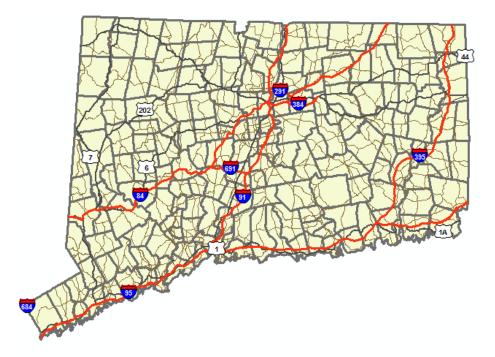
-   Change the **Scale Range** so that the Label Class doesn't draw when zoomed **Out beyond 1:500,000.** Click **OK.** Click **OK** again in the **Layer Properties** window to apply the changes.

- Click the **Zoom to Full Extent** icon on your **Tools Toolbar** to zoom to the full extent of your map data.

What happens to the State Route labels at Full Extent?

Zoom in on your map. At what map scale do the State Route labels turn back on?

- This is a good point to **save** any changes you have made to the map. Remember, save early and often to avoid disasters!

Geodatabase Annotation

Annotation is a special type of feature class stored in a geodatabase. The "features" are the text strings themselves. Each text string has its own properties and XY location that can be edited in the same way that other geographic features are edited in ArcMap. The benefit of annotation over labels is that annotation provides more flexibility in how the labels are formatted and placed on your map features. Because annotation is stored in a geodatabase, it is easy to share and reuse. Labels are a property of layers and can only be stored as a feature of the map document or in a layer file. In this step, you will create a geodatabase annotation class to label streets in the town of Marlborough.

✤ Adding Additional Data Frames

You can add multiple data frames to an ArcMap project. This can be helpful to separate different types of data and as you'll see in the next exercise, it is particularly helpful when creating map layouts. In this step you will create a new data frame and add data to it for the town of Marlborough.
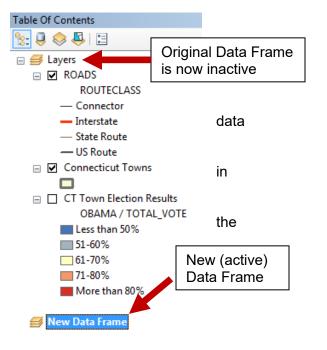
- Click on the **Insert** dropdown menu and select **Data Frame**. A data frame titled **New Data Frame** will be added to the **Table of Contents**.

- You will also notice it is now the active data frame and is displayed in bold text. Note that your other data frame, **Layers** is still in the Table of Contents, however it is inactive. In **Data View**, you can only have one active data frame at a time. The contents of the active frame will be displayed in the Display Area. Because your new data frame does not contain any data yet, nothing will be displayed the Display Area.

- You can click on the **minus sign (–)** next to Layers data frame to collapse it if you wish. We will not be using it for now.

- Double click on the **New Data Frame** name to open its **Properties** window.

- Click on the **General** tab and change the **Name** to "**Marlborough.**" Click **OK** to close the **Data Frame Properties** window. You will notice the data frame name has changed in the **Table of Contents**.

- Click the **Add Data** button on the **Standard** toolbar. Navigate to your **C:/GISEd10/Layers** folder and add the following layer files to your **Marlborough** Data Frame: **Marl Town.lyr, Marlborough Streets.lyr, and Marlborough Water Features.lyr.** You can add all three at the same time by holding down the **Ctrl** key on your keyboard while clicking on each.
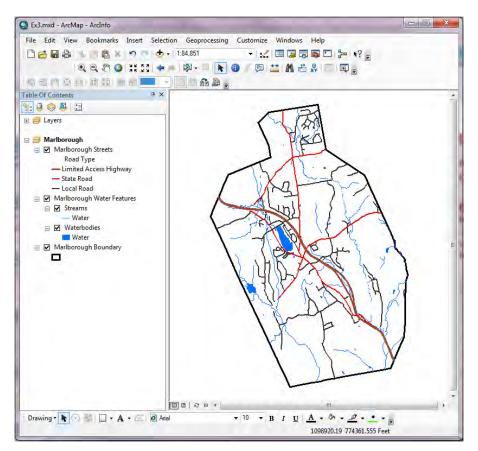
- When the data layers are added as a group to ArcMap, they will remain highlighted or selected in **blue** in the **Table of Contents**. Click anywhere in the white space in the **Table of Contents** to unselect them.
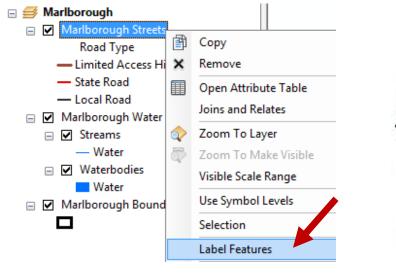
Note, these are Layer (.lyr) files. They do <u>NOT</u> include the actual data, they simply point to the data, which for all three of these layer files is stored in the Marlborough.gdb. These layer files do however, store information about how the layer should be displayed in ArcMap, including symbology and labels.
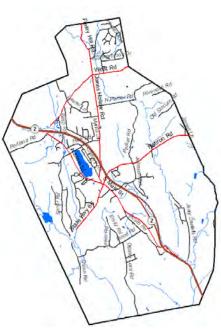
The first thing you will notice is that the layers are already symbolized. This is the beauty of using layer files.

- Right-click on the **Marlborough Streets** layer and click on **Label Features**. You should see the pre-formatted labels appear on the streets layer. Because labels are a property of a layer, they too are saved in a layer (.lyr) file.
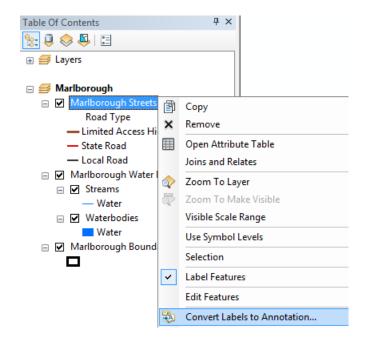
⊕ Create a Geodatabase Annotation Class

The simplest method for creating annotation is to set up labels for a layer and then convert them to annotation that is stored as a feature class in a geodatabase. In this step, you will convert the labels for Marlborough Streets into geodatabase annotation.

-   Zoom in to the large lake.

-   With the labels turned on, right-click on the **Marlborough Streets** layer in the **Table of Contents** and select **Convert Labels to Annotation** in the menu that appears.

-   A **Convert Labels to Annotation** window will open. Take a look at the setting options. Make sure that **(1)** the annotation is set to be stored In a database; **(2)** that you are creating annotation for All features; and **(3)** that your annotation destination is the **Marlborough.gdb**. Your new annotation class will be called **Marlborough_StreetsAnno.**

-   Click **Convert** to create the annotation.

✦ Exploring Annotation

- When the process is complete, you will have a new layer in your **Table of Contents** titled **Marlborough_StreetsAnno**. Click in the check box next to the layer to turn it on/off. Notice the layer is just made up of street labels.

- Double click on the **Marlborough_StreetsAnno** layer to open its **Layer Properties**. Click on the **Source** tab. Note the **Data Source** properties. Here you can see where the layer is stored and what type of feature class and feature type it is. Close the **Layer Properties** window.

- Turn both street layers on. Right click on **Marlborough_StreetsAnno** and select **Open Attribute Table**. Scroll through the attribute table (note, scroll down to the end of the table to view non-"Null" value features). Notice that each label in the annotation layer is its own feature and has a record in the attribute table. Close the table when you are done.

OBJECTID *	SHAPE *	FeatureID	ZOrder	AnnotationClassID *	SymbolID	Status *	TextString	FontName	FontSize	Bold
230	Polygon	3	<Null>	Local Road	2	Unplaced	Bull Hill Rd	Arial	10	No
231	Polygon	14	<Null>	Local Road	2	Unplaced	Stone House Rd	Arial	10	No
232	Polygon	754	<Null>	Local Road	2	Unplaced	Hartinger Rd	Arial	10	No
233	Polygon	755	<Null>	Local Road	2	Unplaced	Reservoir Rd	Arial	10	No
234	Polygon	18	<Null>	Local Road	2	Unplaced	Ogden Lord Rd	Arial	10	No
235	Polygon	4	<Null>	Local Road						
236	Polygon	752	<Null>	Local Road						

Data Source

Data Type:	File Geodatabase Feature Class
Location:	C:\GISEd10\Marlborough.gdb
Feature Class:	Marlborough_StreetsAnno
Feature Type:	Annotation
Geometry Type:	Polygon

Editing Annotation

Because annotation is stored in a feature class, must be edited like other layers using the Editing tools. We'll cover editing in one of the next modules!
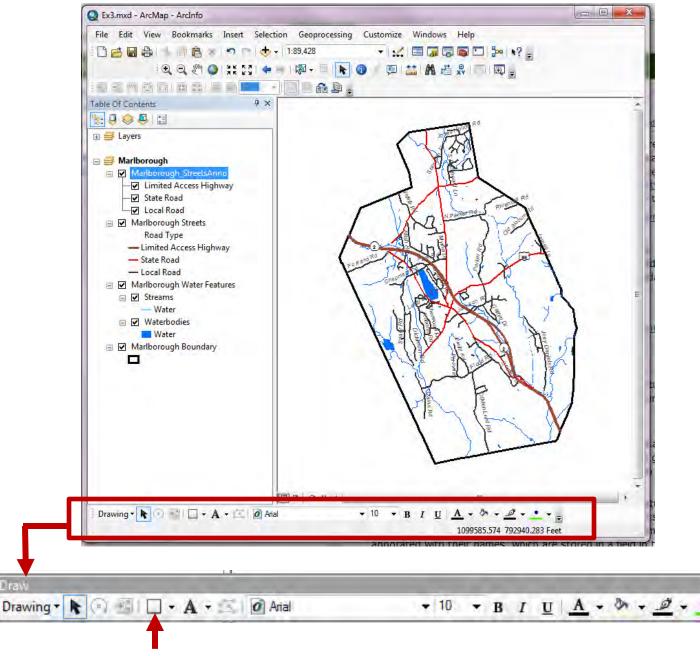
Adding Graphics to a Map

In addition to text and annotation, you can also add graphics to your map. Graphics are basics shapes and text elements that can be added to a map or layout that have properties, but are not linked to layers in the Table of Contents.

✤ **The Draw Toolbar**
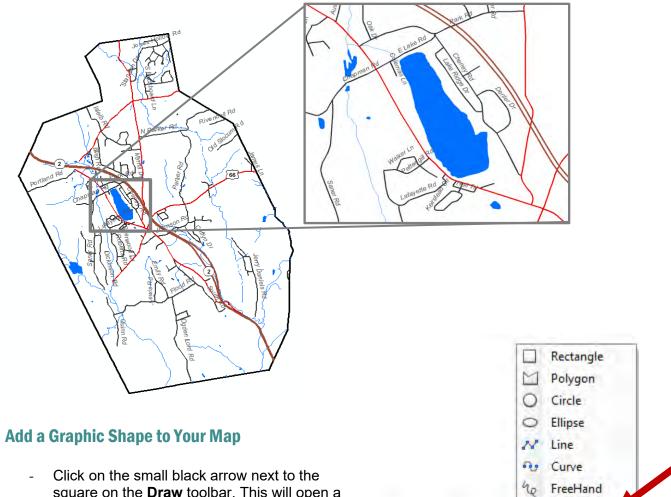
- If it isn't already turned on in ArcMap, turn on the **Draw** toolbar. Click on the **Customize** menu item in the **Main Menu**, hover over **Toolbars** and make sure there is a check next to **Draw**. If not, click on it. The **Draw** toolbar will be added to your interface. Dock it down in the lower left hand corner of ArcMap.

Graphic Tools

- Use the **Zoom** tools to zoom in on Lake Terramuggus.

⊕ Add a Graphic Shape to Your Map
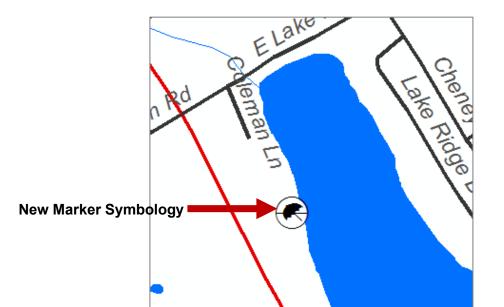
- Click on the small black arrow next to the square on the **Draw** toolbar. This will open a menu with various options for graphic shapes that can be added to your map. Click on the **Marker** icon.

- Click in a location on the northwestern side of the lake (it doesn't have to be exact). You should see a marker point placed on the location where you click.

- ArcMap will use a default green circle to symbolize the point. Let's change the marker symbology to something a little more exciting.

- Right-click on the circle marker and select **Properties** in the menu that appears to open the marker property window.

- Click on **Change Symbol**.

- In the top of the **Symbol Selector**, type in "**beach**" in the keyword box and press **Enter.** ArcMap will load all of the symbols with the word beach in their title. Choose one of the icons (don't choose the Beach Pine icon – we want it to be a sandy beach, not a tree!).

- You can play with the symbol's properties (color, background, size) by clicking on the **Edit Symbol** button in the **Symbol Selector.**

- When you are satisfied with your symbol properties, click **OK** to close the **Symbol Selector**. Your marker point should be updated to reflect your changes.

New Marker Symbology
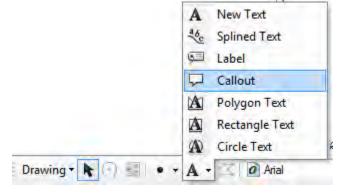
✵ Add a Text Element to Your Map
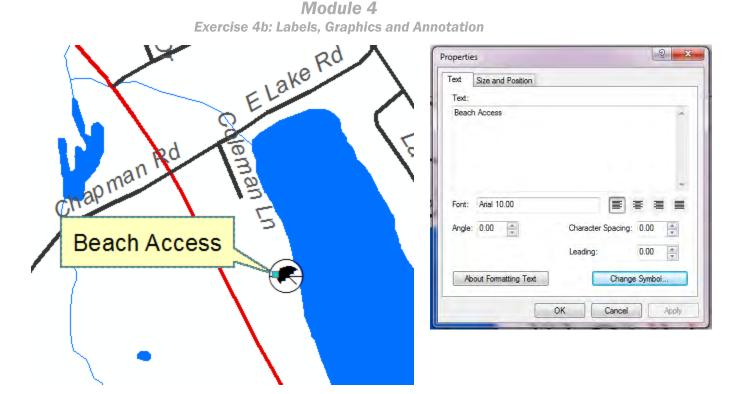
- Click on the little black arrow next to the **Text Tool** on the **Draw** toolbar. This will open a menu with various options for text elements that can be added to your map. Click on the **Callout** icon.

- Hover your mouse over the beach marker you just created and click. In the text box window that appears, type "**Beach Access**" and press **Enter.**

A   New Text
♪ᵉ   Splined Text
▣   Label
▽   Callout
🅐   Polygon Text
🅐   Rectangle Text
🅐   Circle Text

Drawing ▾ ▸ ⟲ ▦ ● ▾ A ▾ ⤬ 🄐 Arial

Beach Access

- After you press **Enter**, the text element should be highlighted. Click on it and while holding down your left mouse button, drag the text box to the side of the beach marker. Try the upper left corner (see graphic). Notice too that the Callout element has a "tail" that you can use to point to the feature you are labeling. Click and drag the callout tail so that it's pointing to the beach marker.

- If you wish to change any of the properties of the text element, you can double click on it to open its **Properties** window.
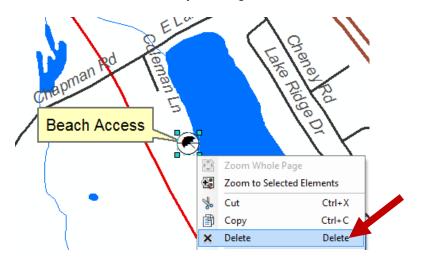
CLEAR

Turn off all of the layers in your Table of Contents. What happens to the graphics? Why did that happen?

⊕ Deleting a Graphic or Text Element

- Using your **Select Elements** tool ⤢ click on one of the graphics you just added to your map. This will select the graphic. Right-click and select **Delete** from the menu options. This will delete your graphic.

- You can undo the delete by clicking the **Undo** icon ↶ on the **Standard** toolbar.

Save Your Work!

✦ Save Your Map Project (.mxd)

- To save the changes you have made, click on **File** on the **Main Menu** and select **Save** from the menu that appears. Save it as **Exercise4b.mxd** in the **Projects** folder. Since we already saved it once, you can overwrite the existing Exercise3b.mxd.

Let's Review!

Congratulations on completing Exercise 3b! This exercise was designed to introduce you to labels, annotation and graphics in ArcMap. We covered a number of important concepts in this exercise including:

- ✓ **Dynamic labels**: Labels are a property of a layer. Dynamic labels can be added to provide context to features on your map. Labels pull their text string from a field or fields in the layers attribute table.
- ✓ **Label Classes:** Label classes allow you to specify different label properties for features within a single data layer. Each label class can have different symbology and text.
- ✓ **Geodatabase Annotation**: Labels can be converted to geodatabase annotation. Annotation allows for more flexibility when it comes to labeling feature on a map because each label is stored as a feature in a geodatabase feature class and has it's own properties and XY location.
- ✓ **Graphics**: Graphic shapes and text elements can be added to your map using the tools available from the Draw Toolbar. Graphics are not dynamic and are not linked to any layer in the Table of Contents.

This concludes Exercise 4b. You can keep the exercise open, you will use it in Exercise 4c.

If you have finished and the class is still working on the exercise, play around with labels and annotation. Try adding a few more graphics to your map. Explore and experiment!!
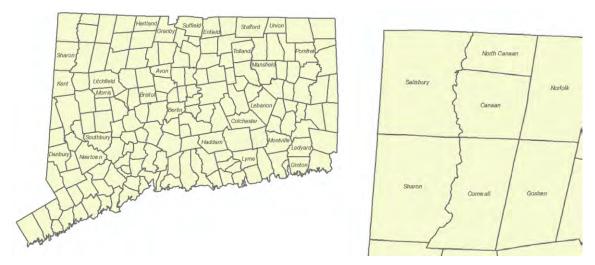
Exercise 4b Answers

Label Placement Properties

What happens when you click "Only place label inside polygon"? Did all of the towns get labeled? What happens when you zoom in or out on your map?

If you have this option checked, a label will only be placed in a polygon if it fits within the polygon's boundaries. When you zoom in on your map, more towns will be labeled. When you zoom out, fewer towns will be labeled because ArcMap can't fit them within the town's boundaries.

Formatting a Label Expression

What do your labels look like now? How about the map, is it legible? What happens when you zoom in?

The resulting label will be stacked (have two lines of text) and will provide more context to the map readers than just the attribute value alone. At full extent the map still looks less cluttered because few labels are drawn. As you zoom in, additional labels appear once the scale threshold is met.

Label Display Scales

What happens to the State Route labels at Full Extent?

They are not visible because we placed a scale threshold on them.

Zoom in on your map. At what map scale do the State Route labels turn back on?

1:500,000

Graphics

Turn off all of the layers in your Table of Contents. What happens to the graphics? Why did that happen?

 The graphics remain on the map even when all of the layers in the Table of Contents are turned off. This is because graphics are not feature-linked but rather are stand-alone static features.
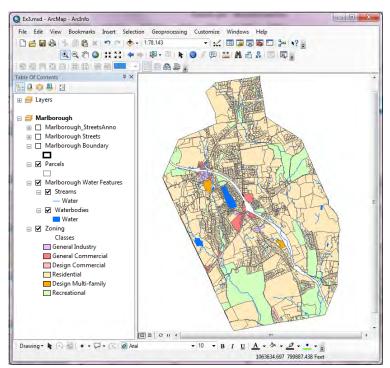
Exercise 4c: Map Layouts

This final part of Module 4 will tie together everything you have learned about map production. You will learn how to create a map layout in ArcMap and prepare the map for printing or export to an image or PDF file. You will work with multiple data frames and map elements in order to create a cohesive and clear map displaying features in the town of Marlborough. If you have additional time when you finish, you can also explore data driven pages by completing the "extra credit" portion of this exercise.

Getting Started: Layout Basics

✸ Set up Your Map

- You will start this exercise where you left off in Exercise 3b. If you have closed the exercise, start a new ArcMap session and open your **Exercise4b.mxd**.

- Before we get started on our layout, let's prepare our **Marlborough** Data Frame for this exercise.

- In the last step of **Exercise 4b**, you added two graphics to your map displaying the location of a beach access point. You may or may not have deleted them from your map. If they are still on your map, select each graphic and delete it. We will not be using them for this exercise.

- Zoom to the full extent of the **Marlborough** Data Frame. You should be able to see the entire town on your map.

- Click the **Add Data** button on the **Standard Toolbar**. Navigate to your **C:/GISEd10/Layers** folder and add **Marl Parcels.lyr** and **Marl Zoning.lyr** to your map.

- In the **Table of Contents** turn off the following layers: **Marlborough_StreetsAnno, Marlborough Streets,** and **Marlborough Boundary.**

- Reorder the layers so that **Zoning** is on the bottom, **Marlborough Water Features** is in the middle and **Parcels** is on the top.

