Lab 7. Georeferencing and Digitizing

Exercise 1. Georeferencing

There is a great deal of geographic data available in formats that cannot be immediately integrated with other GIS data. In order to use these types of data in GIS it is necessary to align it with existing geographically referenced data, this process is also called georeferencing. Georeferencing is also a necessary step in the digitizing process. Digitizing in GIS is the process of "tracing," in a geographically correct way, information from images/maps.

The process of georeferencing relies on the coordination of points on the scanned image (data to be georeferenced) with points on a geographically referenced data (data to which the image will be georeferenced). By "linking" points on the image with those same locations in the geographically referenced data, you will create a polynomial transformation that converts the location of the entire image to the correct geographic location. We can call the linked points on each data layer **control points**.

An important final step is the specification of the frame of reference (coordinate system) for georeferenced image. Since we are using a shapefile to specify the geographic locations of points on the image, we will set (define) the coordinate system for georeferenced image to the same coordinate system.

The selection of control points is important. Some guidelines:

- They should be easy to confirm as representing the same geographic location (street intersection, political boundary, landmark, etc.).
- They should be spread across the image to be registered, one suggestion is to select a control point near each of the corners of the image and a few throughout the interior will often work well.
- Good overlap between the two datasets is also important.
- Make sure you are clicking as close as possible to the same geographic location, zooming in can help in this process.

As you add more control points, the complexity of the transformation maybe increase. This is not always a good thing, 1st, 2nd, and 3rd order polynomials CAN BE calculated; usually a 1st or 2nd order transformation is all that is necessary. In order to complete a 1st order transformation, you need a minimum of **three** control points, for a 2nd order you need a minimum of **six** control points, and for a 3rd order you will need a minimum of **ten** points. A 1st order transformation will shift, scale, and rotate your image while 2nd and 3rd order transformations will bend and curve straight lines, which might be necessary, but is rare.

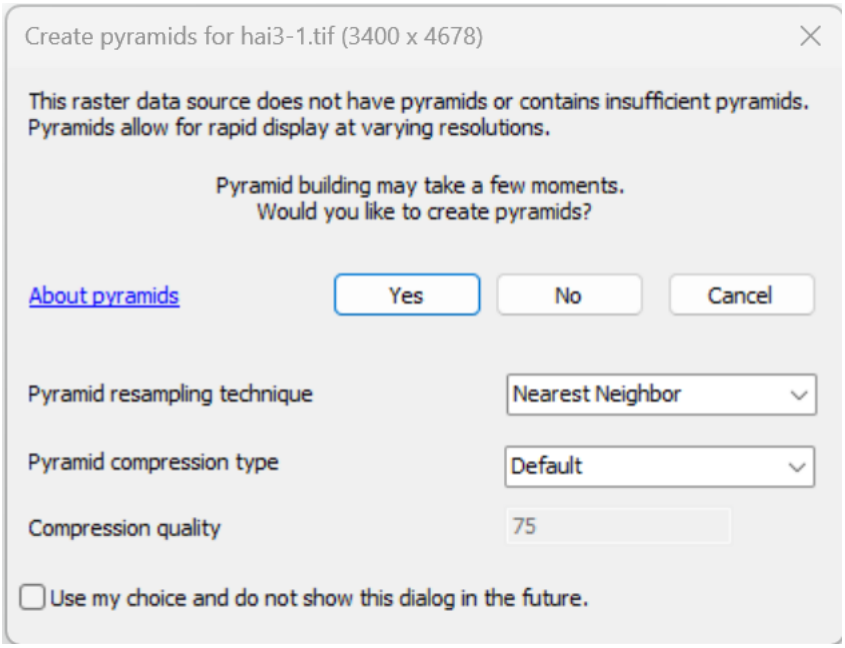
In this exercise, we will use a map of a subbasin of the Hai river, including two tif files:

hai3-1.tif and hai3-2.tif.