- **Save** your map as **Exercise4c.mxd** in your **C:/GISEd10/Projects** folder.
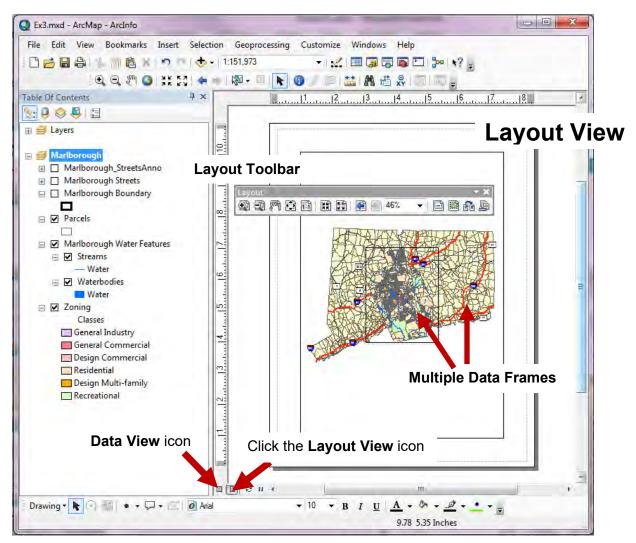
⊕ Working in Layout View

Layouts are the ArcMap equivalent of a desktop publishing system. You can switch back and forth between Data View and Layout View by clicking the appropriate icon at the bottom of the ArcMap view pane.

- Click the **Layout View** icon (it looks like a sheet of paper) at the bottom of the ArcMap view pane.

Notice that the map display changes. The biggest change you will likely notice is the data being displayed on the map. In Layout view, **multiple Data Frames are visible**. Because you have two Data Frames in your map, both will be visible and by default, stacked on top of one another. We'll address that issue in a minute. Also notice there is a **dotted outline** around the Marlborough data that represents the active Data Frame. There will also be a **light gray dotted outline** around the edge of the Layout that represents that printer's margins. ArcMap initially uses the settings for the default printer installed on the PC.

- Try toggling back and forth between **Data View** and **Layout View**. End up on **Layout View**.
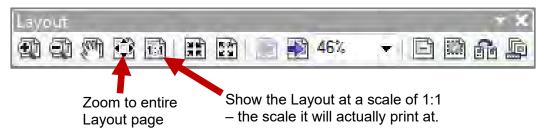
- Expand the **"Layers"** Data Frame in the **Table of Contents**.

- Uncheck the **ROADS** layer. The road lines should disappear on your layout and you should only see a map showing **Connecticut Towns** in the **"Layers"** Data Frame. Map layers displayed in the **Layout View** are "connected" to layers in the **Table of Contents** just as they are in **Data View**. Any changes you make to a layer will be reflected on the map in Layout View.

⊛ The Layout Toolbar

When you first open a layout, the Layout toolbar also will be opened and added somewhere on the ArcMap display. This toolbar has controls that help you move around within a layout.

- Move your mouse over **each** of the **Layout Toolbar controls** and note what the control does. On this toolbar, the pan and zoom functions operate on the virtual sheet of paper that you are preparing for plotting. Thus, when you zoom in, you are making the "paper" larger and you are NOT changing the scale of the map data on the paper.

Zoom to entire
Layout page

Show the Layout at a scale of 1:1
– the scale it will actually print at.

- To change the scale or extent of the actual data being displayed in the layout use the pan and zoom tools on the **Tools Toolbar** – the one you have been using up to this point.

- While in **Layout View**, zoom in, out and pan using the tools on the **Tools Toolbar** and notice how the Layout View changes. Now toggle back to the **Data View** by clicking the **Data View** icon and note how the layers are displayed there.

- Click the **Layout View** icon and then click the **Full Extent** button on the **Tools Toolbar**. This will restore the **Data View** and the **Layout View** to display the entire town of Marlborough.

It's important that you understand the relationship between Data and Layout Views and between the controls on the Layout and Tools Toolbars. Play around with these until you are comfortable with them. If you are uncertain about what's happening, ask an instructor to demonstrate and explain the relationships.

⊕ Data Frames in Layout View
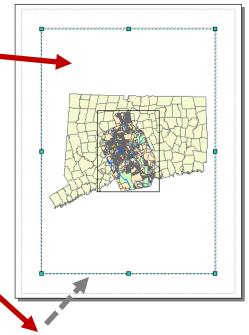
Data Frames automatically appear in the Layout View. If you have multiple Data Frames in the Table of Contents, all will appear in the Layout. Each Data Frame has properties that control its appearance – its border style, background color and pattern and shadowing.
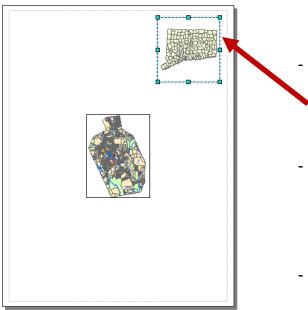
Data Frames can be manipulated in a variety of ways in Layout View. They can be copied, cut and pasted (within the map document and between map documents); they can be repositioned and resized; and they can be deleted. However, **never** (or rarely) delete a Data Frame. Deleting a Data Frame in the Layout also deletes it from the Data View and removes it from the Table of Contents. Of course, you can always use the Undo button to restore a deleted Data Frame.

- Click on the **Select Elements** ⬉ tool on the Tools Toolbar to return your cursor to the black arrow. Click once in the **rectangle containing the statewide data** to select and activate the **Layers** Data Frame.

- In the **Table of Contents**, uncheck all layers except for **Connecticut Towns**. If you can't see the entire state, click the **Full Extent** button.

Notice there are now **cyan boxes** on the edges and corners of the Data Frame. These are resizing "handles". You can click on any of them and drag them to resize the data frame.

- Click on one of the corner handles and drag it towards the center of the Data Frame. This should shrink the entire Data Frame.

- Shrink the **Layers** Data Frame until it is just a small, thumbnail size image on your layout. Position it in the upper right-hand corner of your layout by using the four-way arrows that appear when you hover over the center of the Data Frame.

- After you reposition it, the data within the Data Frame will need to be adjusted. Click on the **Zoom to Full Extent** 🌐 icon on the **Tools Toolbar**. This will zoom the map to the full extent and fit it nicely within the Data Frame.
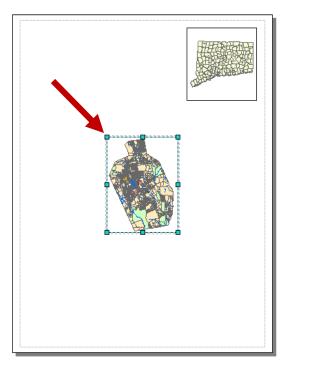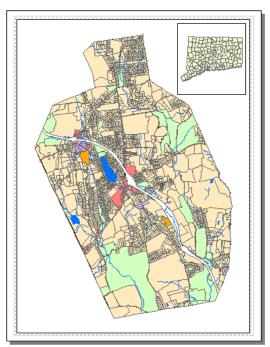
- Great! Now that we have our overview map set, let's focus on our Marlborough Data Frame, which will be the focus of our map layout.

- Click once within the **Marlborough** Data Frame on the Layout. This will select and activate the **Marlborough** Data Frame on the map and in the **Table of Contents**.

- Use the resizing handles to drag and extend the Data Frame so that it fills the majority of the layout. Because it will be the focus of the layout, you want it to be large and centered. After you reposition the Data Frame, click the **Zoom to Full Extent** 🌐 icon again on the **Tools Toolbar** to redraw the Marlborough data layers so that they fill the Data Frame.
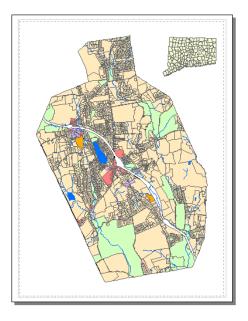
Woohoo, it's starting to look like a printable map! Let's adjust a few more Data Frame settings to clean it up a little more.

- Right click on the **Layers** Data Frame name in the **Table of Contents** and select **Properties**. This will open the Data Frame Properties window. Click on the **Frame** tab in the **Data Frame Properties** window.

- Try clicking on the drop-down arrows and changing the **Border**, **Background** and **Drop Shadow** settings and click **Apply** to see how they affect the Data Frame's display.

- After you are done experimenting with different frame setting, change the **Border**, **Background** and **Drop Shadow** to **<None>**. Click **OK** to apply the changes and close the window.

- You will see a dotted grey line surrounding the **Layers** Data Frame on the layout. This will not show up on your printed map, it is just way for you to see where the edge of the Data Frame is on your layout.

- Right click on the **Marlborough** Data Frame name in the **Table of Contents** and select **Properties**. This will open the **Data Frame Properties** window. Click on the **Frame** tab in the **Data Frame Properties** window.

- Repeat the steps you did previously to set the **Border**, **Background** and **Drop Shadow** settings to **<None>** and click **OK**. This will give you as much space on your layout as possible to add other important map features such as the legend, north arrow and scale bar.

Adding Cartographic Elements
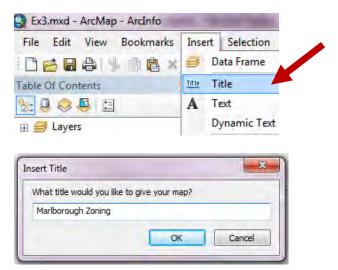
Some cartographic elements are linked to the active data frame including north arrows, scale bars, scale text and legends. Other elements such as titles, graphic elements, pictures, neat lines, reports and graphs can also be added to a map layout but are not linked directly to a data frame. Most cartographic elements can be added to a layout from the Insert menu in Layout View.

⊛ Add a Title

- Click on the **Insert** dropdown menu on the **Main Menu** in ArcMap and select **Title**. In the window that pops up asking for a title, type **Marlborough Zoning** and click **OK**.

  Note: sometimes the Insert Title window doesn't open. If this happened, you should see text titled "Map Production Exercise". Not to worry, just go on to the next step.

- A text box will be added to your map layout. Click on it and drag it to the upper left hand corner of the layout.

- Open the **Properties** window by double clicking on the text box.

Note: The **Insert > Title** tool will add dynamic text that is formatted with a text tag. Dynamic text changes automatically based on the current properties of the map document. The Title tag is linked to the Map Properties dialog box.
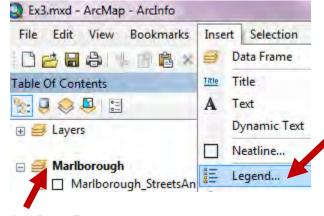
- In the **Properties** window, replace the dynamic text tag with Marlborough Zoning.
- Click on the **Change Symbol** button. In the **Symbol Selector**, increase the size of the text to **28**. If you wish to change the color or font of the title, do so. If you change the font, you may have to go back and adjust the text size as needed.
- Click **OK** to close the **Properties** window.

Add a Legend

A legend is a very important element for almost every kind of map. It tells a map reader the meaning of symbols used to represent features on the map. Legends consist of examples of symbols that are found on the map along with labels containing explanatory text. Whether you use a single symbol or multiple symbols to represent features in a layer, the layer's name and/or field value used to classify the features are included by default in the legend. This step in the exercise will take you through the process of adding a legend to your map using the Legend Wizard.

- Make sure the **Marlborough** Data Frame is **Active**. Remember, the active Data Frame will be the one that is in a **bold** heading in the **Table of Contents**. If it is not currently the active Data Frame, right click on the Data Frame name (**Marlborough**) in the **Table of Contents** and select **Activate** from the menu that appears.

- Click on the **Insert** dropdown menu item and select **Legend.** The Legend Wizard window will open.

The Legend Wizard makes it very easy to create a custom legend. The wizard allows you to:

- o   Choose which map layers will be part of the legend
- o   Specify the number of columns in the legend
- o   Create and symbolize a legend title
- o   Create and symbolize a legend border, background and drop shadow
- o   Customize the size and shape of the legend patches
- o   Set the spacing between legend elements
- o   Preview the look of the legend

The first window of the **Legend Wizard** gives you the option of picking and choosing what layers you would like to include in your legend. For this map, we only want to include **Parcels** and **Zoning**. The box on the left will display all of the **Map Layers** in the Marlborough Data Frame. The box on the right will display the **Legend Items** - all of the layers that will be displayed in the legend on your layout. We want this list to only include Parcels and Zoning.

- To remove **Waterbodies** from the list, click on it to highlight it and then click on the **left pointing arrow** to move it from the **Legend Items** list.

- Repeat the steps above to remove **Streams** from the **Legend** Items list as well. You should now only have **Parcels** and **Zoning** in the box on the right.

- After you have removed the two layers from the **Legend Items** list, click the **Next>** button to go to the next window of the **Legend Wizard**.
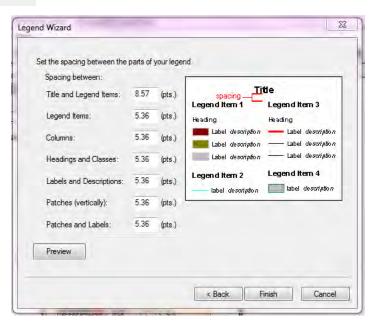
- The next window in the **Legend Wizard** is for formatting a **Legend Title**. Since we don't want our legend to be too large or long, and because most people understand intuitively what a legend is, we are not going to include a title. To remove the title, simply **delete the text** ("Legend") in the box under **Legend Title** and click the **Next>** button to move on.

- Next you will come to a window that includes settings for the **Legend Frame**. Here you can specify a **Border**, **Background** and **Drop Shadow**. Go ahead and experiment with a few different colors and settings. If you wish to include any of these, remember to keep the colors toned down so they do not distract from the actual map symbology. When you are done, click the **Next >** button.

- The next window in the **Legend Wizard** controls the size and shape of the symbol patch used to represent line and polygon features in your legend. It isn't necessary to change these, but if you want to "spice up" the look of your legend, go for it! Click the **Next>** button when you are ready to move on.

- The final window of the **Legend Wizard** allows you to control the spacing between different legend items. You can click on each legend item name in the window and it will show you the corresponding spacing as it will appear in the legend. For now, just leave them set to the default values.

- If you would like to **Preview** what your legend will look like before exiting the **Legend Wizard**, click the **Preview** button. Your legend will appear on your map. You can click the **<Back** button in the **Legend Wizard** to go back and change a setting if you wish.

- Click **Finish** to close the Wizard.

- Your legend will be added to your layout. Like other map elements, you can click on it to select it and position and resize it on our layout.

- If you would like to adjust any of the legend properties, double-click on the legend. This will open the **Legend Properties** window where you can access all of the properties and settings that were available through the legend wizard.

- You can reorder the **Legend Items** from the **Legend Properties** window. Click on the **Items** tab and click on **Parcels** in the right-hand window under **Legend Items**. Click on the **down arrow** to the right of the **Legend Items** box. Click **OK** to close the **Legend Properties** window. This will move the Parcels layer under the Zoning layer in your legend.
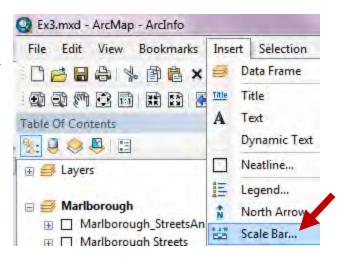
- Note that the legend is directly connected to the layers in your **Table of Contents**. If you turn off **Zoning** in the **Table of Contents**, it will disappear from the legend. If you rename a layer in the Table of Contents, the layer name in the legend will also change.

⊛ Add a Scale Bar
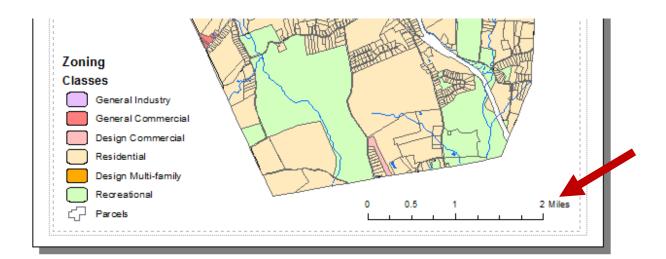
- Scale bars are also linked directly to the Data Frame that is active when you add the scale bar to your map. Because we want our scale bar to measure features in Marlborough accurately, make sure the **Marlborough Data Frame** is **Active**.

- Click on the **Insert** drop down menu on the **Main Menu** and select **Scale Bar**.

- In the **Scale Bar Selector** that opens, choose a scale bar style from the available options. Because readers of this particular map may only be interested in general distance measurements, you may want to choose one of the **Scale Line** designs over an **Alternating Scale** design. Make sure the **Scale to Fit** box on the right side of the window is **NOT** checked.

- Once you choose a scale design, click on the **Properties** button. There are many specific properties you can control relating to a scale bar. Take a minute to look at some of the options. The only one that we'll change right now is the **Division Units**. On the **Scale and Units** tab, change the **Division Units** from **Feet** to **Miles**. Click **OK**. Click **OK** again in the **Scale Bar Selector** to apply your scale bar.

- It will be added to the center of your Data Frame. Click on in and drag it to the bottom of your layout.

✪ Add a North Arrow
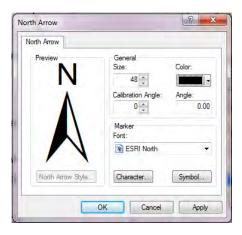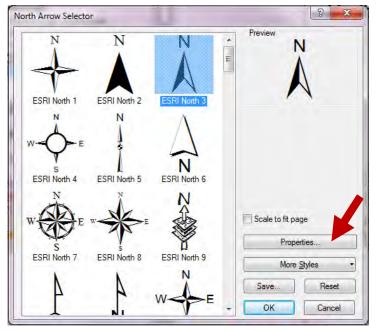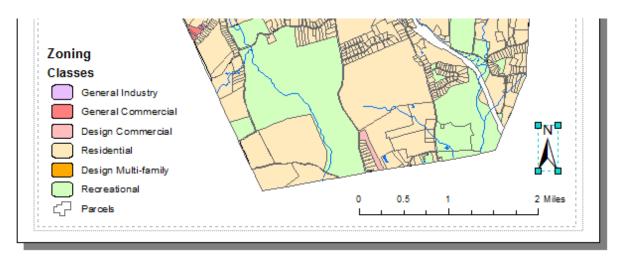
Like legends and scale bars, north arrows are also directly linked to a data frame. By default, North is always straight up in ArcMap, however you can rotate a data frame by using the Data Frame Toolbar. If you change the orientation of a data frame and add a north arrow, the orientation of the north arrow will change to reflect the northern orientation of the data frame.

- Click the **Insert** dropdown menu on the **Main Menu** and select **North Arrow.**

- Choose one of the **North Arrow** symbols from the **Symbol Selector**.

- If you wish to change the arrow's color or size, click on the **Properties** button.

- When you are satisfied, click **OK.** A north arrow will be added to your map.

CLEAR
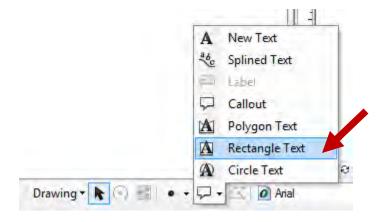
- Like other map elements, you can click on the North Arrow and drag it around your map. You can also select it and use the corner "handles" to resize it.

⊛ Add a Text Element

You may want to add a short paragraph or a few lines of text to a map to help the map reader understand what the map is portraying or to provide references. You can easily add text and graphics to your map layout using the tools on the Draw toolbar.

- If it is not already added to your ArcMap interface, add the **Draw** toolbar from the **Customize > Toolbars** menu.

- Click on the **Add Text** tool on the **Draw** toolbar and select the **Rectangle Text** tool option. This will allow you to define a rectangular text box on your layout. The text will wrap within the extent of the text box. This tool can be helpful for defining a precise area for text on your map.

- Draw a rectangular box on your layout just under the statewide overview map.

- Double-click on the text box to open the **Properties** window. Type the following text into the text window: ***This map shows zoning classes for the town of Marlborough, CT. It was created by {YOUR NAME HERE} on {DATE}. It does not include any authoritative data.***

- Click on the **Frame** tab and change the **Border** to **<None>.** Click **OK** to close the **Properties** window.

- You may find that you need to stretch, shrink or otherwise resize the text box in order to see all of the text. Remember to use the Zoom In tool on the Layout Toolbar (not the Tools Toolbar!) to take a closer look.
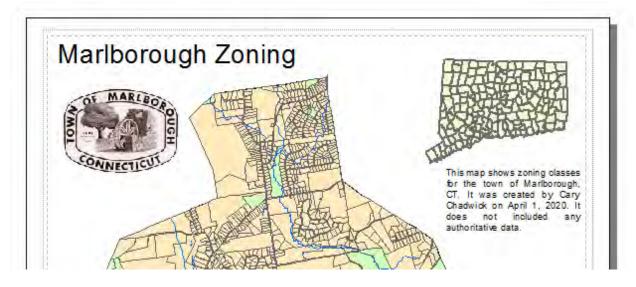
✴ Add an Image

The last thing we'll do to our layout is add a graphic of the town seal.

- Click on the **Insert** dropdown menu on the Main Menu and select **Picture**.