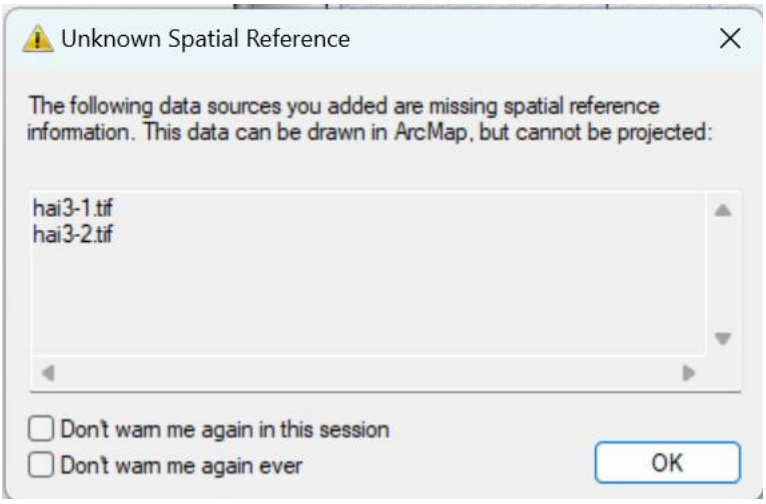
Georeferencing images

Tools: The primary tool we will be using is the **georeferencing** toolbar. The georeferencing toolbar is probably not visible when you first open ArcMap, you can open it by clicking on **customize**, selecting toolbars, then clicking on the georeferencing toolbar option. The toolbar should appear in the ArcMap window. Or right click on the menu, and the toolbars window will also appear. See the Georeferencing tool below.

1. Use the Add Data button to add the scanned map image (e.g., *hai3-1.tif*) to the map document. If asked if you would like to build pyramids (see screenshot belows), click **yes**. Building pyramids improves the speed in which raster datasets load, and is optional.

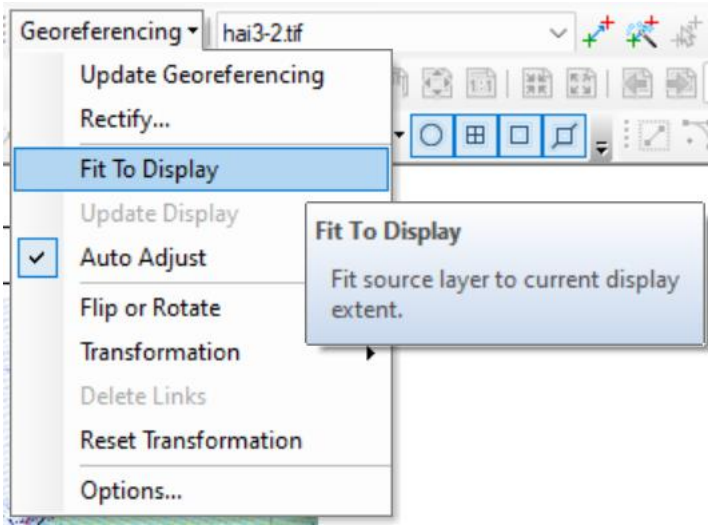


2. You should receive the following warning message after adding the scanned image to ArcMap:



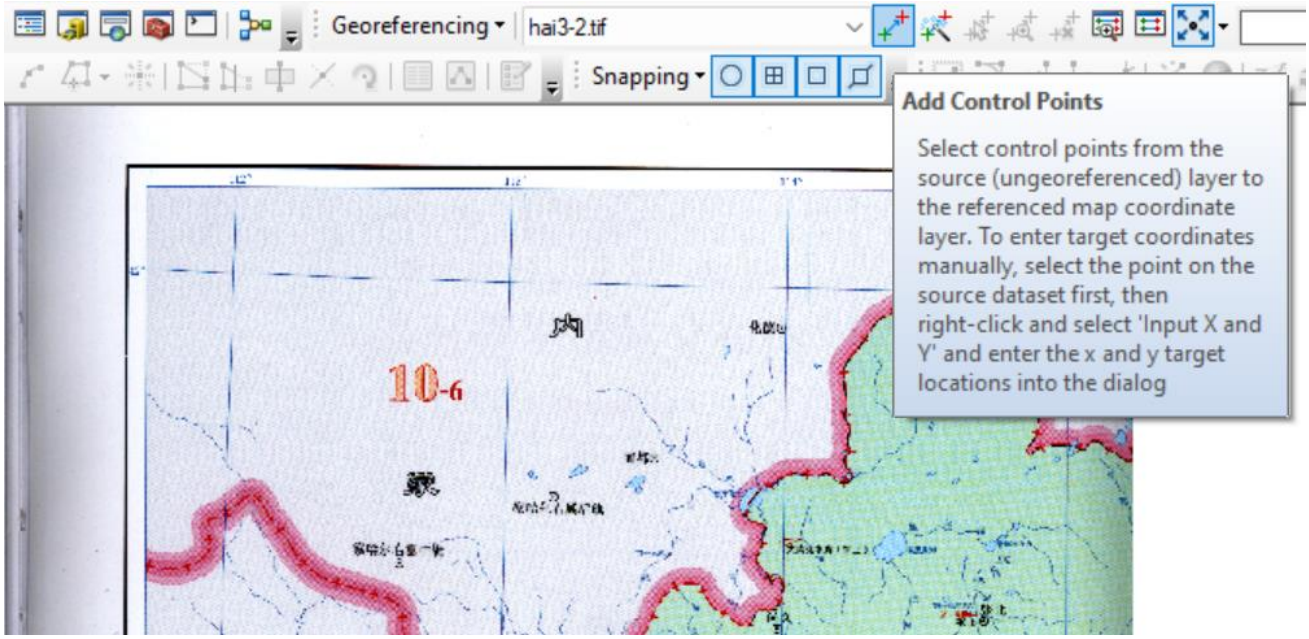
Note: The georeferencing process in ArcGIS will solve the issue of missing spatial references. Click OK. Because ArcMap does not know where to locate this raster dataset, it will not display on the map, but will be visible in the Table of Contents.