- Navigate to your **C:/GISEd10/Images** folder and select **town_seal.jpg** and click **Open**.

- The image will be added to your map. Click and drag it to the upper left-hand corner, just under the map title.

And there you have it! Your map is looking good. So far we have added: two data frames, a title, legend, scale bar, north arrow, text and image. There are a few other items you can add from the Insert dropdown menu. If you wish, you can explore some of these other options, but be careful not to create a map that is too cluttered.

⊛ Customize the Overview Map

We have one last thing to do to our map before we are ready to print and save. Right now, your overview map showing the state of Connecticut is not terribly helpful. We want the overview map to show where the town of Marlborough is relative to the rest of the towns in the state. To do this, we will select the town and change the selection symbology so that the town of Marlborough stands out on the map.

- If the **Layers** Data Frame is collapsed, click on the **+** symbol to expand it so that you can see the contents of the Data Frame.
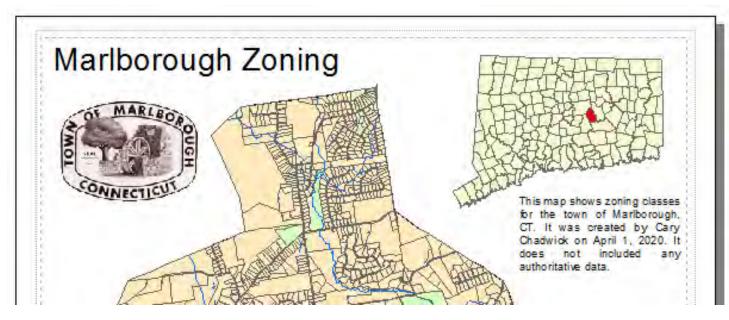
- Right-click on **Connecticut Towns** and select **Open Attribute Table.**

- Locate the **TOWN** field and right-click on it. Select **Sort Ascending**. This will sort the field in alphabetic order. Scroll down the list until you find **Marlborough.**

OBJECTID *	Shape *	TOWN_NO	TOWN	TOTAL_SQMI	LAND_SQMI	WATER_SQMI	COUNTY	PLAN_ORG	DEP_DIST
127	Polygon	76	Madison	36.3	36	0.3	New Haven	South Central Conn	DEP Eastern District
45	Polygon	77	Manchester	27.2	26.9	0.3	Hartford	Capitol Region	DEP Eastern District
40	Polygon	78	Mansfield	45.2	45.1	0.1	Tolland	Windham	DEP Eastern District
75	Polygon	79	Marlborough	23.5	23.4	0.1	Hartford	Capitol Region	DEP Eastern District
99	Polygon	80	Meriden	24	23.7	0.3	New Haven	South Central Conn	DEP Western District
101	Polygon	81	Middlebury	18	17.5	0.5	New Haven	Central Naug Valley	DEP Western District
104	Polygon	82	Middlefield	13.3	12.7	0.6	Middlesex	Midstate	DEP Eastern District

(1 out of 169 Selected)

- Click on the **Marlborough** record in the **Attribute Table** to select it. Remember, if a record is selected in the Table of Contents it will also be selected on your map as well. **Close** the **Attribute Table**.

- Double click on **Connecticut Towns** in the **Table of Contents** to open the **Layer Properties** window.

- Click on the **Selection Tab**. Change the "**Show selected features**" option **with this color** and click on the empty box. Choose a **bright red** color to symbolize the selected features. Click **OK** to close the **Layer Properties** window.

Notice that the town of Marlborough is selected on your overview map and is displayed in bright red on your map. You can play with the size of the overview map and the colors of the layer (hint: make the town borders thinner) to make the town stand out better.

- **Save** your project.

> **Tip:** Another way to enhance the overview map is to use an **Extent Indicator** which shows the extent of the data in another data frame and automatically updates if the extent changes. To set an **Extent Indicator**, double click on the **Layers** heading in the **Table of Contents** to open the **Data Frame Properties** window. Select the **Extent Indicators** tab. Click on **Marlborough** to highlight it and click the **>** arrow to move the data frame to the right. Click **OK**. The extent will be shown as a box.

Creating a PDF Map
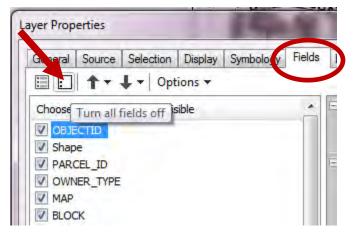
✦ Preparing Your Layout for Export

You can save your map layout from ArcMap in several different formats (.jpg, .bmp, .gif, .tif, .pdf, etc.). Beginning in ArcGIS 9.2, ESRI added functionality so that when you export a map to a PDF, the resulting PDF will contain native PDF layer information reflecting the layers in your map. Anyone using Adobe Acrobat Reader version 6 or higher will be able to view the PDF and turn a layer on or off using the Layers control in Acrobat Reader. This makes PDFs a very useful resource for sharing GIS data with others who do not have GIS software or understanding of GIS concepts. In ArcGIS 9.3 and ArcGIS10, ESRI furthered the functionality of exported PDF maps by adding the ability to use your cursor to identify coordinate locations on the map and also the ability to export feature attributes with the layers in your map. (*NOTE: this only works with Adobe Reader 9). In this step you will export your layout as a PDF and view it in Adobe Reader 9.

- Click on the **Add Data** button. You are going to add a point dataset to your Marlborough map. This dataset is less complex than some of the others in the map document so we'll use it as the example for exporting feature attributes to PDF.

- Navigate to your **C:\GISED10\Layers** folder and add **Marl Public Wells.lyr** to your map. You will see the public well points on your map and since you added a layer file, they will already be symbolized. The symbols may be difficult to see if you still have a **Reference Scale** set on the Data Frame from Exercise 3b. To clear the **Reference Scale**, right-click on the **Marlborough Data Frame** name and select **Reference Scale>Clear Reference Scale**. Now you should be able to see the well symbols without needing to zoom in on your map. The dataset name and symbol will also automatically be added to the legend on your map.

If you plan to take advantage of the ability to embed feature attributes in your PDF (available only in ArcGIS 9.3 and 10 using Adobe Reader 9), then it is wise to only export values in the layers and fields that you wish to embed. Otherwise, the system will get bogged down and your PDF will perform very slowly (or not at all!). In this step, you will turn off the visibility of all of the fields in all of the layers except for the ones you wish to export for the Marlborough Public Wells layer.

- Double-click on the **Parcels** layer to open the Layer Properties.
- Click on the **Fields** tab.
- Click on the **Turn all Fields off** icon in the upper left-hand corner. This will uncheck all of the fields in the list, essentially making them "invisible". When you export your map to Adobe PDF, the feature attributes stored in these fields will be ignored. This will improve the performance of your PDF.

- Once all of the fields have been turned off, click **OK** at the bottom of the **Layer Properties** window.

- Repeat the process for all of the other layers in the map *except for Marlborough Public Wells*. Marlborough Water Features is a group layer so you will have to turn off fields for the **Streams** and **Waterbodies** layers separately. Once you are finished, the only layer that should have visible fields is **Marlborough Public Wells.** When you export your map, all of the spatial features in your layers will be carried over, however only the attribute data stored in visible fields will be exported to the PDF. Turning off fields in the layers we don't need attribute information for will GREATLY improve the performance of a PDF!
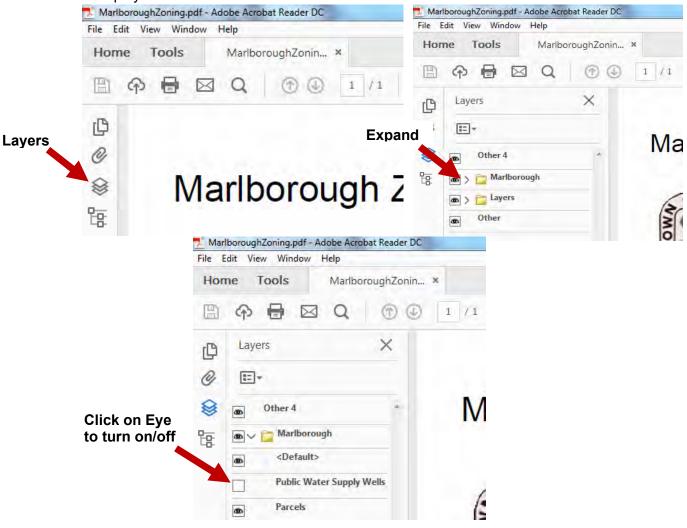
✴ Export to PDF

- Now you should be ready to export your map to a PDF. Click on the **File** from the **Main Menu** in ArcMap and select **Export Map…**

- In the **Export Map** window, navigate to your **C:\GISEd10\Results** folder.

- In the **Save as type:** box click the down arrow and select **PDF (*.pdf).**

- In the **File name:** box, type in **Marlborough Zoning.**

- Click on the **Advanced Options Tab** at the bottom of the **Export Map** window.

- On the **Advanced Tab,** click on the dropdown arrow next to **Layers and Attributes** and select **Export PDF Layers and Feature Attributes**.

- Make sure **Export Map Georeference Information** is checked.

- Take note of the **Warning** at the bottom of the screen (this is why you turned off fields).

- Click **Save** in the **Export Map** Window to export your data to PDF.
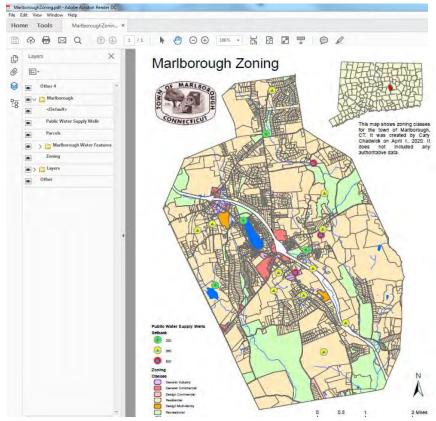
✤ **Explore Your PDF**

- Minimize ArcMap.

- Right click on the **Windows Start** menu, select **Explore** (or **Computer** in newer Operating Systems).

- Navigate to your **C:\GISEd10\Results** folder and double click on **Marlborough Zoning.pdf** to open it in Adobe Reader.

- When the PDF opens, click on the **Layers** tab on the left side of the window. This will expand the **Layers window**.

- Click on the **>** sign (arrow) next to **Marlborough** to expand the contents of the data frame.

- You should now be able to see all of the datasets that were in your Marlborough Data Frame listed in the Layers tab in Abode Reader.

- Click the eye icon to the left of each layer name to toggle the layer on/off in the PDF display window.

Layers

Expand

Click on Eye to turn on/off

CLEAR
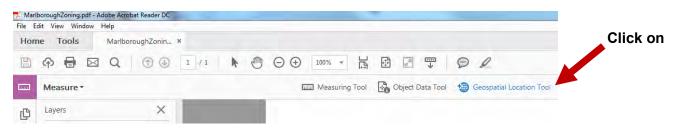
- Take a minute or two to turn each layer on and off. Every layer or group layer as well as any text or graphics present in your Data Frame at the time you exported your data will appear as a layer in your PDF and can be toggled on and off.

Advanced PDF Functions

In ArcGIS 9.3 and ArcGIS10, ESRI added the ability to export coordinate information and feature attributes. In this step, you will explore these features.

- In Adobe Reader, click on the **Edit** dropdown menu and select **Manage Tools,** then chose the **Measure Tool.** The **Measure** toolbar will appear at the top of the screen, click on the **Geospatial Location Tool**. This will add a tool that can display coordinate locations on your PDF map.

Click on
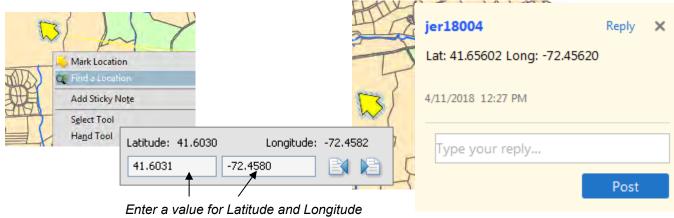
- Move your cursor over the map. Notice the tool reports the **Latitude** and **Longitude** in a grey box in the lower right corner of your map. The values represent the current location of your mouse.

Latitude: 41.6128   Longitude: -72.4377

- You can also right-click on the map and select **Mark a Location** or **Find a Location**. This will allow you to click on a location or enter a specific **Latitude** and **Longitude** and the tool will add a placemark in that location. Give it a try!

Mark Location
Find a Location
Add Sticky Note
Select Tool
Hand Tool

Latitude: 41.6030   Longitude: -72.4582
41.6031   -72.4580
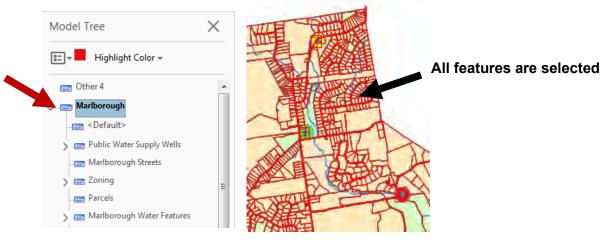
*Enter a value for Latitude and Longitude
and Press the Enter key*

jer18004   Reply   ✕
Lat: 41.65602 Long: -72.45620

4/11/2018 12:27 PM

Type your reply...

Post
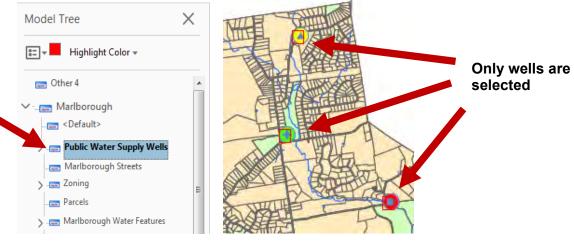
- Next, click on the **Model Tree** tab on the left side of the window. This will expand the **Model Tree window.** Click once on the **Marlborough** data frame.

- Notice many of the layers are outlined in red on your map. This is a first order selection. Basically Adobe selected all of the features in the Marlborough data frame that were ***selectable***.

- Click on **Public Water Supply Wells** layer to create a second order selection. Notice that the **Public Water Supply Wells** layer is now highlighted in bold in the **Model Tree**. This tells you that Adobe has narrowed in on this dataset…we're getting closer!

- Click on one of the wells under the **Public Water Supply Wells** layer to create a third order selection. Since Adobe knows which layer to look in, this click will narrow it down to the exact feature you clicked on. Notice that the feature attributes for the well are displayed in the bottom of the **Model Tree** window. Pretty cool! Try it again for another well feature. Remember…three clicks!

- Play around and experiment with the different layers and tools in Adobe Reader. When you are finished, close the PDF.

CLEAR

First Order Selection

All features are selected

Second Order Selection

Only wells are selected

Third Order Selection

Individual well is selected
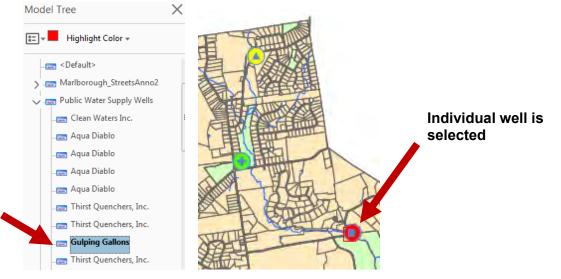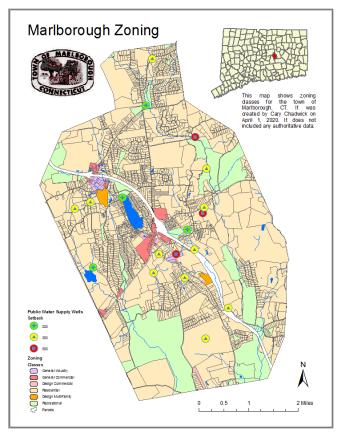
Printing & Sharing a Map

✦ Print Your Map

Whew – done!

Now you're ready to print the Layout in ArcMap. Return to your map in ArcMap. Click the **File** drop-down menu and select **Print Preview…** to review the layout as it will print. If all appears in order, then click the **Print** button. A **Print** window will open where you can set some printer parameters. This is just like printing from most other Windows programs. Click **OK** and send the layout to the printer.

Tip: It is easy to print a map at a specific scale. Just type the desired scale into the **Map Scale** [1:55,000 ▼] field. However, be sure the printer and paper size are adequate for the scale specified.

✦ Creating a Map Package
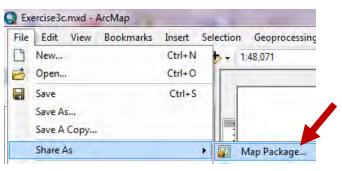
Map packages (.mpk) make it easy to share complete map documents with others. A map package contains a map document (.mxd) and the data referenced by the layers it contains,

packaged into one convenient, portable file. Map packages can be used for easy sharing of maps between colleagues, across organizations and with other ArcGIS users of ArcGIS Online.

- In ArcMap, click on **File > Map Document Properties**. Type a short description of the map into the **Description** window. It can be brief, but it should describe a brief overview of what the map contains.

- Add your name to the **Author** field.

- Click **OK.**

- From the **Main Menu**, click on **File > ShareAs> Map Package.**

- Save the **Map Package** to **C:\GISEd10\Projects\Exercise3.mpk**.

- Uncheck "**Include Enterprise Geodatabase data instead of referenceing the data**"

- Click on Item Description in the left column. Add a few keyword tags under the Tags heading.

- In the upper right corner of the window, click **Analyze** and then **Share**.

- You should get a message that your **Map Package** file has been successfully created. You can check your **C:\GISEd10\Projects** folder to verify that the file exists.

Let's Review!

This exercise taught you how to create maps for printing and display. A number of techniques for creating good layouts were covered including:

✓ **Using the layout view:** Layout view is where you set up the structure of how you map printout will appear. The Layout Toolbar provides a number of tools that help you navigate around the layout view.

✓ **Adding map elements:** A number of map elements can be added to a layout from the Insert dropdown menu on the main menu. Elements such as a title, scale bar, north arrow, and legend are key map elements for any layout. The legend wizard, which can be opened from the Insert menu, provides step-by-step instructions for creating a legend for your map.

✓ **Adding text and graphics**: The drawing toolbar is useful for adding additional elements to your layout.

✓ **Repositioning features:** The graphics toolbar allows you to align, distribute, rotates and in other ways manipulate any selected elements in the layout.

✓ **Exporting to a PDF:** When you export your map to a PDF, the resulting file contains PDF layer information for each of your layers in your Table of Contents. When you view the PDF in Adobe Reader 6 or higher, you can turn each layer on/off in the document. If you are working with ArcGIS 9.3 and Adobe 9, PDF functionality is furthered with the ability to find coordinates on your map and view feature attribute data. This makes sharing GIS data even easier!

✓ **Printing your layout:** When you create a layout in ArcMap, you can set the page properties to the size printer or plotter you are using. This makes it easy to create prints that look exactly like they do on screen.

✓ **Map Packages:** A map package contains a map document (.mxd) and the data referenced by the layers it contains, packaged into one convenient, portable file. Map packages can be used for easy sharing of maps between colleagues, across organizations and with other ArcGIS users of ArcGIS Online.

This concludes Exercise 4c.

Save your ArcMap session in your C:\GISEd10\Projects folder as Exercise4c.mxd

Close ArcMap.

Exercise 5a: Digitizing Basics

This exercise is designed to introduce you to the very basics of digitizing within ArcMap. You will open a premade map document (.mxd), start an editing session, and create some points, lines, and polygon features. Again, this is just the basics to familiarize yourself with editing tools. Do not get bogged down trying to be too accurate or creating too many features.

Getting Started:

- Open **ArcMap**. For detailed instructions, refer to Exercise 1a.
- Open the **Digitizing.mxd** which is in the **C:\GISEd10\Projects** folder.
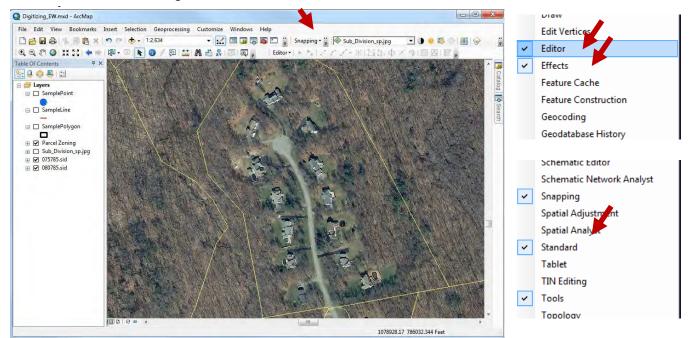
Editing Tools

Once open, the ArcMap GUI will look something like what you see below. If it looks slightly different, it's because additional functionality (toolbars, etc.) may have been turned on or enabled by a previous user. When ArcMap is closed, it "remembers" these settings and restores them when it is reopened.

✵ Preparing the View for Editing

To start an editing session you will need the **Editor** Toolbar and for this exercise the **Snapping** Toolbar.

- To add the toolbars, right-click on a blank section above the map view and select
  - **Editor** from the list.
  - Repeat to add the **Snapping** toolbar.
  - Repeat once more and add the **Effects** toolbar.
  - Once checked they will be visible. Dock the toolbars if they appear as "floating" windows.