3. Now you should see the hai3-1.tif appears in the georeferencing toolbar. But if you did not see the scanned image on the screen, just right click the layer and click the “zoom to layers” button or click the “Fit to Display” from the dropdown menu of georeferencing.



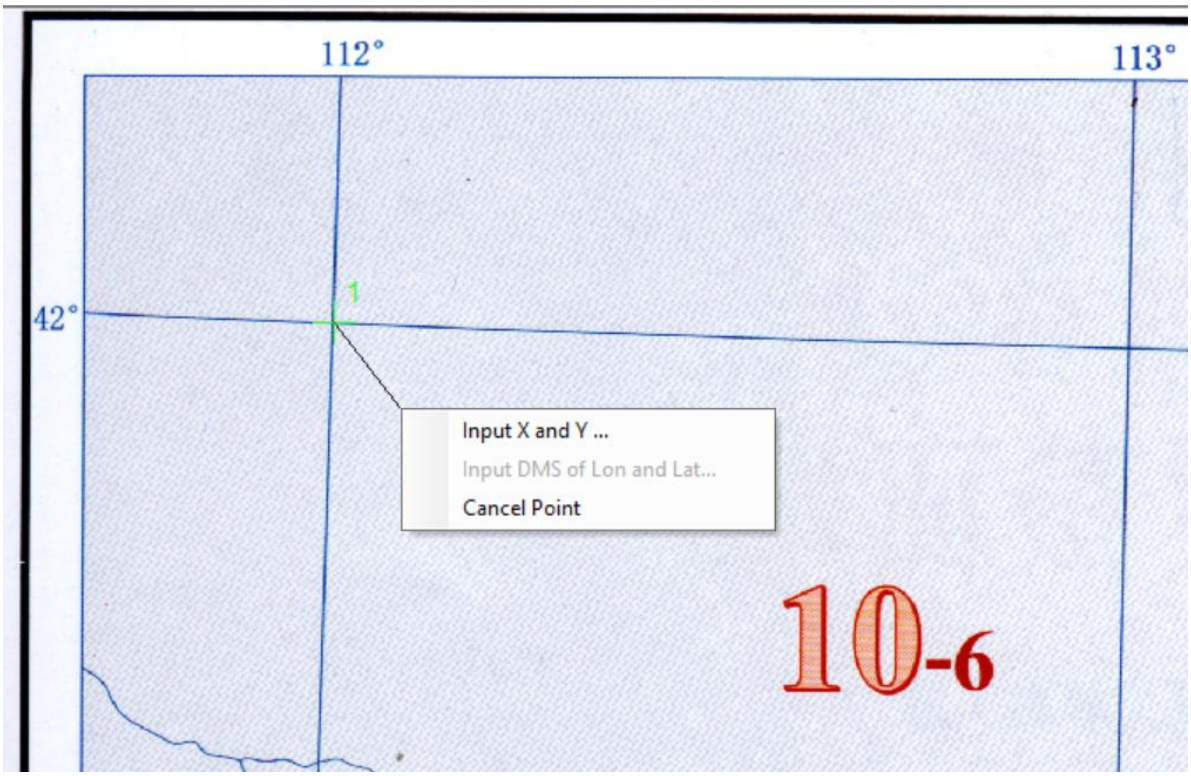
4. You may see the **Auto-Adjust** option within the **Georeferencing** toolbar is checked. This option automatically updates the display and adjusts the raster image with each new control point added. It is recommended that the Auto-Adjust option be selected for most GIS needs so that you can monitor the georeferencing process in real time.

5. Click on the Add Control Points button in the Georeferencing toolbar. This tool allows you to associate points in a scanned map or aerial image with their real-world spatial coordinates within your GIS.



6. To add a Control Point to your map, first click on a location on the scanned map (a ‘plus’ sign will appear as seen in the first image below), then right click a window will pop out as seen below. Click on the “Input X and Y”, and you can enter the coordinates (remember that x stands for the longitude and y for the latitude). In this example, we will select the

centre of the intersection of longitude and latitude grids on the scanned map as control points (Note that, try to select control points that are distributed unevenly).



7. Once you add one point, the map may disappear since it is “Auto Adjust”. You need to click the “Update Display” in the Georeferencing tool dropdown menu or right click the raster name and click on “zoom to layer”. Now you should see the raster again and continue adding control points. In the link table, you can view the Total RMS Error as well as the Residual for each link that contributes to the overall total. The errors are associated with the amount of disagreement between the two control points for each link once the transformation is set (once you’ve added more than three links). In the window, you can also remove links if you think they are in error; when you do this, the registration is automatically recalculated without that pair of points. If you add no less than 6 points, you can also choose the 2nd order polynomial transformation but might be not as good as the 1st order polynomial if points are not well distributed.

Link

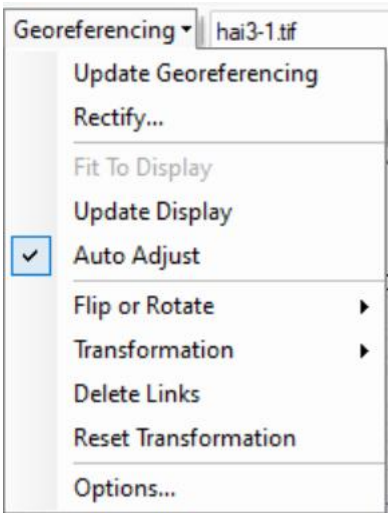
Total RMS Error: Forward:0.0257163

Link	X Source	Y Source	X Map	Y Map	Residual_x	Residual_y	Residual
1	1.71851812	10.36067051	112.00000000	42.00000000	-0.03269479	-0.00111145	0.03271367
2	3.73095054	7.36998422	113.00000000	41.00000000	0.00083603	0.00062827	0.00104579
3	7.99371839	10.21100127	115.00000000	42.00000000	0.03010506	0.00196812	0.03016932
4	1.43003061	1.53678607	112.00000000	39.00000000	0.02875214	0.00192198	0.02881630
5	7.97202776	1.39468147	115.00000000	39.00000000	-0.03321018	0.00039583	0.03321254
6	5.80385971	4.39608770	114.00000000	40.00000000	0.00621174	-0.00380275	0.00728331

Auto Adjust Transformation: 1st Order Polynomial (Affine)

Degrees Minutes Seconds Forward Residual Unit : Unknown

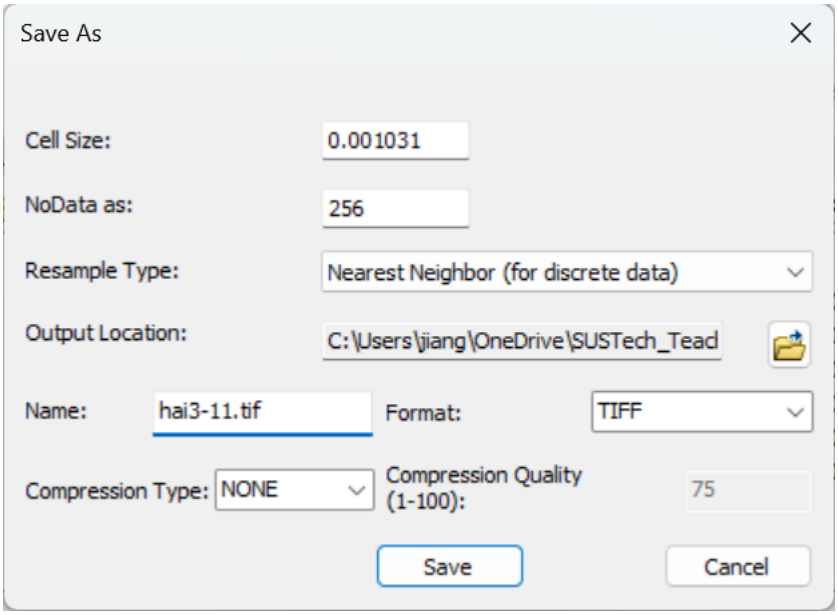
8. Before the next step, but after you are happy with your registered image, click **save**, this will **save** the data in your link table to a text file that can be opened up in word for later reference. Now your image should be with the correct coordinates as displayed in the bottom-right corner of ArcMap.
9. Open the Georeferencing menu in the toolbar.