✦ Starting an Edit Session
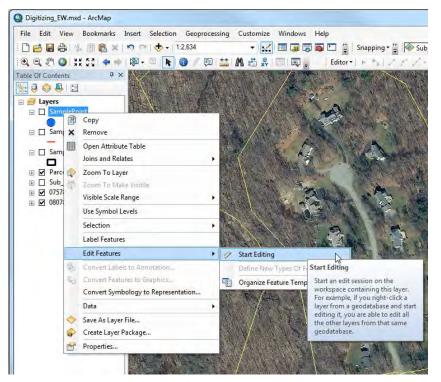
The risk of crashes increase with editing, so first save the project in your own file, then save periodically as you go along.

-   From the menu click **File>Save As…** and save your project as
    C:\GISEd10\Projects\Exercise5a.mxd

There are at least two ways to start an Edit Session. The first way you will try is easier, but does not provide as much information about the layers and folders within an editing session. Because all layers within the workspace or folder you are editing can be modified (on purpose or by accident), knowing more can be useful. The second procedure for starting an edit session is more complex, but provides more control. It will be up to you to choose the first or second technique in the future, but for now, try both methods.

First, the quick way:

-   Because it is the layer you want to edit, **right-Click** on the layer called **SamplePoint** in the Table of Contents.

-   Select **Edit Features>Start Editing**. This starts an edit session. You will see a **Create Features** window open in a pop-up or docked on the right side of the ArcMap interface. We'll get to that in a minute.
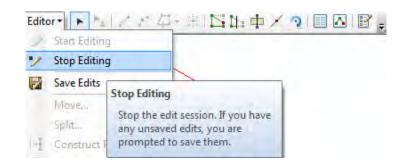
Tip: Hover your mouse over any menu item or icon on a toolbar (like the Editor toolbar!) for a helpful explanation.

-   For now, let's close this edit session so you can try the second approach. Stop the editing session by selecting **Editor>Stop Editing** from the **Editor** toolbar. If no edits were made it should close without a prompt.

The second technique is a more controlled approach for starting an edit session.
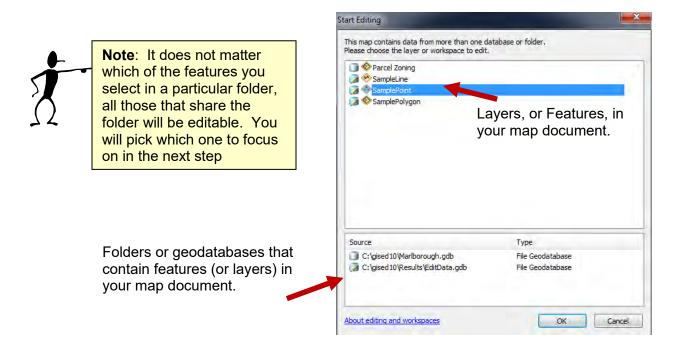
- On the **Editor** toolbar, select the **Editor menu** and then **Start Editing**. A **Start Editing** window opens because layers in the **Table of Contents** have different source folders and/or geodatabases.

- Click on a layer from the list at the top of the **Start Editing** window and notice how the icons change from 🗄 to 🖉 in both the top and bottom windows.

Those with the **pencil icon** 🖉 are part of the same editing "space." You can choose either the feature (top list) or the folder (bottom list) to open the session.

- Choose the **SamplePoint** feature and click **OK** at the bottom to open the session.

Note: It does not matter which of the features you select in a particular folder, all those that share the folder will be editable. You will pick which one to focus on in the next step

Layers, or Features, in your map document.

Folders or geodatabases that contain features (or layers) in your map document.
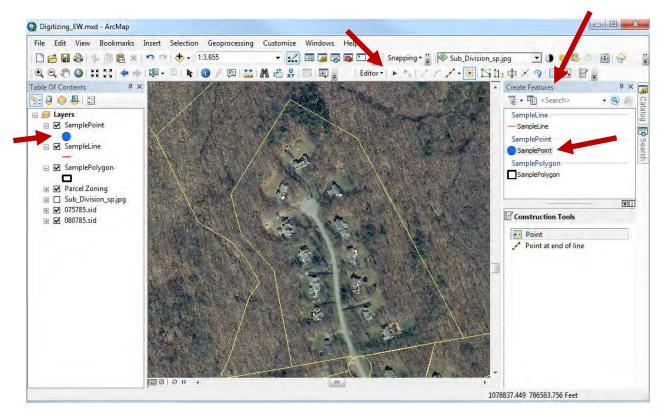
⊕ The Editing Environment

With **Editing** started you should now see the **Create Features** window on the right side of your ArcMap window.

- Locate the **Create Features** window. If it is not open, click the **Create Features** icon on the **Editor** toolbar to open it.
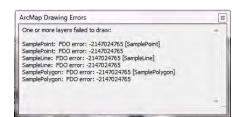
- If you don't like the symbology of the **SamplePoint** layer (or **SampleLine** or **SamplePolygon** for that matter), click on the symbol in the **Table of Contents** to change it before you start digitizing.

At this point you could start editing; anything within the edit folder can be modified at this time. However, before you start you will check to make sure Snapping is set properly.

- Click on **Snapping** from **Snapping** Toolbar to open the droplist and make sure **Use Snapping** is checked.

- Make sure each of the buttons to the right of the word **Snapping** is **depressed**. This can be hard to tell at first. To check, click on one of them, then move the mouse cursor off of it. It will display as either "off" (up) or "on" (down). You want them "on" (down).
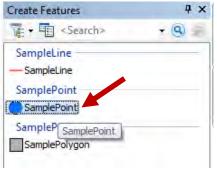
NOTE : If an "**ArcMap Drawing Errors**" window pops up at any time to indicate that one or more layers have failed to draw, just close it for now.

✸ Digitizing Points

First we will add some points. This is the simplest form of digitizing. Once several points are added, you will update some of their attributes.

- In the **Create Features** window, select **SamplePoint.** This means that new points created will be part of the **SamplePoint** layer when saved.

- Make sure "**Point**" is selected in the **Constructions Tools** box at the bottom.

- On the **Editor Toolbar**, be sure that the "**Point**" method is selected.

- To set up your map:
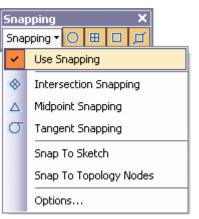
  o Maximize ArcMap so that it fills your screen by clicking on the square button in the upper right corner .

  o Use the stored bookmark to zoom to the correct area. On the **Bookmarks** menu, choose **Marlborough Subdivision**.
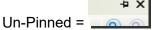
      o   Un-pin the **Create Features** window by selecting the **Auto Hide** button (pin icon 📌 in the upper right corner). When it shows a horizontal pin, the window should disappear and more of the map will show. To bring it back, simply put your mouse cursor over the **Create Features** tab on the right.

      Pinned =   Un-Pinned =
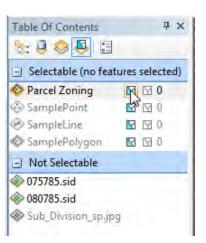
      o   Modify the **Selectable layers** so that ONLY the **SamplePoint**, **SampleLine** and **SamplePolygon** layers can be selected. If you forget how to do this, go to the **List by Selection** icon in the **Table of Contents**. Click on the icon next to Parcel Zoning to change it from Selectable to Not Selectable.

-   The map should be an image of the Marlborough subdivision. Practice using the mouse to zoom while in the editing session:
      o   To **Zoom In**, roll back the **Scroll Wheel** on the mouse.
      o   To **Zoom Out** roll it forward.
      o   To **PAN**, press down the **Scroll Wheel** and move the mouse or hold down the "**C**" key on your keyboard.

-   **Zoom in** so that you can see several houses with swimming pools.

-   **Left-click** on several of the pools to add them as points.

-   Once added, the newest point will be **highlighted** because it is selected (cyan). The prior points are drawn with the feature symbol (in this case a blue circle). Notice that when you hover over a previous point, the snapping symbol activates.

-   After adding a few points, on the **Editor** toolbar, select the **Editor menu** and **Save Edits**. Do this whenever you feel you have a lot to lose.

> **NOTE**: You won't be able to use **Edit>Undo Create** once the changes are saved, so saving edits can be a trade-off. Also, saving the entire project (which is also wise), does not automatically save your edits (it will, however, prompt you to save them if you Close the project).

- Now pan around and add more swimming pools.

- When you have had your fun clicking, try deleting some points. Select the **Edit Tool** from the **Editor** Toolbar ▶ and then select a point by clicking on it. Once the point is selected (highlighted), press the **Delete** key OR right-click and select **Delete** from the droplist.

> **TIP**: Remember the **Clear Selected Features Tool** 🔲 in the **Tools toolbar** if you accidently select the wrong thing while using the **Edit Tool**.
>
> To begin digitizing (adding points) after using the **Edit Tool**, click back on the
>
> **SamplePoint layer** in **the Create Features** window. 🔵 SamplePoint

> **OPTIONAL**: **To delete more than one point at a time**
> - Select multiple points with the **Edit Tool** ▶ (drag a box around them or hold down the SHIFT key while clicking on the points)
> - Open the attribute table by right-clicking on the layer in the Table of Contents and choosing **Open Attribute Table**.
> - With the table open and active, press the **Delete** key or right-click over the row box and select **Delete Selected** from the menu. -All of the selected records will be deleted.
> - Close the table.
>
> **NOTE**: You can select **Edit>Undo** if deleting was not your intention. If you try this, keep some points behind for the next step.

.
- Save your edits (**Editor** menu on the **Editor** toolbar, **Save Edits**). Now you will edit some data attributes for the new points.

✥ Adding Attributes

- Select the **Attributes Icon** on the **Editor Toolbar** to open the **Attributes** window.

- If the top dialog window is empty (no features are shown), select the **Edit Tool** ▶ from the **Editor** Toolbar, then click on a pool point on your map. Notice that the 3 attributes that exist in the **SamplePoint** table are visible (**OBJECTID**, **pointType** and **Description**).

- Click in the box next to **pointType** and type in *pool*. In the **Description** field type either *above* or *below* to indicate if it is an above ground pool or an in ground pool.
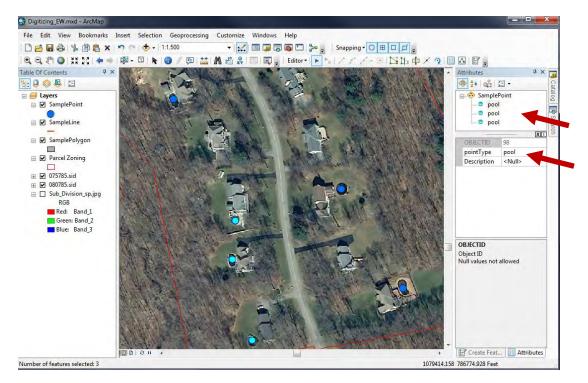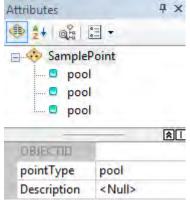
- Select another pool point with the **Edit Tool** ▶ and add the attribute information.

Later, when you save edits, what you add to the attributes here will be saved in the table. **OBJECTID** is light gray, meaning that it can't be edited.

- Next, select multiple pools. Be sure that your mouse is the **Edit Tool** ▶, then drag a box to surround multiple points that are over the roof. Alternatively, while your mouse is the **Edit Tool**, hold down the **SHIFT** key while clicking on several points.

- Next, click on the layer name (the word **SamplePoint**) in the **Attributes** window.

- To the right of the field **pointType** type in *pool*. All of the selected points will now have a **pointType** attribute of *pool*. Clicking on the layer name means that the attribute will change for all selected features below it.
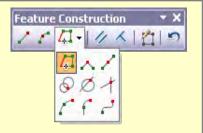
> **TIP**: It is possible to edit the attribute data for each individual point or multiple points by selecting just one feature or several features listed below the layer name (use CTRL-Click to pick more than one). Only those selected will be updated. For additional details on how to edit multiple attributes, search the ESRI help for "**Applying the same attribute values to multiple features in a layer.**"

- When you are satisfied with adding points, save your edits (**Editor** toolbar, **Editor** menu, **Save Edits**), then move on to the next section.

> **The Feature Construction Toolbar**: You will notice while you are editing features there may be a semi-transparent Feature Construction Toolbar floating around near your cursor. This can be annoying at first, but as you begin to understand the functions of the tools it will prove very handy. If you are an advanced user, try some of the tools as you add features in this exercise.
>
> If the floating toolbar covers and area you plan to add a feature, press the TAB key to move it. Or if you don't plan to use it you can close it.

✦ Digitizing Lines

Adding line features requires thinking about the starting point, the vertices along the line, and closing the line feature. In this section you will digitize the centerline of the main road and several driveways. No need to be too precise - this is just to give you a feel for sketching line features with the ArcGIS tools.

- To begin, make sure the **Create Feature** window is open.
  - If it was un-pinned from the right side of the ArcMap interface, you can open it again by clicking on the **Create Feature** tab on the side.

  - If you had the attributes window open, the **Create Features** tab may be at the bottom of that window.

  - If you don't see any tabs, select the **Editor** menu on the **Editor toolbar,** then **Editing Windows, Create Features.**

- Select **SampleLine** from the features list.

- Select **Line** in the **Construction Tools** window and **Straight Segment** on the **Editor** Toolbar.

- Use **Pan** and **Zoom** so that you can see the main rode in the image.

- To create a line segment down the middle of the main road:

  - Start with a **left-click** at or near the beginning of the subdivision on the south side (bottom) of the image. Because snapping is on and the parcel layer is visible, your mouse will likely snap to the parcel boundary which is fine.
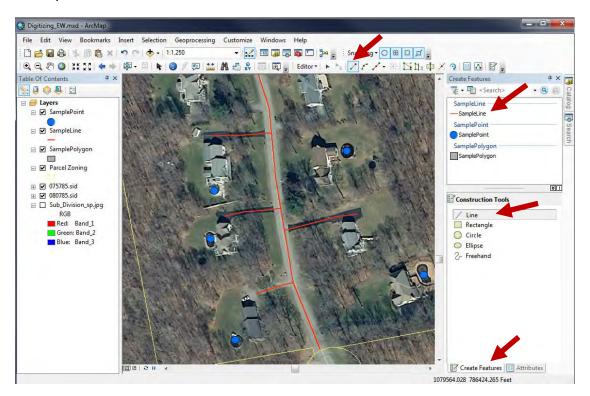
o **Left-click** a few times as you work your way up the center of the road, then **double-left-click** when you reach the middle of the cul-de-sac. A line segment will be drawn down the middle of the road.

- If you place a point in the wrong spot or by accident, right-click and select **Delete Sketch** and create it again.

- **Repeat** this for several driveways. Remember to use the mouse scroll for zooming and panning.

> **TIP:** While digitizing, press and hold the **spacebar** to see how this temporarily disables snapping. This is useful when you want to be close to, but not snap to, an existing feature.

Your map may look something like the image below. In the image, the **Create Features** window is "pinned" to show how the tabs look at the bottom.

- Save your edits by clicking on the **Editor** heading on the **Editor Toolbar** and selecting **Save Edits** from the drop down menu.

Now you will update the attributes for a few of the line segments (just enough to get a feel for it).

- Select your road line segment or segments using the **Edit** tool ▶. Click on the **Attributes** icon 📄 on the **Editor** Toolbar or the **Attributes** tab if it is visible.

- Click on the layer named **SampleLine** in the Attributes window, and then update the **lineType** field by typing *road* or *driveway*.

- Repeat for several lines.

- Save your edits by clicking on the **Editor** menu on the **Editor Toolbar** and selecting **Save Edits** from the drop down menu.

Attributes	
SampleLine	
⬜ 581.095992	
OBJECTID	20
SHAPE_Length	581.095992
lineType	road

> **NOTE**: Notice how the attribute entries for lines apply to the entire segment from the starting to the ending point. This is very useful in certain scenarios. For example, if you were creating a trail network and wanted to have different information about portions of the same trail you could break the line into multiple segments.
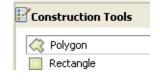
✳ Digitizing Polygons

Polygons require thinking about the start point, the vertices, and an ending point that closes the polygon. For this portion of the exercise, you will digitize house roofs as polygons.

- To start, make sure the **Create Features** window is open, then select **SamplePolygon** from the feature list.

- Zoom in to a level where you can see the roof of a house.

- Select **Polygon** from the **Construction Tools** window and the **Straight Segment** button on the **Editor** Toolbar.

Construction Tools	
Polygon	
Rectangle	

- Start your polygon by left-clicking on a corner of the roof.

- Work your way around the roof by left-clicking at the corners along the way. **Note**: It is a good habit to work in a clockwise direction because of how the software handles geometry behind the scenes.

- When you get to the last building corner just before your starting point, **double-click**. The last segment will be tied, completing the polygon.

- Repeat for several more houses.

⊕ Edit a Vertex

- With your mouse as the **Edit tool** ▶, double-click on a roof polygon OR click on the **Edit Vertices** button on the Editor toolbar.

- The **sketch geometry** is revealed and is evident by the green squares that represent vertices. The **Edit Vertices** toolbar will also be visible.

Move a Vertex

- Place your mouse over a green square (vertex) and notice that the mouse changes to this symbol

    ◈. When this symbol is visible, **left-click** and **drag** the vertex. Do this for several vertices to re-shape the roof.

- The temporary sketch is visible until you **Finish the Sketch**. Click on the **Finish Sketch** button on the **Edit Vertices** toolbar. OR right-click and choose **Finish Sketch** on the menu.

Add a Vertex

There are several ways to add a vertex, but perhaps the easiest is to use the **Edit Vertices** toolbar.

- Be sure you can see the **sketch geometry** (green squares of the polygon) which means the **Edit Vertices** toolbar is visible.

- Click on the **Add Vertex** button.

- Click anywhere on the polygon border to add a vertex. Drag the new vertex to a new location.

- The temporary sketch will be visible until you **Finish the Sketch**. Click on the **Finish Sketch** button on the **Edit Vertices** toolbar.

Delete a Vertex

- Be sure you can see the **sketch geometry** (green squares of the polygon) which means the **Edit Vertices** toolbar is visible.

- Click on the **Delete Vertex** button.

- Click on any vertex to delete it. You can also drag a box which will delete all vertices contained.

- Another way is to mouse-over a vertex until the mouse changes to this . Right-click and select **Delete Vertex** from the menu.

- The temporary sketch will be visible until you **Finish the Sketch**. Click on the **Finish Sketch** button on the **Edit Vertices** toolbar.

- On the **Editor menu** on the **Editor toolbar**, choose **Stop Editing** and save your edits.

Advanced Editing

This section will provide a taste of one editing tool, the Cut tool. It will also demonstrate the advantage of editing when a geodatabase has been prepared with domains and sub-types.

In this section, you will add the new parcels of the subdivision to the town-wide parcels layer. Conceptually, you will be cutting one polygon into pieces.

⊕ Prepare Your Map

- Using **List By Selection** in the **Table of Contents**, make the **ParcelZoning** layer **Selectable.**

- **Turn OFF** (uncheck) the **SamplePoint**, **SampleLine** and **SamplePolygon** layers in the **Table of Contents** so they are not visible.

- **Turn ON** (check) the **Sub_Division_sp.jpg**.

- On the **Effects** toolbar that you added at the beginning, be sure **Sub_Division_sp.jpg** is selected in the drop-down menu and use the **Transparency** icon to change the transparency to about 30.
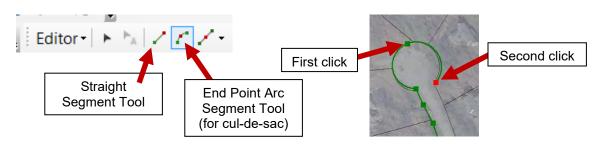
❖ The Cut Polygons Tool

- On the **Editor menu** of the **Editor toolbar**, choose **Start Editing**.

- Choose to edit **Parcel Zoning**.

- Using the **Edit Tool** (from the **Editor** toolbar), select the subdivision polygon.

- Select the **Cut Polygons** tool from the **Editor Toolbar.**

- Use the scroll wheel to **zoom in** so that you can see the road right-of-way polygon (which looks like a lollipop).

- **Left-click** just below and **OUTSIDE** the subdvision polygon where the new road meets the existing cul-de-sac.

- **Continue clicking** along the road right-of-way until you get to the corner of the cul-de-sac. To make a perfect curved line around the feature, click on the **End Point Arc Segment** tool on the Editor toolbar. Next, click **half way across** the cul-de-sac. ArcMap will create a semi-circle path along the arc of the feature. Click again at **the opposite corner** of the cul-de-sac to complete the curve.
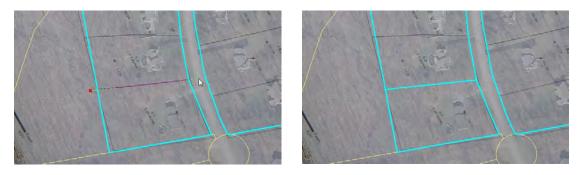
- Before going on, switch back to the **Straight Segment** tool and continue digitizing the roadway using straight lines.