Using the **Update Georeferencing** tool will store the transformation information with the raster file, which can be internal or external depending on the type of raster dataset being used (ie. for a the current raster dataset, that is a TIFF file, the transformation will be stored in what is known as a world file, with a .tfw or .tfwx extension). Once you done this, you can see a new file **hai3-1.tfwx** is added to your data folder. However, this updated raster file cannot be correctly displayed in other GIS tools since the .tfwx is only limited to ArcGIS.

10. Using the **Rectify** command will allow you to create a new raster dataset that is georeferenced using both map co-ordinates and spatial references which can be saved in a number of different formats (BIL, BIP, BMP, DAT, GIF, TIFF, ESRI GRID, IMG, JPEG,

JPEG 2000, PNG). **This command can be useful if you wish to perform further analysis with the raster dataset or use it in an external program that does not recognize the external georeference information created in the ArcGIS world file (eg. tfwx).**



11. Note, once you done **Update Georeferencing**, the **Rectify** command goes grey. So you have to redo the control points selection. But, if you have saved the links, you can click on the **View Link Table** and **open** the links you have saved. Now you are able to use the **Rectify** command again.
12. Now repeat the above steps to correct the hai3-2.tif image.

Assignment: Submit your georeferenced maps and corresponding control points.

Exercise 2. Digitizing features

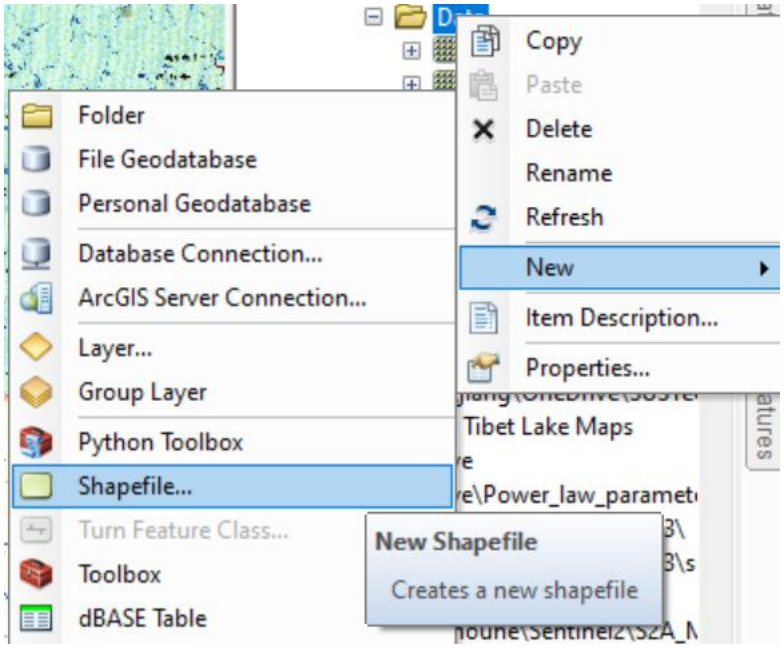
Now you are going to begin digitizing features of these maps. Digitizing is the process of making features we can see on the Hai river basin image editable and making them features to which additional spatial and non-spatial attributes can be assigned. This means we are going to follow a process of making digital versions of objects that will have an attribute table associated with them.