- When you get back to where the road meets the parcel again and double-click **OUTSIDE** of the selected polygon parcel. Notice how the polygons flash and the new polygon has been "cut" out of the bigger one.

- Use the **Cut tool** again to cut along a parcel line. Remember to start AND end outside of the polygon.
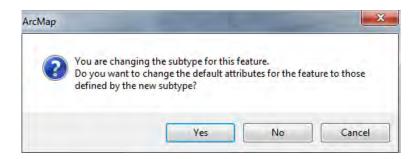
- Repeat a few times.

You will now give attributes to the new parcels. The *zone_code* attribute has been created with sub-types so you can pick from a pre-created list as opposed to typing. This speeds up the process and reduce error.

- Use the **Edit Tool** on the **Editor Toolbar** to select the right-of-way that you first cut (the lollipop).

- Open the **Attributes** window by clicking on the tab at the bottom of the **Create Features** window OR by clicking on the **Attributes** icon on the **Editor** toolbar.

- In the **zone_code** attribute, choose **Right of Way**.

- If this warning appears, select **YES**.

- Select one of the new parcels with the **Edit Tool**.

- Change the **zone_code** to **Residential**.

Isn't it nice to have the choices ready and waiting?

Save

Excellent! Let's save the edits and close the editing session.

- **Save** your edits from the **Editor** toolbar by clicking **Editor > Save Edits**.

- End your **Edit Session** from the **Editor** toolbar by clicking **Editor>Stop Editing**.

- **Save** your ArcMap project.

Extra Credit

- Continue working on your parcel layer by using the cut tool and adding attributes.

- Continue adding pools to the **SamplePoint** layer and roof polygons to the **SamplePolygon** layer.

- **Save** your edits and end your edit session using the **Editor** toolbar.

- **Save** and **Close** your project.

Hurray! This concludes Exercise 5a.

Let's Review!

Congratulations on completing Exercise 5a! This exercise was designed to introduce you to basic desktop editing tools in ArcGIS10.

You learned a number of important concepts were covered including:

- ✓ **The Editor Toolbar:** The Editor toolbar provides basic and advanced tools for adding and updating vector features in an ArcMap session.

- ✓ **Edit Sessions:** During an edit session, you can create or modify vector features or tabular attribute information. When you want to edit, you need to start an edit session. When you are done editing, the edit session must be closed and save or discard any changes to your map features.

- ✓ **Digitizing Points, Lines and Polygons:** Vector data can be created in ArcMap using the edit tools on the Editor toolbar and the Create Features window. Attributes can also be added using the Attributes window accessible from the Editor toolbar.

- ✓ **Cutting a polygon and using subtypes to populate an attribute.** Advanced editing tools can be extremely useful to change, add to or edit existing vector data.

Exercise 5b: ArcToolbox

Exercise 5b is designed to introduce you to some common tools in ArcToolbox including data management tools and spatial analysis tools. Often times the spatial extent of your datasets is either too large for your needs or your area of interest is so large that multiple datasets are needed to cover it. In this exercise you will learn how to clip a dataset to the extent of another and generalize data with the dissolve operation.

Spatial analyses allow us to go beyond asking questions about what something is or creating a subset of data. With spatial overlay analyses, it becomes possible to evaluate the spatial relationships among features in different layers and to create new geospatial data sets based on relationships between and among features. In this exercise you will use a variety of ArcToolbox tools to create some new datasets and perform basic spatial analyses. You will learn how to:

- Open tools using the Geoprocessing menu, Search, ArcToolbox and ArcCatalog
- Clip a dataset
- Use the Dissolve tool
- Create buffers
- Use the Union overlay tool
- Use the Union results with table functions
- Use the Intersect overlay tool

Getting Started: Opening ArcMap
- Open **ArcMap**. For detailed instructions, refer to Exercise 1a.
- Open a New Map.

⊕ Save Your Map

- On the **File** menu, select **Save As** OR click the **Save** icon 💾 .
- Name the file **Exercise5b** and save it in the **Projects** folder.
- Click **Save**.

Exercise Overview
In this exercise, you will use a series of tools to answer the questions:
How much of a subdivision as a whole is covered by wetlands?
How many parcels in the subdivision have wetlands?
What percentage of each parcel in the subdivision is covered by wetlands?
How many parcels are covered with more than 50% wetlands?
How many buildings are partially or fully inside the 100 foot buffer zone?

Often, GIS analyses require a number of steps to get to the desired output and answer the original question. Here, you will take the following steps:
- **Clip** the Marlborough soils data by the subdivision boundary.
- **Dissolve** the soils so that the wetland soils all belong to one class. In Connecticut, wetlands are determined solely by soil type.
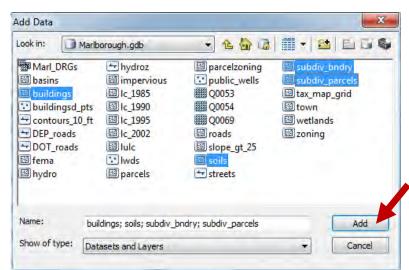
- **Export** the wetland polygons to a new layer. This is one way to get rid of the non-wetland areas.
- **Buffer** the wetlands to create and determine the 100 foot buffer zone.
- Use the **Union** tool with wetlands and parcels in order to determine how much of each parcel is covered by wetlands. This requires several table functions also.
- Use the **Intersect** tool to determine how many buildings are partially or fully inside the 100 foot buffer zone.

⊕ Set up Your Map Document

- Click on the **Add Data** button ✛ on the **Standard Toolbar**. This will open the **Add Data** window.
- Navigate to **C:\GISEd10** and double-click on the **Marlbourough.gdb** geodatabase.
- While holding down the **CTRL** key, click on:
    - **buildings**
    - **soils**
    - **subdiv_bndry**
    - **subdiv_parcels**

  so that all four are selected.
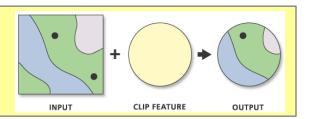
- Click **Add**. All four data layers will be added to the ArcMap Table of Contents and will remain selected (highlighted in blue).

- Click anywhere on the white space in the Table of Contents to unselect the layers.

Basic Geoprocessing Tools

⊕ Using the Clip Tool

CLIP Tool Review: Extract input features that overlay the clip features. Use this tool to cut out a piece of one feature class using one or more features in another feature class as a "cookie cutter."

INPUT   CLIP FEATURE   OUTPUT

The first step in any spatial analysis is to prepare the data. Here, we need to clip the townwide soils by the subdivision boundary.
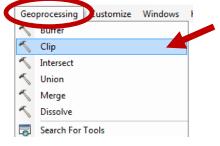
- Click on the **Geoprocessing** menu item from the Main Menu in ArcMap and choose **Clip** from the dropdown list.

- Fill out the **Clip** box as follows:

- Click and **drag** the **soils** layer from the ArcMap **Table of Contents** to the **Input Features** field in the **Clip** dialogue box.

- Click on the small, black down arrow next under **Clip Features** and click on **subdiv_bndry**.

- Click on the folder icon next to **Output Feature Class** and navigate to **C:\GISEd10\Results**. Double-click on the **CT_Results.gbd**. Name the output feature class **subdiv_soils**. Click **Save**.

- Click **OK** to run the **Clip** tool.

TIP: Use the tool **Help** if you unsure about a setting or if the tool is the right one for the job.
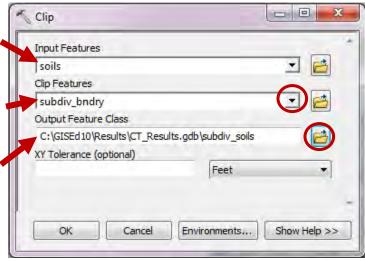
Check the bottom bar of ArcMap to see if the tool is running. Blue text will scroll letting you know that ArcMap is working. Depending on the complexity of the input data and the tool, some processes take a long time to run. Clip...Clip...Clip...Cli 1086979.038 772112.833 Feet

When the tool is finished, a notification will pop up in the corner of your screen. Depending on your settings, ArcMap may also ask if you want the new layer added to ArcMap. Say **Yes**.

- You will see a new layer added to the Table of Contents called **subdiv_soils**. Right-click on the layer name and select **Zoom to Layer**. This will zoom to the full extent of the **subdiv_soils** layer.

- To make your map easier to view, let's change the symbology a bit. In the Table of Contents, change the order of your layers so that the layers are listed in this order from top to bottom: **subdiv_parcels**, **subdiv_bndry**, **buildings**, **subdiv_soils** and finally, **soils**.
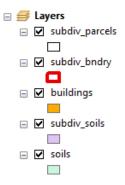
- Change the symbology of the **parcels** layer so that it has a **hollow fill** and a **black thin outline**. Change the **subdivision boundary** layer so that it also has a **hollow** fill with a **red** outline. After you make the changes your map should look like the image to the right. Notice how the new **subdiv_soils** layer contains soils only for the area of the subdivision.
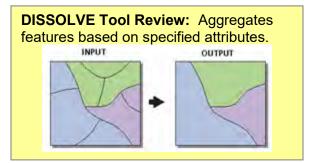
TIP: There are **three ways to add layers to ArcToolbox tools**.
1. **Drag** a layer from the ArcMap **Table of Contents** to the field (such as Input Features below) in the tool dialogue box.
2. Click on the **down arrow** next to the field and choose one of the available layers in your map document.
3. Click the **folder icon** and navigate to the shapefile or feature class that is on your hard drive or network drive. Use this option if the Input layer is not in your ArcMap document.

⊕ Using the Dissolve Tool

The next step is to use the Dissolve tool to aggregate the wetland soils and create a wetland map.

- Right-click over **subdiv_soils** in the **Table of Contents** and **Open Attribute Table**. Scroll through the table and study the attribute fields.

DISSOLVE Tool Review: Aggregates features based on specified attributes.

To create a layer where all wetland soils are grouped, which attribute would you use? Why?
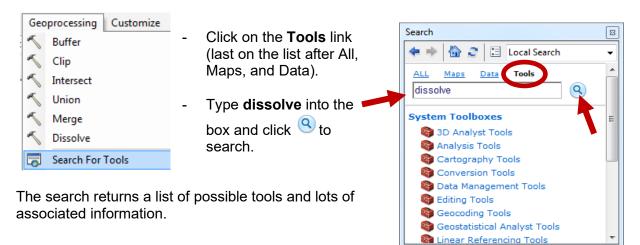
The **HYDRIC** field is the right choice because it only has two values: **No** and **Yes**. Although **CTWET** may be tempting, it includes two classes for wetlands (1. Poorly drained and very poorly drained soils and 2. Alluvial and floodplain soils) so the output would have two wetland classes instead of the desired one wetland class.
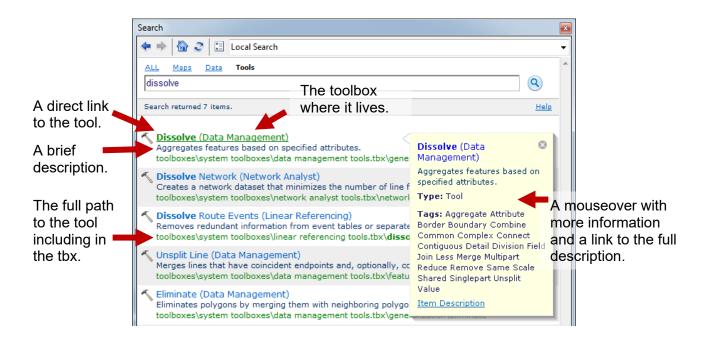
- Close the **Attribute** table.

✹ Search for ArcToolbox Tools

- From the **Geoprocessing** Main Menu, choose **Search for Tools**. Search is useful when you can't remember which category and toolbox a particular tool belongs to.

- Click on the **Tools** link (last on the list after All, Maps, and Data).

- Type **dissolve** into the box and click 🔍 to search.

The search returns a list of possible tools and lots of associated information.

A direct link to the tool.

A brief description.

The full path to the tool including in the tbx.

The toolbox where it lives.

A mouseover with more information and a link to the full description.

- Take a minute to explore the search results.

✵ The Dissolve Tool Interface

- In the Search window, click on the first item **Dissolve (Data Management).**

Setup the Dissolve window as follows:

- Set the **Input Features** to **subdiv_soils**.

- Save the **Output Feature Class** in **C:\GISEd10\Results** in the **CT_results.gdb** called **subdiv_hydric**.

- Choose **HYDRIC** as the **Dissolve Field(s).** You may need to expand the Dissolve window to see all of the tool settings.

- Under **Statistics Field(s)** click the small black arrow and choose the **ACREAGE** attribute.

- **ACREAGE** is added to the box below and a red x appears indicating that something more is needed.

    ❌ Statistics Field(s)

- Click the box to the right of **ACREAGE** and below **Statistic Type** and select **SUM**. See the Tip box below.

- Check to **Create multipart features**.

- Click **OK** to run the **Dissolve** tool.

TIP: The optional **Statistics Field(s)** for the **Dissolve** tool provides the choices of which field(s) and statistic(s) can be summarized with a dissolve. Text attribute fields may be summarized using FIRST or LAST. Numeric attribute fields may be summarized using any statistic.

FIRST - Finds the first record in the Input Features and adds its value.
LAST - Finds the last record in the Input Features and adds its value.
SUM - Adds the total value for the specified field.
MEAN - Calculates the average for the specified field.
MIN - Finds the smallest value for all records of the specified field.
MAX - Finds the largest value for all records of the specified field.
RANGE - Finds the range of values (MAX–MIN) for the specified field.
STD - Finds the standard deviation on values in the specified field.
COUNT - Finds the number of values included in statistical calculations. This counts each value except null values.

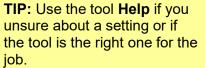Look for the blue text indicating that ArcMap is working. Depending on the complexity of the input data and the tool, some processes take a long time to run.

olve...Dissolve...Dis 🌐 1081648.536 808640.663 Feet

> **TIP:** Use the tool **Help** if you unsure about a setting or if the tool is the right one for the job.

Look for the notification telling you that the operation is finished. Depending on your settings, ArcMap may also ask if you want the new layer added to ArcMap. Say **Yes**.

✓ Dissolve ✕

- Take a look at your new **subdiv_hydric** layer. You should notice there are two unique classes in the layer that represent hydric or non-hydric soils. You can change the layer's symbology if you would like so you can visualize the two classes. You will also want to drag the new layer down below the buildings layer in the Table of Contents.

*How is the **subdiv_soils** layer different from the **subdiv_hydric** layer?*

We are after a layer of only wetlands. What do we have to do next?

⊛ Export a Subset of a Data Layer

The next step is to remove all non-wetland soils so we are left with a layer of just wetlands. The easiest way is to select all the wetland areas and export them as a new feature class or shapefile.

- **Select** all wetland areas. See the review box below for methods for selecting features. You may find it helpful to turn off all layers except **subdiv_hydric** before making your selection.

> **REVIEW:** There are many ways to select. Here are a few.
>
> - **Select tool**.
> - **Selection** menu > **Select By Attributes**.
> - **Attribute Table** > **highlight** by clicking on the records (use shift or control keys)
> - **Attribute Table** > **Select By Attributes**

How do you know that this is a multipart layer? What would be different if this was a single part layer?
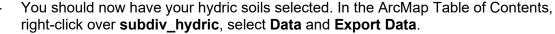
REVIEW: *How do you change a multipart layer to a single part layer? Or a single part layer to a multipart layer?*
In ArcToolbox, **Data Management Tools**, **Features**, there is a **Multipart to Singlepart** tool. To create a multipart layer from a singlepart layer, simply run the **Dissolve** tool but don't dissolve by anything. Be sure **Create multipart features** is checked.

- You should now have your hydric soils selected. In the ArcMap Table of Contents, right-click over **subdiv_hydric**, select **Data** and **Export Data**.
- Fill out the **Export Data** box. Be sure to choose **Selected Features**. Save the file in **C:\GISEd10\Results** in the **CT_Results.gdb** called **subdiv_wetlands**.
- Click **OK**.

- Say **Yes** if ArcMap asks if you want to add the exported layer to your map.
- Turn off the **subdiv_hydric** layer in the **Table of Contents**. Turn the **subdiv_bndry** layer back on so you can see the boundary of the subdivision and the wetland areas within it. Also, take a minute to **Save** your project.

Your wetlands layer should look something like this. If it doesn't, ask an instructor for help.
Optional: symbolize the wetlands in your map.

TIP of CAUTION: ALWAYS evaluate the output of any spatial analysis. Does it make sense? Is it what you expected? Did I use the right tool with the right inputs and settings?

ANAYSIS QUESTION: *How much of the subdivision is covered by wetlands?*

SOLUTION: *How much of the subdivision is covered by wetlands?*
Use the attribute table to determine the area of the single wetland polygon (because it is a multipart polygon). Open the **attribute table**. You may be tempted to use the **SUM_ACREAGE** field but this would be incorrect. If you trace back the SUM_ACREAGE field, you will find that it was a sum of the acreage of the wetland polygons BEFORE they were clipped. Remember, attributes are not recalculated or changed even if the polygons change (with the exception of **Shape_Area** and **Shape_Length** fields which are maintained if the data is in a geodatabase).
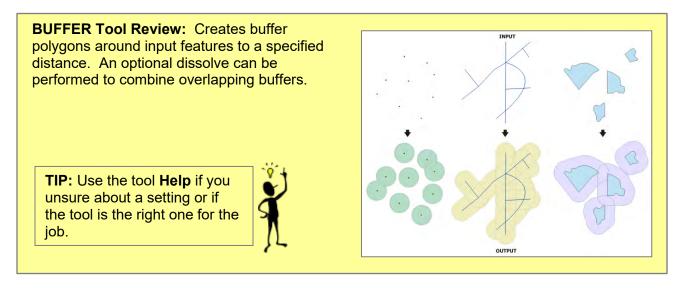
Area needs to be calculated. There are two ways to do this:
1) Add a new **float** field to the table and use **Calculate Geometry** to calculate area in acres.
2) Use the **Shape_Area** field to calculate area in acres. Recall that the **Shape_Area** field is updated because the data is a feature class inside a geodatabase. The **Shape_Area** field uses the unit of the projection of the feature class – in this case, feet. To calculate acres from feet, divide the area in feet by 43,560.

More Advanced Geoprocessing Tools

✸ The Buffer Tool

In this step you will buffer the new wetlands layer to create a buffer zone around the features. This area will represent a wetland review area.

BUFFER Tool Review: Creates buffer polygons around input features to a specified distance. An optional dissolve can be performed to combine overlapping buffers.

TIP: Use the tool **Help** if you unsure about a setting or if the tool is the right one for the job.
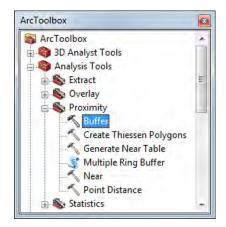
The next step is to buffer the wetlands by 100ft to create polygons of the buffer zones.

-   Open **ArcToolbox** by clicking on the **ArcToolbox icon** on the **Standard** Toolbar.

- Locate the **Analysis Tools** toolbox and click the ⊞ to expand it.
- Locate the **Proximity** toolset and click the plus to expand it.
- Double-click on **Buffer** to open the tool.

REMEMBER: ArcToolbox with an ArcInfo license has many more tools than ArcToolbox with an ArcView License.
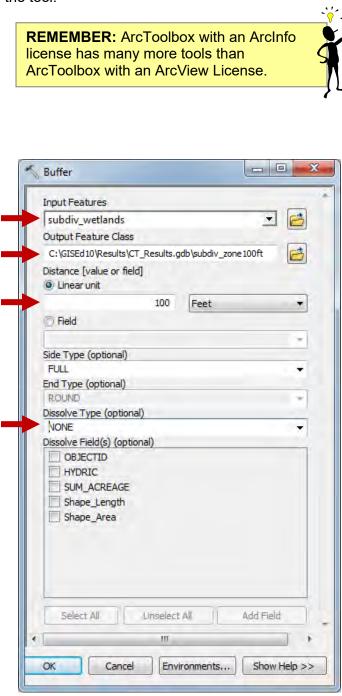
Fill out the **Buffer** box as follows:

- The **Input Features** should be **subdiv_wetlands**.

- Save the **Output Feature Class** in the **CT_Results.gdb** and call it **subdiv_zone100ft**.

- Use a **Linear unit** of **100 Feet**.

Because none of our buffer areas will overlap, it is not necessary to set a dissolve type. However, in the case that they did overlap, we would likely use dissolve.

- Click **OK**. Your subdiv_some100ft buffer layer should look like the graphic below.

TIP of CAUTION: ALWAYS evaluate the output of any spatial analysis. Does it make sense? Is it what you expected? Did I use the right tool with the right inputs and settings?

CLEAR
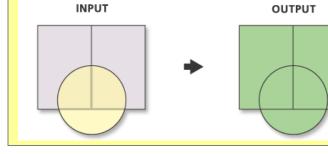
✧ The Union Tool

- In this step you will union the wetland areas and the parcels. First, get your layers in order and set symbology. The parcel layer (**subdiv_parcels**) should be on top and should be drawn using only outlines (no fill). The next layer should be **subdiv_wetlands** with **subdiv_zone100ft** under that.

UNION Tool Review: Computes a geometric intersection of the Input Features. All features will be written to the Output Feature Class. All features will be "burned" together.
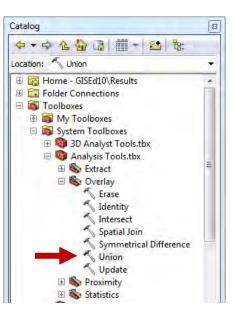
TIP: Use the tool **Help** if you unsure about a setting or if the tool is the right one for the job.

- Open **ArcCatalog** by clicking on the **Catalog Window** icon on the **Standard** Toolbar.

- In ArcCatalog, scroll down and open:
  - o the **Toolboxes** folder
  - o **System Toolboxes**
  - o **Analysis Tools.tbx** toolbox
  - o **Overlay** toolset

- Double-click on **Union** to open the tool.
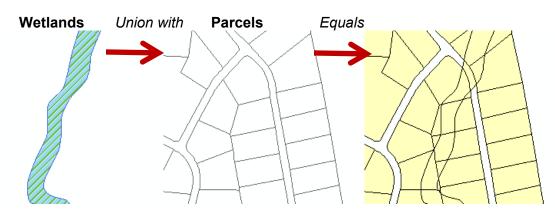
- Add **subdiv_parcels** to **Input Features** by either dragging and dropping from the ArcMap TOC or selecting it from the drop-down menu. The layer, **subdiv_parcels**, should be added to the list of **Features** that will be used in the Union.

- Add **subdiv_wetlands** to **Input Features** by either dragging and dropping for the ArcMap TOC or selecting it from the drop-down menu. It should be added to the list of **Features**.

- In the **Output Feature Class**, use the folder icon to navigate to **C:\GISEd10\Results** and double-click on **CT_Results.gbd.** Name the layer **union_parcels_wetlands.**

- Choose to **Join ALL Attributes.** This means that attributes from both the **subdiv_parcels** layer and the **subdiv_wetlands** layer will be present in the newly created attribute table for **union_parcels_wetlands**.

- Click **OK**.

- Look for the blue ticking text indicating that ArcMap is working. You know it is finished when the notification shows in the corner of your screen. on...Union...Union...

- Take a minute to explore **union_parcels_wetlands**. Use the **Identify** tool to explore how the wetland boundaries are "burned" into the parcel boundaries.

Wetlands   *Union with*   **Parcels**   *Equals*

ANAYSIS QUESTION: *How many parcels have wetlands?*

SOLUTION: *How many parcels have any wetlands?*
Open the Attribute table and select any records (parcel or parcel piece) where hydric=yes. At the bottom of the table, notice how many records are selected.

⊕ Analyzing the Results
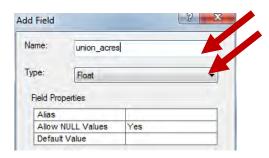
Next you will use the **Attribute Table** of the **Union** results to answer questions.

Which parcels have what percent covered by wetlands?
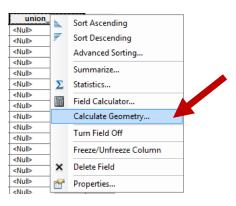
- In the ArcMap TOC, right-click over **union_parcels_wetlands** and **Open Attribute Table**. Notice that the table contains fields from parcels (PARCEL_ID, MAP, BLOCK, LOT, STREET_ADD, acres_parcel, etc.) and fields from soils (HYDRIC, SUM_ACREAGE, etc.).

The **acres_parc** field contains parcel area before the union. Now you need area of the parcel pieces after the union so you can create a percentage.

- In the table, click on the **Table Options** menu and choose **Add Field**.
- Name the field **union_acres** and choose **Float** for the type.
- Click **OK** to add the field.

- Right-click over the new **union_acres** field and select **Calculate Geometry**.

- If a warning pops up about calculating outside of an edit session, click **Yes**.

- Choose **Property: Area** and **Units: Acres US [ac]**. Click **OK**.

Now it is time to create a percentage ONLY for parts of parcels that are wetland.

- On the **Table Options** menu, choose to **Add Field**.
- Name the field **wetlandsPC** with **Type: Float**.

So that the percentage calculation is only performed on areas with wetlands, it is necessary to first select polygons where HYDRIC=Yes.

- Select polygons where **HYDRIC=YES**. You could use the **Select by Attributes** dialogue as shown. Or you could sort the **HYDRIC** field and select the records by highlighting.

- With the records selected, right-click over the **wetlandsPC** field and select **Field Calculator**.
    - o In the **Fields:** box, double-click on **union_acres**.
    - o Click the **/** button.
    - o In the **Fields:** box, double-click **acres_parc**.
- Click **OK**. Scroll to the selected records to see the updated calculations.

ANAYSIS QUESTION: *Which parcels have what percent covered by wetlands?*

Don't bother actually writing out the answers, but can you find the answers?

SOLUTION: *Which parcels have what percent covered by wetlands?*
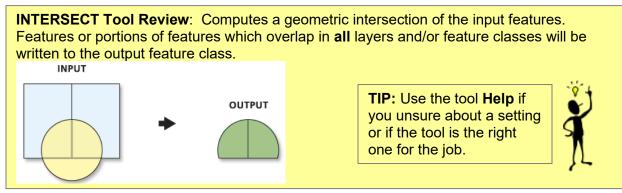
Look at the **wetlandsPC** attribute in the table.

ANAYSIS QUESTION: *How many parcels have more than 50% wetlands?*

SOLUTION: *How many parcels have more than 50% wetlands?*
Open the Attribute table and sort the **wetlandsPC** field. Count how many records are 0.5 or

> SELECT * FROM union_parcels_wetlands WHERE:
> "wetlandsPC" >.5

greater. Or, do a **Select by Attributes**   .

⊛ The Intersect Tool

> **INTERSECT Tool Review**: Computes a geometric intersection of the input features. Features or portions of features which overlap in **all** layers and/or feature classes will be written to the output feature class.
>
> INPUT
>
> OUTPUT
>
> **TIP:** Use the tool **Help** if you unsure about a setting or if the tool is the right one for the job.

How many buildings are partially or fully inside the 100 foot buffer zone?

- Clear any selected features on your map. You can do this with the **Clear Selection** tool on the **Tools** Toolbar.

- Open the **Intersect** tool. Use the **Geoprocessing menu** shortcut or **Search for Tools** on the Geoprocessing menu, or navigate to **Anaysis Tools** > **Overlay** in **ArcToolbox** or **ArcCatalog**.

- Add **buildings** to the **Input Features**. It should appear on the **Features** list.

- Add **subdiv_zone100ft** to the **Input Features**. It should appear on the **Features** list.

- Save the layer in the **CT_Results.gdb** called **buildings_in100zone**. Click **OK**.

ANAYSIS QUESTION: *How many buildings are in the 100 foot wetland buffer zone?*

SOLUTION: *How many buildings are in the 100 foot wetland buffer zone?*
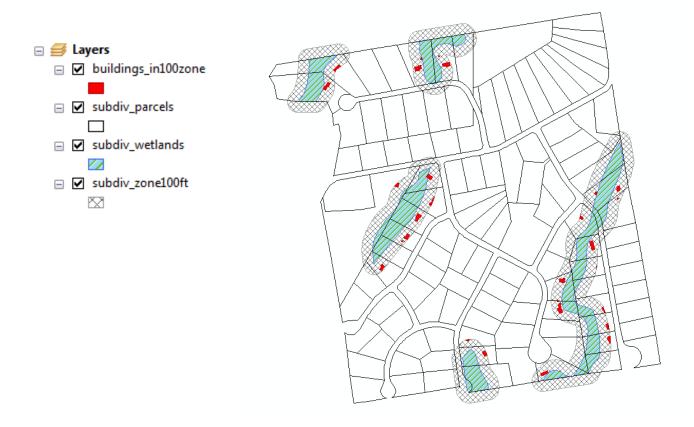
Open the Attribute table and determine how many records are in the table.

Save Your Work!

✵ Save Your Map Project (.mxd)

Any time you make a significant change to your Map Document, you should save it. Unfortunately, ArcMap does not "auto save" and while it has improved greatly over previous releases of the software, it has been known to crash without warning. So, you'd be wise to follow the mantra "save early and often" when working on important projects!

- To save the changes you have made, click on **File** on the **Main Menu** and select **Save** from the menu that appears. Name it **Exercise5b.mxd** and be sure to save it in the **Projects** folder.

Let's Review!

Congratulations on completing Exercise 5b! This exercise was designed to introduce you to basic geoprocessing tools in ArcGIS.

In this exercise you learned two more methods for making your datasets more manageable. You already know about some methods, such as **Definition Queries** and **Layer files**.
- **Dissolve**: Aggregates features in a layer based on specified attributes.
- **Clip**: Extracts input features that overlay the designated clip features. Use the clip tool when you want to cut out a piece of one layer using one or more features in another layer as a "cookie cutter." This is useful for creating geographic subsets of features when your area of interest is much smaller than the extent of the source data.

You also explored many of the spatial analysis tools that are available with the ArcView license. The tools can be used alone or in combination with one another to produce a wide variety of new datasets. Creatively combining the results of these tools with selection sets based on attributes and/or locations can produce all sorts of powerful analyses. Experiment, test out ideas, think about how you might string together a series of analyses to produce some results that are not directly available. Remember, every time you run an analysis and produce new data, you can further analyze it using other tools you have learned – **Statistics**, **Summarize**, **Select by Attribute or Location**, **Export** data, **Calculate Geometry**, etc.

To summarize, this exercise introduced you to the following spatial analysis functions:

- **Buffer**: Use Buffer to create areas of interest surrounding points, line or polygons. The output can then be used in a **Clip**, a **Union** or an **Intersect** to help evaluate other layers of data. A good example would be to create a buffer around a stream and then use it to clip land cover and assess possible land cover impacts with the riparian zone and their potential impacts on water quality.

- **Union**: Use Union when you want to combine two or more polygon layers. Remember that it combines geographic features by calculating where polygon edges intersect each other and then building new polygons. All attributes from the input layers are combined. Area fields MUST be updated using the **Calculate Geometry**.

- **Intersect**: Use Intersect to overlay two polygon layers and preserve only areas common to both. This tool combines geographic features by calculating where polygon edges intersect each other and then building new polygons for the overlapping areas. All attributes from the input layers are combined. Area fields MUST be updated using the **Calculate Geometry**. Intersect can also overlay a polygon layer with point or line layers.

This concludes Exercise 5b.

If you have finished and the class is still working on the exercise, move on to the extra credit below.

Extra Credit

Be sure your **Exercise5b.mxd** is still open. If not, open it.

Pick one or more of the following:

Use Tools and Spatial Analysis to Answer a Question

➢   *How much of the subdivision is covered by the 100ft review zone?*
Hint: Clip the review zone (**subdiv_zone100ft**) by the subdivision boundary (**subdiv_bndry**).
Calculate area in the table.

➢   *How many parcels would be touched by the 100ft review zone?*
Hint: Use **Select By Location**. Select Features from the subdivision parcels (**subdiv_parcels**)
that intersect the review zone (**subdiv_zone100ft**).

➢   *What is another way to determine how many buildings are inside the buffer zone?* Try it.
Hint: **Select By Location**.

Do a Spatial Join

Pick a point layer (such as **APAWELLS** or **buildings**) and a polygon layer (such as **surficial
materials** or **land use**). Right-click over one of the layers in the TOC and choose **Join**. In the
Join box, under **What do you want to join to this layer?** choose the second choice – **Join
data from another layer based on spatial location**. Fill out the **Join Data** box (read the
choices) and review the output.

Make a Map

Make a map of the **impact of the 100ft review zone
on the subdivision**. Think about what layers may
help show the impact. Consider adding and
symbolizing the wetland areas, the review zone area,
buildings inside the review zone.

It may be necessary to show parcels colored based
on the percent wetland. Here are the suggested
steps. Select from **union_parcels_wetlands** where
hyrdric=yes or **wetlandPC>0**. Export to a new file.
Join the new file to **subdiv_parcels** based on the
parcel ID attribute. Symbolize the **wetlandsPC**
field. Because all parcels without wetlands are null,
they will not draw in this scenario. **Copy** the
subdiv_parcels layer (right-click over it in the TOC
and select **Copy**). On the **Edit** menu, choose **Paste**.
Drag the copy below the original **subdiv_parcels**.
Although two separate copies, they will appear to be
the same file.

Exercise 5b Answers

*How is the **subdiv_soils** layer different from the **subdiv_hydric** layer?*

The soils layer had many more polygons and classes. The hydric layer contains only two types of soil polygons – hydric and non-hydric.

We are after a layer of only wetlands. What do we have to do next?

At this point, the **soils_hydric** layer contains both wetlands AND non-wetland areas. The next step is to get rid of the non-wetland areas. We suggest selecting the wetland areas and then exporting them as a new file.

How do you know that this is a multipart layer? What would be different if this was a single part layer?

You know it is a multipart layer because there is only one record to select. This is true whether you use the select tool or the table. If this was a single part layer, there would be five or so records in the table and the select tool would require clicking on each polygon.

ANAYSIS QUESTION: *How much of the subdivision is covered by wetlands?*

ANAYSIS QUESTION: *How many parcels have wetlands?*

(31 out of 148 Selected)

ANAYSIS QUESTION: *How many parcels have more than 50% wetlands?*

ANAYSIS QUESTION: *How many buildings are in the 100 foot wetland buffer zone?*

Table — buildings_in100zone

OBJECTID*	Shape*	FID_buildings	AREA	PERIMETER	BUILDINGS_	BUILDINGS1	BLDGTY
1	Polygon	7	165.953	51.53	8	2973	
2	Polygon	8	45.156	26.922	9	2974	
3	Polygon	9	103.781	42.065	10	2975	
4	Polygon	10	2212.566	211.318	11	2976	
5	Polygon	11	4989.445	313.499	12	2977	
6	Polygon	13	2350.797	217.297	14	2979	

(0 out of 29 selected)

Extra Credit: *How much of the subdivision is covered by the 100ft review zone?*

Table — zone100_subdivbndry

acres	BUFF_DIST	Shape_Length	Shape_Area	acres_1
14.063692	100	14361.10807	1692634.082468	38.857533

(0 out of 1 Selected)

Extra Credit: *How many parcels would be touched by the 100ft review zone? Select by Location*

(47 out of 117 Selected)

Extra Credit: *What is another way to determine how many buildings are inside review zone?*
Select By Location. Right-click over one of the layers in the TOC and choose **Join**. In the **Join** box, under **What do you want to join to this layer?** choose the second choice – **Join data from another layer based on spatial location**. Fill out the Join Data box (read the choices) and review the output.

This method selects the entire building. Using intersect will cut the building in two if the buildings falls on the line. Sometimes this is beneficial, sometimes not.

Reference Exercise 6a: Mad About Metadata

Metadata, or data about data, is a critically important component of digital geospatial datasets. It helps document datasets, describe their history, quality and content and increasingly will be used by organizations to find datasets based on keywords and geographic coverage.

ArcGIS has a number of tools to create, edit, import and use metadata which are accessed through ArcCatalog.

In this exercise, you will use ArcCatalog to look at some examples of metadata and you'll create some metadata for a USGS streamflow gages point layer.
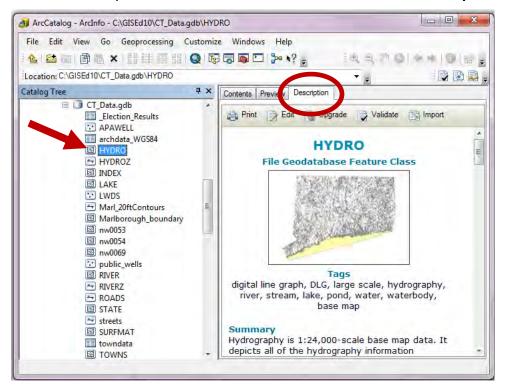
Getting Started: Metadata in ArcCatalog

- Open **ArcCatalog**.

✦ Explore Existing Metadata
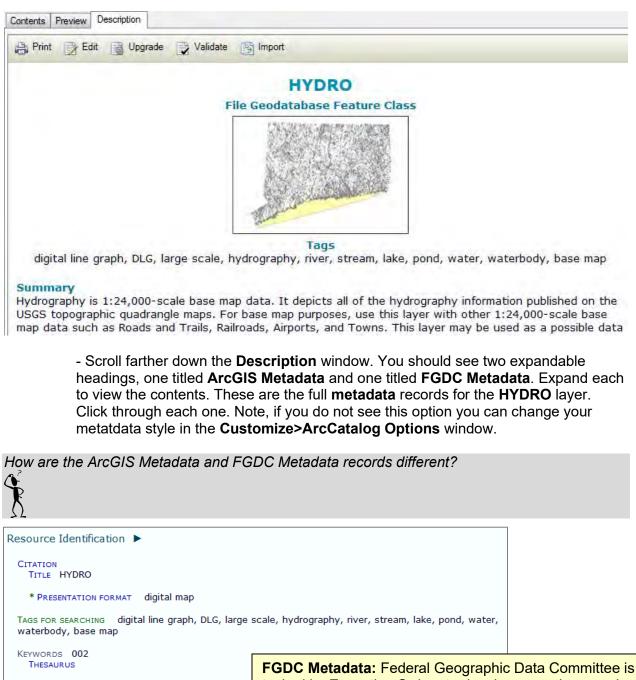
In this step you will look at several datasets with varying amounts of metadata. Some will have just the basic metadata that ArcGIS creates automatically while the others will have extensive metadata created by the CT Department of Environmental Protection.

- In ArcCatalog, expand the connection to the folder **C:\GISEd10\CT_Data.gdb** in the **Catalog Tree**.

- Click on the shapefile **HYDRO** feature class and then click the **Description** tab.

- A data description for **HYDRO** will be displayed in the window beneath the **Description** tab.

- Take a minute to skim through the information provided in the **Summary, Description, Credits** and **Access and use limitations**.

| Contents | Preview | Description |

Print Edit Upgrade Validate Import

HYDRO
File Geodatabase Feature Class

Tags

digital line graph, DLG, large scale, hydrography, river, stream, lake, pond, water, waterbody, base map

Summary

Hydrography is 1:24,000-scale base map data. It depicts all of the hydrography information published on the USGS topographic quadrangle maps. For base map purposes, use this layer with other 1:24,000-scale base map data such as Roads and Trails, Railroads, Airports, and Towns. This layer may be used as a possible data

- Scroll farther down the **Description** window. You should see two expandable headings, one titled **ArcGIS Metadata** and one titled **FGDC Metadata**. Expand each to view the contents. These are the full **metadata** records for the **HYDRO** layer. Click through each one. Note, if you do not see this option you can change your metatdata style in the **Customize>ArcCatalog Options** window.

How are the ArcGIS Metadata and FGDC Metadata records different?

Resource Identification ▶

CITATION
   TITLE HYDRO

   * PRESENTATION FORMAT   digital map

TAGS FOR SEARCHING   digital line graph, DLG, large scale, hydrography, river, stream, lake, pond, water, waterbody, base map

KEYWORDS   002
   THESAURUS

ABSTRACT (DESCRIPTION)
   Hydrography Polygon includes the polygon fea
   is a 1:24,000-scale, polygon and line feature-l
   depicted on the U.S. Geological Survey (USGS
   State of Connecticut. This layer only includes

FGDC Metadata: Federal Geographic Data Committee is tasked by Executive Orders to develop procedures and assist in the implementation of a distributed discovery mechanism for national digital geospatial data. They are also responsible for creating a content standard for metadata. A fully compliant FGDC metadata record must meet all of the criteria established in these standards.

⊕ **No Metadata?**

- In the **Catalog Tree**, locate the **USGSGAGES** feature class in the **C:\GISEd10\CT_Data.gdb**. Click on the feature class in the **Catalog Tree** and view its description and metadata from the **Description** tab.

Does the USGSGAGE feature class have metadata? Can you think of a scenario where it could be a problem that a dataset is missing metadata?

Editing Metadata

The metadata that ArcGIS automatically creates is valuable information that will help you make effective use of various geospatial datasets. However, it is important that whenever possible you create complete metadata for the geospatial datasets that you create. This is especially true for "core" or "framework" datasets created by or for your organization and to a lesser degree for derived datasets generated as part of a project. In this step you will explore editing metadata for the **USGSGAGES** feature class.

ArcCatalog includes several metadata style options. These determine how the metatdata is viewed, exported and validated and which page appears when editing metadata. When you edit metadata, ArcCatalog uses the metadata style that is specified in **ArcCatalog Options**.

⊕ **Metadata Style Options**

- To specify a metadata style, click on the **Customize** drop-down menu and select **ArcCatalog Options…**

- Click on the **Metadata** tab and take a minute to review the contents of the page.

- Click on the down arrow under **Metadata Style** and view the options available. Make sure the **Style** is set to **FGDC CSDGM Metadata**.

- Under **Metadata Updates**, make sure the box is checked next to **Automatically update when metadata is viewed.**

- Click **OK** to close **the ArcCatalog Options** window.

✸ Editing Metadata

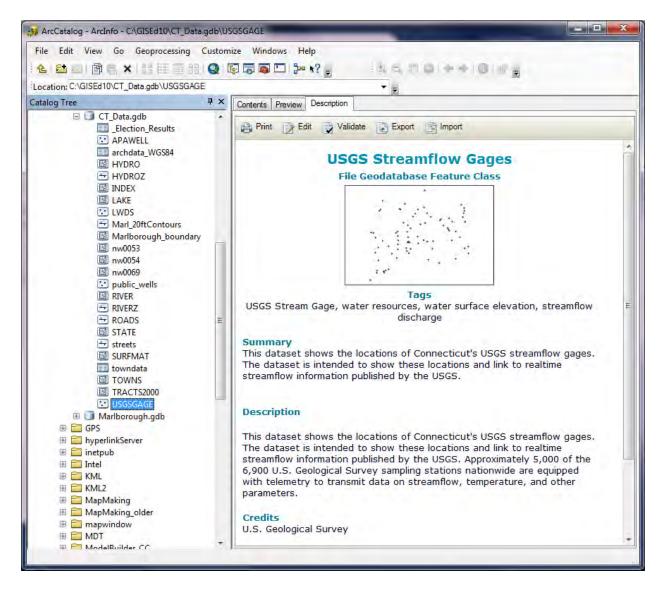- Under the **Description** tab, click on the **Edit** button.

- The editor will open in the **Description** tab. For the purposes of this exercise, you will only fill out a few of the fields required for a fully compliant metadata record. If this was a "real world" dataset, you would want to create a complete metadata record.

- Under **Item Description**, add text to the **Title, Tags, Summary, Description, Credits** and **Use Limitations** fields. Because this is only an exercise to show you how to create metadata, it doesn't matter what you type in. Make it up, be creative, have fun. If you need guidance, use the text shown below.

  - **Title:** USGS Streamflow Gages
  - **Tags:** USGS Stream Gage, water resources, water surface elevation, streamflow discharge
  - **Summary:** This dataset shows the locations of Connecticut's USGS streamflow gages. The dataset is intended to show these locations and link to realtime streamflow information published by the USGS.
  - **Description:** This dataset shows the locations of Connecticut's USGS streamflow gages. The dataset is intended to show these locations and link to realtime streamflow information published by the USGS. Approximately 5,000 of the 6,900 U.S. Geological Survey sampling stations nationwide are equipped with telemetry to transmit data on streamflow, temperature, and other parameters.
  - **Credits:** U.S. Geological Survey

- Click through some of the other headings under **Overview, Metadata** and **Resource**. Take a minute to read through these and take note of some of the additional metadata topics that you would need to include in a fully compliant metadata record. If you have the time or inclination, add some additional content to the metadata.

- When you are done, click the **Save** button under the **Description** heading to save your updates.

- OK – now you have the idea of what's involved in creating metadata. And now you probably have a good idea why it's everyone's least favorite thing to do!

- Once you save your metadata, you should see your changes reflected in the metadata for the **USGSGAGE** feature class. Take a minute to check out the updates.

- Congratulations! You have successfully created your first metadata record!

Let's Review!

Metadata is an integral component of GIS data which includes spatial, attribute and metadata. It shouldn't be something that gets created only when time permits. Such an attitude results in metadata not being created and that important information ultimately gets "lost."

In the exercise you worked in ArcCatalog and:

- ✓ Explored some examples of complete metadata produced by the Connecticut Department of Environmental Protection to document the DEP's framework datasets.
- ✓ Learned what an incomplete metadata record looked like in ArcCatalog.
- ✓ Created partial metadata for the USGS feature class using the Metadata Editor

Exercise Answers

How are the ArcGIS Metadata and FGDC Metadata records different?

The ESRI metadata includes ArcGIS specific information such as thumbnails, geoprocessing history and enclosures and as a general observation is easier to read.

Does the USGSGAGE feature class have metadata? Can you think of a scenario where it could be a problem that a dataset is missing metadata?

No. the USGSGAGE feature class does not have any metadata. This could be a problem because a user doesn't know key information about the dataset including who created it and when, how it was created and what standards were used and who to contact for questions.

This concludes this Exercise.

Lightning Round: Getting Coordinate Data into ArcMap

In this exercise, you will create a point layer by having ArcMap "read" X,Y coordinate locations directly from a text file. For the exercise you will use a fictitious database of archaeological sites discovered in Marlborough. The data points are stored in a geographic coordinate system (degrees of longitude and latitude), similar to how a handheld GPS receiver records data.

This type of data creation is particularly valuable if you have coordinate data in an electronic format from a GPS or an existing database. The technique, albeit more laborious, also can be used to "import" data from maps, surveys, reports and files that are not in an electronic format. In this case, the coordinates would first have to be determined, recorded in a file or database and then entered into ArcMap.

Getting Started: Opening ArcMap
- Open **ArcMap**. For detailed instructions, refer to Exercise 1a.
- Open a **New Map**.

⊛ Add Data
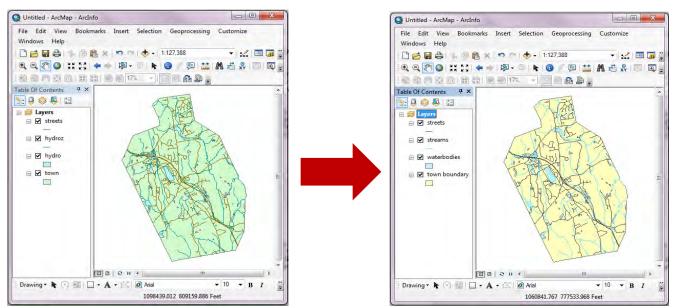
Click the **Add Data** button on the **Standard Toolbar** and navigate to the **C:\GISEd10\Marlborough.gdb** and add the following data layers: **streets**, **hydro**, **hydroz** and **town**.

⊕ Symbolize Your Data

If you care to, change the symbology and names for the data layers to something more appropriate.

⊕ XY Data Formats

ArcMap can read XY coordinate data from a variety of formats. If you have data in a dBase® file you can add it as a table to ArcMap. In ArcGIS 9.2 and higher, you can add and use Microsoft Excel files in their .xls format – however you cannot edit data in these files, therefore it may make sense to save your Excel documents as a dBase® file before working with it in ArcMap. Comma separated text files also can be used by ArcMap which is what you will use in the next step. (Note: Text files can use symbols other than commas as the separation character, search the Help Index for "delimited text files" to learn about this.)

- To examine the native comma separated text file format, let's first look at the file outside of ArcMap. Right-click on the **Windows Start** button on the toolbar in the bottom left-hand corner of your computer and click **Explore** (or **Computer** on newer operating systems).

- In the **Explore** window, navigate to your **C:** drive and find your **C:\GISEd10\Tables** folder. You should see a file in the folder titled **archdata_WGS84.txt.** Double click on it to open.

- The file will open in **Notepad**. Notice that the first line the file includes four text items. These will become the field names when the textfile is added to ArcMap. The remaining lines each contain four items separated by commas. These will become the data values in ArcMap.

- Close **Notepad**. If you are interested, you can also preview the text file in ArcCatalog. The information in the text file will be displayed on the **Preview** tab in an organized table format.

⊕ Add the XY Table to ArcMap

- In ArcMap, click on the **File** drop-down menu and hover your mouse over **Add Data**. From the **Add Data** menu, select **Add XY Data**.

- The Add XY Data window will open allowing you to enter parameters to instruct ArcMap where to find and how to use XY coordinates sotred in a table in the map or on disk.

- Click the open folder button next to the field named **Choose a table from the map or browse for another table:** and navigate to **C:\GISEd10\Tables**. Double click on the file **archdata_WGS84.txt**

- ArcMap will automatically add **Long** and **Lat** to the **X** and **Y Fields**. It is "smart" enough to recognized the X and Y in the field name and since these are numeric fields, it automatically plugs them in.

The last step is to specify the coordinate system that the data are in. These data are in geographic coordinates of longitude and latitude. You will have to tell ArcMap what coordinate system definition to assign to the dataset. The coordinate system definition for longitude, latitude is WGS84 (World Geodetic System, 1984).

- Click the **Edit…** button to open the **Spatial Reference Properties** form and click the **Select…** button.

- In the **Spatial Reference Properties window,** click the small search icon .

- In the folder below, expand the **Geographic Coordinate Systems**. Scroll to the bottom of the list and double click on the folder next to **World**.

- Finally, scroll to the end of the list of coordinate systems in the **World** folder and select **WGS 1984.prj.** Click **Add.**

- Click **OK in the Spatial Reference Properties** window.

- The **Add XY Data** window should look like the one below. Click **OK**.

- After you click **OK**, you should see a message window pop up telling you the table does not have an **Object-ID** field. <u>Read</u> the message and click **OK** to continue.

- A new layer should be added to your **Table of Contents** titled **archdata_WGS84.txt Events**. This is an **Event Layer**. Take a minute to explore it. Notice that you can turn
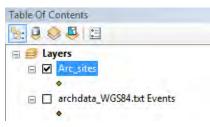
it on/off like other layers, you can view the table and you can symbolize features. Because the layer does not have an Object-ID field, you will not be able to select, query or edit the features. You must save the layer to a shapefile or feature class to enable these functions.

⊕ Save Data Points as a Feature Class

The point layer (called an "event" layer) that you just made is created "on-the-fly" by ArcMap. If you close ArcMap without saving the map document, the text file will still exist but the layer will not. Recall too that when you created this layer, there was a message that it lacked Object-IDs. Without Object-IDs you can't select or query features, establish joins, etc. You can make the layer permanent by saving the event layer as a shapefile. When saving the data to a shapefile, ArcMap will create the Object-IDs, increasing the functionality of the data. In this step, you will save the archdata.txt event layer as an ArcMap shapefile.
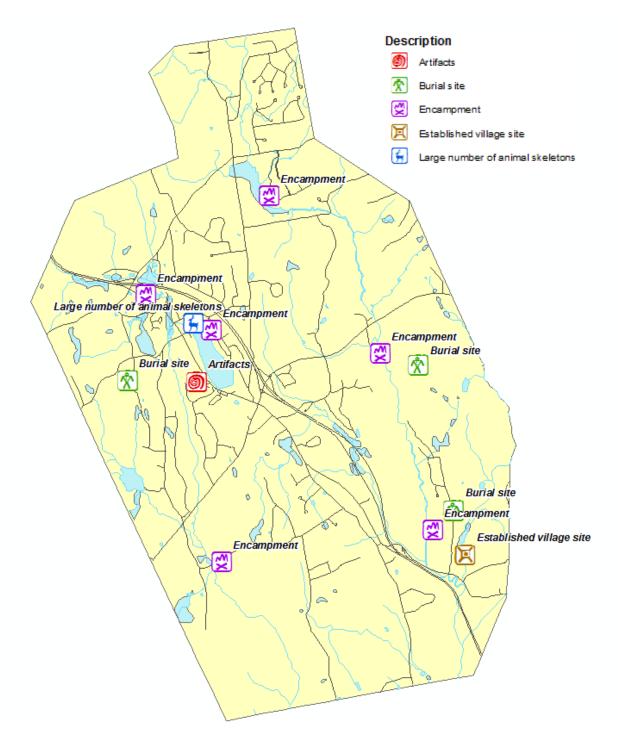
- Right click on **archdata_WGS84.txt Events**, mouse over **Data** and select **Export Data…**

- Save the data as **Arch_sites** in your **C:\GISEd10\Results\CT_Results.gdb.**

- If ArcMap asks if you would like to add the layer to your map, select **Yes**.

- Take a minute or two to explore the feature class. Notice that you can now create queries and selections on the layer (because it now has Object-IDs). You can also now edit the features in the layer.

⊕ **Optional: Create a Layout**

If you have a little extra time or would just like to practice your cartography skills, create a layout showing the archeological sites in the town of Marlborough. Use the **Descrip** field to label each point location. You can also symbolize the sites into categories based on the **Descrip** field. Be sure to include a title, scale bar, north arrow, and legend. When you are satisfied with your map you may print the layout or simply save it to a PDF. Refer to the **Map Production Module** if you need help remembering how to do any of these tasks.

Let's Review!

In this exercise you learned how to create a geospatial dataset from a text file containing X,Y coordinate locations. This technique is often used when you have coordinate data in an electronic format from a global positioning system or an existing database. This exercise covered the following:

- ✓ How to set up a text document so that it can be "read" by ArcMap.
- ✓ How to add files containing X,Y coordinate data to ArcMap using the Add XY Data tool.
- ✓ How to save your resulting ArcMap event layer as a feature class in ArcMap.
- ✓ Creating a layout to show the spatial locations of the XY events.

This concludes this Exercise.

If you have finished and the class is still working on the exercise, go back and try of the tasks you just learned on your own or go on to another exercise.

Save your project in the **C:\GISEd10\Projects** folder. When you are done, **close ArcMap** by clicking on the **red X** in the top right corner of ArcMap.
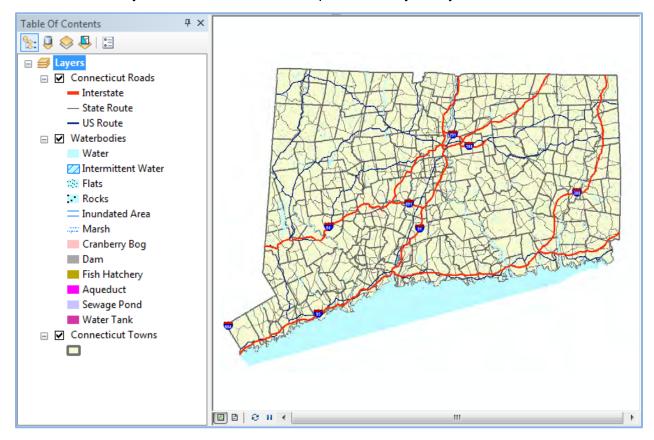
Lightning Round: Data Driven Pages

Data Driven Pages is new at ArcGIS10. Thy allow you to create multi-page map series from a single map document. This can be very helpful when you need to "mass produce" a number of maps that look similar.

Data Driven Pages – Set Up

✦ Prepare Your Map Document

- **Open** a new, blank map.

- In the new map, add the following layers to your map from your **C:/GISEd10/Layers** folder: **Connecticut Roads.lyr, Connecticut Towns.lyr,** and **Connecticut Waterbodies.lyr**. Make sure the roads layer is above waterbodies which is above towns in your **Table of Contents**. Be patient while your layers draw.
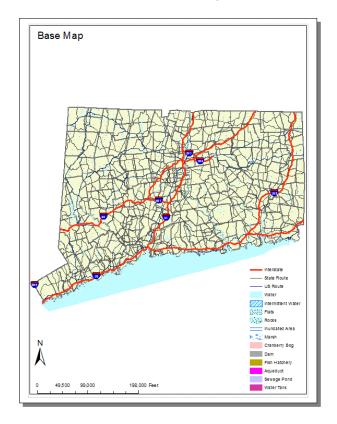
You will use the **Data Driven Pages** toolbar to create a PDF "map book" that includes a page and layout for each town in the state displaying these three basemap layers. That's 169 maps…all from one Map Document!

⊕ **Prepare Your Layout**

- Click on the **Layout View** icon to launch **Layout View** 🖹 .

- Add the following elements to your map:
    o Title: "Base Map"
    o Scale Bar (units of miles)
    o North Arrow
    o Legend (include Connecticut Roads, Waterbodies)

- Stretch the **Data Frame** so that it fills the Layout.

⊕ **Data Driven Pages Setup**

- Click on the **Data Driven Pages** 📑 tool on the **Layout** toolbar.
- This will open the **Data Driven Pages** toolbar.
- Click on the **Data Driven Pages Setup** 📑 icon on the toolbar.
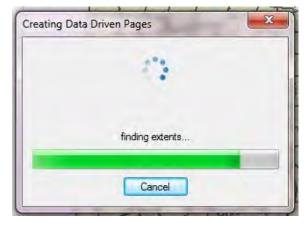
- The **Data Driven Pages Setup** window will open. Specify the following settings in the window. When you are done, it should look like the graphic below.

  o Check the box next to **Enable Data Driven Pages**
  o Under **Index Layer**, specify **Layers** as the **Data Frame**; **Connecticut Towns** as the **Layer**; **TOWN** as the **Name Field**, **TOWN** as the **Sort Field** and **check** the box next to **Sort Ascending**.
  o Leave all of the **Optional Fields** set to their default setting.
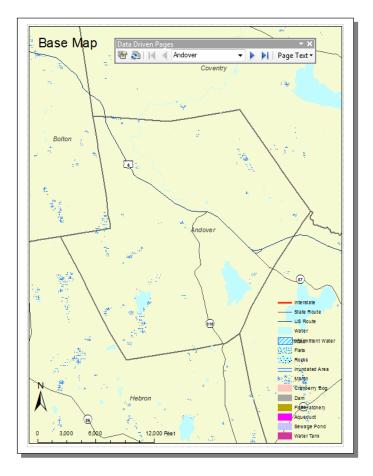
- Click **OK.**

- It will take a minute for ArcMap to create the pages. Be patient.

- When it is done, your Data Frame extent will change. You should be seeing the town of Andover centered on your map.

- On the **Data Driven Pages** toolbar, click the **Next Page** ▶ icon. You should now be looking at Ansonia. If you continue clicking the **Next Page** ▶ icon, you will eventually page through all 169 Connecticut Towns, in aphabetic order.

✦ **Dynamic Text**

- Notice how the "**Base Map**" title doesn't change. Let's fix that! Double click on the "**Base Map**" text box to open its **Properties** window.

- In the window, replace the dynamic text tag to **<dyn type="page" property="NAME"/>.** You should only have to change the text within the two sets of quotation marks.

- The text in the **Title** box should now be the town name. As you advance to a different page, the text string in the **Title** box should also change. Cool!

- You can change the **Properties** for the **Title** text box to make it more legible on the page by double click on the town name and selecting **Properties>Change Symbol**. Same goes for the **Legend, Scale Bar** and **North Arrow**.

✦ **Generating a PDF Mapbook**

- You are ready to export your maps to PDF. Click on the **File** dropdown menu from the main menu and select **Export Map.**

- In the **Export Map** window, navigate to your **Results** folder. Name your file **CTBasemaps.pdf**. Be sure you change the **Save as type** to **PDF (.pdf).**

- Click on the **Pages Tab** at the bottom of the window. Click the radio button next to **All (169 pages)** – this means ArcMap will generate one PDF with 169 pages – that could take a long time! If you don't want to wait, you can choose the **Current** option or **Page Range** option.

- Click on the **Advanced Tab** at the bottom of the window. Select **Export PDF Layers Only.**

- You should be ready to go! Click **Save.** ArcMap will begin to generate your PDF.

- If you chose the **All (169 pages) option**, it may take several minutes for ArcMap to generate your Mapbook. Remember, it is essentially creating a PDF for each town. Be patient.

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- When the process is complete, browse to your **C:/GISEd10/Results** folder from your Start menu. Locate your new **CTBasemaps.pdf** and double click on it. This will open the PDF in Adobe Reader.

- Click on the **Pages tab** on the sidebar. Notice you can sort through all 169 PDFs.

- Also notice you have access to the **Layers tab** and can turn data layers on and off for each layout.

The Data Driven Pages tool is a great way to mass produce PDFs for a large geographic area. It is particularly helpful if you wish to create a cohesive "look and feel" to the layout outputs or if you are looking to create a map book that includes multiple ArcGIS layouts.

Lightning Round: ArcGIS Online

A useful tool for creating, editing and sharing web maps is Esri's ArcGIS Online. It requires a free user account to store data and maps online. You can connect to your user account from ArcGIS Desktop as well. The following exercise outlines steps to introduce you to the basics of ArcGIS Online.

Create a Public ArcGIS Online Account:

- Open an Internet browser (Firefox or Chrome). Go to https://www.arcgis.com/home/createaccount.html and complete the form to create an account. It may be necessary to authorize your account before using it.
- In an Internet browser, go to https://www.arcgis.com/home/ and click on Sign In in the upper right. Sign in with your new credentials.

Create a New Map:

- Click on MAP at the top of the web page. This will open the ArcGIS Online web map.
- Click on the Add button (upper left) and select Search for Layers.
- Type in "Connecticut" in the Find box. Click Go, All data layers tagged with Connecticut in their keywords (tags) or description will appear in the window below. Click on the word ADD next to a layer to add it to your map. When done, click on DONE ADDING LAYERS.

Add a Layer From File:

- Click on the Add button again. This time select Add Layer from File.
- Browse to your C:/GISEd10/Tables folder and click on archdata_WGS84 text file. Select Import Layer. The text file will be added to your map (ArcGIS Online will recognize the lat/long values in the table and place the points on the map).

Change Symbology:

- The Change Style side window will automatically open when you import your data.
- Click on the down arrow next to the number 1 and select the Descrip attribute to show. Under step 2, use the Options under Types (unique symbols) to change the symbol, color and size used to represent the points on your map. Click Done when you are finished changing the symbols.

Customize Pop-Up Windows:

- Click on a point on the map. Notice the pop up information window. This can be customized to include additional text and photographs.
- Click on the down arrow next to arch data layer name. Select Configure Pop up Window.
- There are several settings that can be configured within the pop up window. You can add a title, display a list of attributes or create a custom display, and add media such as a photograph or chart. Explore these settings. Click Save Pop-up to exit.
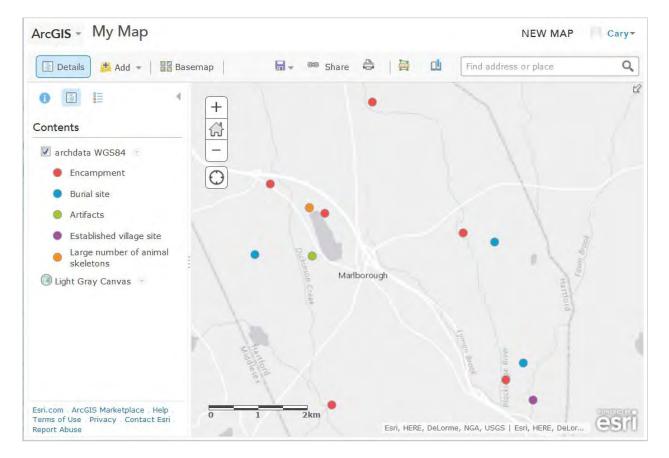
Using the ArcGIS Online Map Viewer:

- Click on waypoints to view field information.
- Use the Measure tool to measure distance and area in various units.
- Change the basemap (imagery, topo maps, street maps, etc)
- Add data from various sources (search for data, upload data, create map notes)

Save and Share Your Map:

- Click Save at the top of the map. Provide a Title, Tags and short Summary. Click Save map. The map will be stored in your user profile. You can view and open your maps from the My Content section of ArcGIS Online.
- Click Share. Check box next to Everyone (public). You can now link to the map using the URL provided in the "Link to this map" window. Send it to a friend, post to social media. Have fun. Notice you can also embed the map in a website using HTML or create a web application on ArcGIS Online. This option will create a template around the web map to make sharing and displaying your data easy and fun.
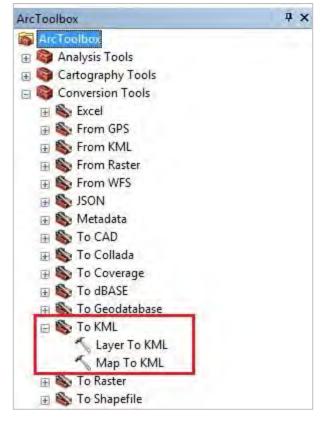
Lightning Round: Converting to Google KML

Just about everyone has spent a little (maybe a lot!) of time playing with Google Earth or Google Maps. Did you know you can convert GIS data into Google data? Google's mapping programs, along with many other web and 3D earth viewers, use a data format called KML (stands for Keyhole Markup Language). KML is an XML-based format for storing geographic data and associated content. KML files have either a .kml extension, or a .kmz extension for compressed KML files. Review the lightning talk slides or Google, "What is KML" for a review of this. The steps below show you how to convert shapefiles to KML using ArcToolbox.

The To KML Tool

- Start ArcMap.
- Add a shapefile or feature class to your map.
- Symbolize features.

- Click the Geoprocessing tab, and click ArcToolbox to open the ArcToolbox window.

- Expand Conversion Tools.
- Expand To KML.
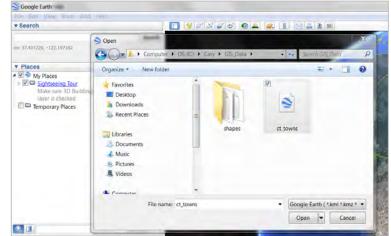
- To open the conversion tool window, double-click **Layer To KML** for an individual shapefile, or double-click Map To KML for compressed KML files.

- Under the **Layer drop-down box**, select the desired shapefile, or drag and drop the desired shapefile into the box.

- Specify the location to store the KML file.
- Click OK.
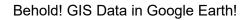
View KML in Google Earth
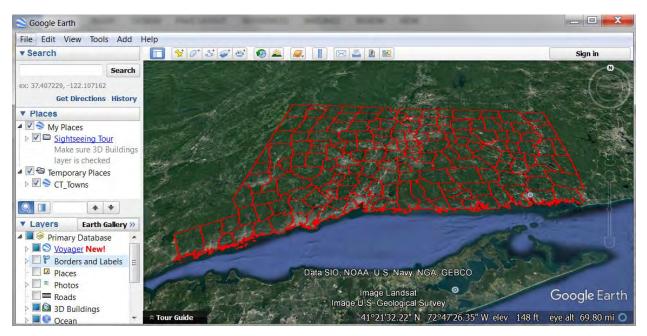
- If you do not have Google Earth installed on your computer, download the latest version at https://www.**google**.com/**earth**/.

- Install the program.

- Open Google Earth. From the drop down menu at the top, select **File > Open**.

- Browse to the location where you stored your KML file output. Select and open it.

Behold! GIS Data in Google Earth!

Lightning Round: Georeferencing

Georeferencing is the process of assigning coordinates from a known reference system, such as latitude/longitude, UTM, or State Plane, to a raster (image) or a planar map. Georeferencing raster data allows it to be viewed, queried, and analyzed with other geographic data.

This exercise provides you with two commonly used georeferencing tasks. The first is to georeference a scanned subdivision map so that it fits inside an existing parcel. The new parcel lines could then be digitized and added to the town's parcel data. The second task is to georeference an aerial image so that it can overlay with other vector and raster data.

The general steps to georeferencing are:
- **Step 1: Add Data**
- **Step 2: Roughly line-up the datasets**
- **Step 3: Add Ground Control Points**
- **Step 4: Evaluation**
- **Step 5: Iterations**
- **Step 6: Acceptance**
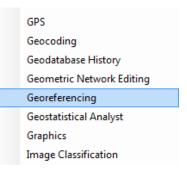
Getting Started

- Open ArcMap.
- Open a New Map.
- Save the map in the **Results** folder called **Georef.mxd**.

Open the Georeferencing Toolbar

- On the **Customize** menu, choose **Toolbars** and click on **Georeferencing** so that it is checked. The Georeferencing toolbar should open. Dock it if you wish.

READ THIS! Choose your own adventure:
You have **two options** in this exercise. The first option is to **georeference a scanned subdivion map to match a parcel layer**. The second option is to **georeference an aerial image** to match another aerial image.

First option: Keep going to **Option 1: Georeference a Scanned Subdivision Map**, skip the Option 2 section and proceed to **Evaluate Ground Control Points**.
Second option: skip the Option 1 section below, and go right to **Option 2: Georeference an Aerial Image**.

Option 1: Georeference a Scanned Subdivision Map to Match a Parcel Layer

Step1: Add Layers to ArcMap

- Add the following layers to your ArcMap document:
    - **C:\GISEd10\Layers\Marl Parcels.lyr**
    - **C:\GISEd10\Images\Sub_DivPlan.jpg**

An **Unknown Spatial Reference** box may open when you add the **Sub_DivPlan.jpg**. This should not be a surprise as the point of the exercise is to give this image spatial reference!

Explore the Layers
Be sure all three layers in your map document are turned on (box is checked).
- Right-click over **Parcels** and select **Zoom to Layer**. The parcels for Marlborough should look familiar.
- Right-click over **Sub_DivPlan.jpg** and choose **Zoom to Layer**. This is a proposed subdivision of a parcel in Marlborough. It was scanned and needs to be georeferenced so that the new parcel boundaries can be added to the town parcel layer.

- Click on the view **Full Extent** icon.

Why does it make the Marlborough parcels so small?
Can you find the scanned image?

ANSWER: The **Sub_DivPlan.jpg** doesn't have coordinate information so the GIS doesn't know where to put it. Now you will give the aerial coordinate information so it will line up.

Step 2: Rough Line Up – Fit to Display
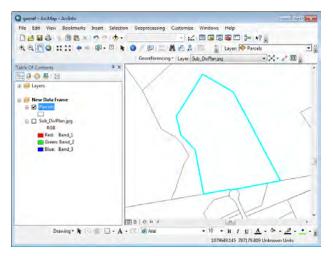
- Turn on the **Georeferencing Toolbar** if you haven't already.
- On the **Georeferencing** toolbar, BE SURE that **Sub_DivPlan.jpg** is listed as the **Layer**. **BE EXTRA sure that the Parcels layer is NOT listed as the Layer**. This is very important because you will be moving the **Sub_DivPlan.jpg** and you do **NOT** want to move the **Parcels** layer as it is your reference.

- In the Table of Contents, right-click over
  Sub_DivPlan.jpg and choose **Zoom to Layer**.
- Look closely at the subdivision and make mental notes
  about its size and shape.
- In the Table of Contents, right-click over **Parcels** and
  choose **Zoom to Layer**.
- Open the **Attribute Table** for Parcels and locate the
  parcel with **Parcel ID 9/27/5-7** and **DEED_ID 120 526.**
  Notice how, when rotated, the subdivision will fit inside
  this parcel.
- Zoom in on the parcel so that it nearly fills the map display.

- On the **Georeferencing toolbar** on the
  Georeferencing menu, choose **Fit to Display**.
  This moves the **Sub_DivPlan.jpg** (because it is
  the designated Layer on the Georefencing toolbar)
  to the display extent.

- Three tools on the Georeferencing toolbar are
  helpful when roughly lining up **Sub_DivPlan.jpg**
  with the parcels. These tools work on the layer
  that is listed on the georeferencing toolbar (in this
  case, **Sub_DivPlan.jpg** image). They are:
    - **Rotate** – interactively rotate the dataset
    - **Shift** - interactively drag the dataset (similar to the pan tool)
    - **Scale** – rescales (zooms in or out) the dataset. After selecting the scale tool,
      hold the mouse and move it down (towards you) to zoom out and move it up
      (away from you) to zoom in.
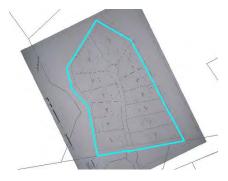
- Use these tools, in combination, to roughly match the scanned subdivision plan with the parcel. A typical workflow would be to first **rotate** the image, then **shift** it into place, then use the **scale** tool to get it to be about the right size.

Notice that the datasets are much closer than they were, but do not perfectly match. If necessary, repeat the zoom and **Fit to Display** steps to get the images close. They will not be exact – that is what the next step is for.

Step 3: Add Ground Control Points
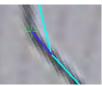
Control points "tie" the to-be-referenced data (the scanned subdivision) to the already-referenced data (the Parcels layer). It is important that you use multiple points and that they are spread across the image. Start with the corners and then do a few in the middle of the image.

- Zoom far in to the bottom right corner of the subdivision.

- Click on the **Add Control Points** icon on the Geoereferencing toolbar. Notice that your mouse changes to a **+** sign.
- Add a **Control Point**:
    - Click on the corner of the subdivision as shown on the source (to be referenced, or scanned subdivision). A green **+** is drawn and a line is now connected to your mouse. You can still use your zoom tools and turn on and off layers in the Table of Contents.
    - Locate the same corner of the parcel on the target (Parcel layer). **Click on the corner**. A red **+** is drawn and that control point is complete.

- Add another **Control Point**, this time in the opposite corner of the subdivision.
    - Zoom out and find an opposite corner.
    - Click on the **Add Control Points** icon.
    - Click on your desired location on the source (scanned subdivision). A green **+** is shown.
    - Click the same location on the target (Parcels). A red **+** is shown.
    - You now have two control points.
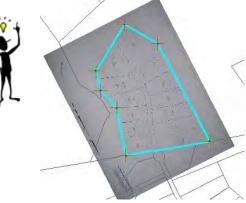
- Continue the process until you have at least seven points and they are spread across the subdivision. Ideally, the points should be in all corners and the center. In this case, the center is difficult (okay, impossible). As you add points, the line connecting the two points will get longer. This occurs as ArcMap uses the Control Points to guess how the image should be transformed so it best lines up.

TIP: Use the **ESC** button to get out of a point if you clicked by accident or in the wrong spot.

Skip the next section, Option 2, and proceed to **Evaluate Ground Control Points**.

Option 2: Georeference an Aerial Image

Step 1: Add Layers to ArcMap

- Add the following layers to your ArcMap document:
    - **C:\GISEd10\Layers\Connecticut Towns.lyr**
    - **C:\GISEd10\Images\CT2012_georef.sid**
    - **C:\GISEd10\Images\CRCOG_RawImage.tif**

An **Unknown Spatial Reference** box may open when you add the **CRCOG_Rawimage.tif.** This should not be a surprise as the point of the exercise is to give this image spatial reference!

- Change the symbology of **Connecticut Towns** so that it has a hollow fill.

What is CRCOG?
CRCOG is the **Capital Region Council of Governments** that represents 30 municipalities in the greater Hartford Area. CRCOG received a grant from the Office of Policy and Management to purchase high resolution imagery. It is leaf off, 0.25 feet pixel resolution and is fantastic. Follow the link to CT ECO for more information about the CRCOG imagery.
https://cteco.uconn.edu/guides/Ortho_2009_Color_CRCOG.htm

What is NAIP?
NAIP is the **National Agriculture Imagery Program** which is administered by the USDA's Farm Service Agency (FSA). It is summer, leaf on, 4 color bands (includes Near-IR), with 3.39ft pixel resolution. It covers all of Connecticut and is collected every two years so imagery from 2008 and 2010 is also available for Connecticut.
https://cteco.uconn.edu/guides/Ortho_2012_Color_NAIP.htm

Explore the Images
Be sure all three layers in your map document are turned on (box is checked).
- Right-click over **CT2012_georef.sid** and select **Zoom to Layer**.
- Use the **Identify** tool or **Zoom Out** to determine which town in Connecticut the image is showing.
- Right-click over **CRCOG_RawImage.tif** and choose **Zoom to Layer**.
- Click on the view **Full Extent** icon 🌐.

Why didn't the CRCOG_RawImage.tif belong to a town? Why does the Full Extent View look odd?

ANSWER: The **CRCOG_RawImage.tif** doesn't have coordinate information so the GIS doesn't know where to put it so that it will overlay with the other layers in the map. Now you will give the aerial coordinate information so it will line up.

Step 2: Rough Line Up – Fit to Display

- Turn on the **Georeferencing Toolbar** if you haven't already.

- On the georeferencing toolbar, BE SURE that **CRCOG_RawImage.tif** is listed as the **Layer**. **BE EXTRA sure that CT2012_georef.sid is NOT listed as the Layer**. This is very important because you will be moving the **CRCOG_RawImage.tif** and you do **NOT** want to move the **CT2012_georef.sid** as it is your reference.

- In the Table of Contents, right-click over **CRCOG_RawImage.tif** and choose **Zoom to Layer**.
- Look closely at the image and make mental notes about what is covered by this image and what is in the corners. Notice some of the parking lot in the upper left and a portion of a building in the lower right.

- Now, in the Table of Contents, right-click over **CT2012_georef.sid** and choose **Zoom to Layer.**
- Use your zoom tools to zoom in so that your map display window in ArcMap is showing a similar extent to that covered by the CRCOG image.

- On the **Georeferencing toolbar** on the **Georeferencing menu**, choose **Fit to Display**. This moves the CRCOG image (because it is the designated Layer on the Georeferencing toolbar) to the display extent.

- Three tools on the Georeferencing toolbar are helpful when roughly lining up the datasets. These tools work on the layer that is listed on the georeferencing toolbar (in this case, the CRCOG image). They are:
    - **Rotate** – interactively rotate the dataset
    - **Shift** - interactively drag the dataset (similar to the pan tool)
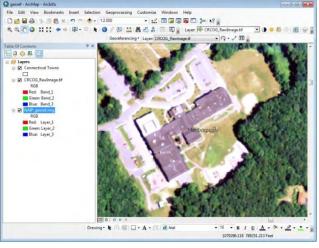   - **Scale** – rescales (zooms in or out) the dataset

- Make the CRCOG image semi-transparent so you can see through it. To do so, turn on the **Effects toolbar** and **Adjust Transparency** using the icon .

Notice that the images are much closer than they were, but do not perfectly overlap. If necessary, repeat the zoom and Fit to Display steps to get the images close. They will not be exact – that is what the next step is for.

Step 3: Add Ground Control Points

Control points "tie" the to-be-referenced image (the CRCOG) to the already-referenced image (NAIP). It is important that you use multiple points and that they are spread across the image. Start with the corners and then do a few in the middle of the image.

- Zoom far in to the building in the bottom right of the image.

- Click on the **Add Control Points** icon on the Geoereferencing toolbar. Notice that your mouse changes to a **+** sign.

- Add a **Control Point**:
    - Click on the corner of the building as shown on the source (to be referenced, or CRCOG image). A green **+** is drawn and a line is now connected to your mouse. You can still use your zoom tools and turn on and off layers in the Table of Contents. You may want to turn off the CRCOG image (uncheck it) so you can see the NAIP.
    - Locate the same corner of the building on the target (NAIP). **Click on the corner**. A red **+** is drawn and that control point is complete.

- Add another **Control Point**, this time in the opposite corner of the CRCOG image.
    - Zoom out to find the opposite corner. Find a location that you can clearly see on both images. This could be the corner of the parking lot.

    - Click on the **Add Control Points** icon .
    - Click on your desired location on the source (CRCOG image). A green **+** is shown.
    - Click the same location on the target (NAIP) image. A red **+** is shown.
    - You now have two control points.

- Continue the process until you have at least seven points and they are spread across the image (in all corners and the center). As you add points, the line connecting the two points will get longer. This occurs as ArcMap uses the Control Points to guess how the image should be transformed so it best lines up.

TIP: Use the ESC button to get out of a point if you clicked by accident or in the wrong spot.

Step 4: Evaluate Ground Control Points

- Open the Link Table by clicking on the **View Link Table** icon ⊞. The Link Table lists all of your points (called links). If you have 6 or more points, you can choose between 1st order polynomial and 2nd order polynomial in the Transformation dropdown menu.

Link	X Source	Y Source	X Map	Y Map	Residual
1	1004.036800	-769.792200	1080043.817715	789018.954085	4.32325
2	31.126279	-68.306321	1079038.693305	789696.433714	16.06686
3	522.659952	-45.147657	1079561.099590	789732.450677	12.16523
4	232.332237	-772.210333	1079269.052804	789007.525227	0.80307
5	57.204904	-433.768979	1079098.133071	789343.280884	11.59631
6	674.391360	-308.622558	1079702.337077	789473.901905	4.53322
7	425.113365	-358.873283	1079456.871747	789422.345410	2.78675

Select 2nd order polynomial and view the image. Do you think this is a better fit? Keep reading.

1st Order vs. 2nd Order Transformations
- In general, use a first-order transformation if your raster dataset needs to be stretched, scaled, and rotated.
- Use a second- or third-order transformation if the raster dataset must be bent or curved.
- The higher the transformation order, the more complex the distortion that can be corrected. Higher-order transformations require more links and thus will involve progressively more processing time.

The **residual error**, or **Root Mean Square (RMS)** error is also a measure of the accuracy of the transformation. See the box below for an explanation of RMS error.

On the image, the length of the line between the first **+** (the to-be-referenced target) and second **+** (the already referenced source) for each point correlates with the size of the RMS error. For example, if the point has a low RMS error, both crosses will be in nearly the same location.

The same points on the map are listed in the table. To determine which is which, click on the link in the table. The line connecting the two crosses on the map will be highlighted with a **yellow** line.

> **Root Mean Square (RMS) Error**
> The degree to which the transformation can accurately map all control points can be measured mathematically by comparing the actual location of the map coordinate to the transformed position in the raster. The distance between these two points is known as the residual error. The total error is computed by taking the root mean square (RMS) sum of all the residuals to compute the RMS error. This value describes how consistent the transformation is between the different control points (links). Links can be removed if the error is particularly large, and more points can be added.

Step 5: Iterations

- If any of the links in the table have an exceptionally high RMS error compared to the others, take a look at the point in the map. Did you make a mistake when adding the point? To remove the point, highlight it in the Links table and hit the Delete key on the keyboard. You may want to add at least one more new point.

> **IMPORTANT**: A high RMS error does not necessarily mean a point is bad. It is common for one part of an image to have more distortion than other areas. That point may be accounting for this and the end result will be far better WITH the point than without. If a point has a high RMS error, carefully review the location and its quality. If it is a reliable spot and is the best you can do, keep it.

- Continue tweaking the points and their locations until you are satisfied with the residual error for each point and the total RMS error.
- Click **OK** to close the **Link Table**.

Step 6: Acceptance

Save the Georeferencing Information

Once you are satisfied with the registration, click **Update Georeferencing** on the Georeferencing toolbar to save the transformation information with the raster dataset. For most rasters, the georeferencing information is stored in a separate file with the same name as the raster but with an .aux file extension.

Rectify the Raster Image

You can permanently transform your raster dataset after georeferencing it by using the **Rectify** command on the Georeferencing toolbar. Rectify creates a new raster dataset that is georeferenced to map coordinates. You can save this in GRID, TIFF, or IMAGINE format. ArcMap doesn't require you to rectify your raster dataset to display it with other spatial data in ArcMap. You might choose to rectify your raster dataset if you plan to perform analysis with it or want to use it with another software package that doesn't recognize the external georeferencing information created by ArcMap.

Congratulations! You have completed ALL of the Introduction to GIS Exercises. You may now put on your super hero cape!