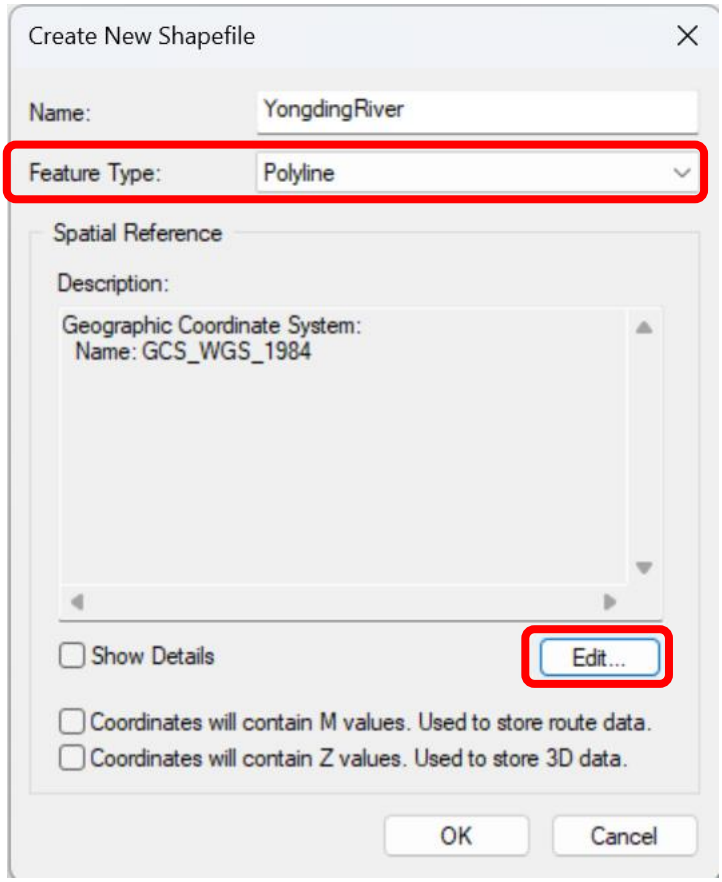
Our primary goal will be digitizing the Yongding river (永定河) (polyline feature), the river basin (boundary, polygon feature), and major reservoirs (polygon features) which are highlighted in on the second map. Once they are digitized and have an associated attribute table, these objects will also be known as polyline and polygon features. When digitizing we can digitize points, lines, or polygons. By digitizing these features, you make them available for mapping once you have added the tabular data to the attribute table (as you know there are a few ways you can do this). The digitizing process is started by **creating new layers** in Catalog window, and then **adding features to them** in ArcMap.

Before digitizing, you need to define a coordinate system for the maps. Just use GCS_WGS_1984.

1. Create an empty shapefile

Open the Catalog pull-out. We are going to create a new shapefile that we can edit in ArcMap—this will be a **polyline** feature shapefile to which we will add the main river. In Catalog window, browse to the **location** of your project. This is the **folder** in which you will create your new shapefile, so select that folder and **right click** on it. Go to **New** → **Shapefile**… to open the **Create New Shapefile** window. Give the polyline shapefile an appropriate name such as *YongdingRiver*, make sure you select “Polyline” as the Feature Type. Click on **Edit**… to specify the WGS 1984 as the Geographic Coordinate System.





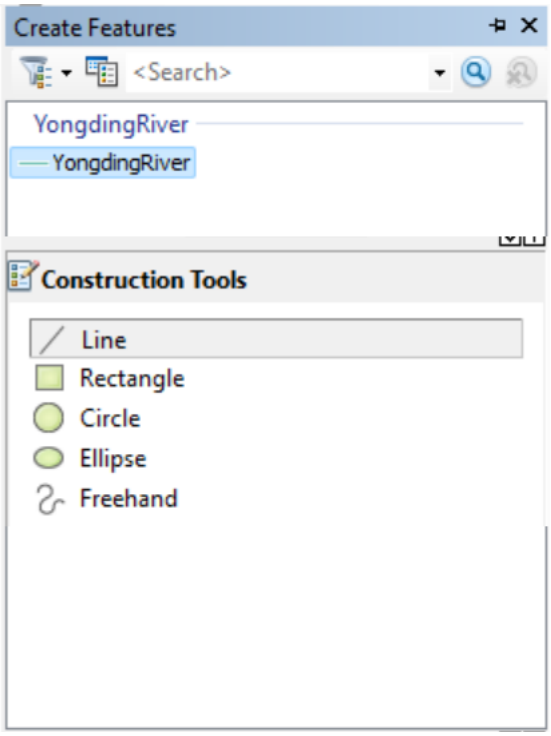
2. Add a new field in the Attribute Table

Now you are able to see a new layer “YongdingRiver” appears in the Table of Contents (TOC). If not, you just need to manually add the new shapefile to the TOC. If you open the Attribute Tables of this shapefile you will find it empty. We are going to use this empty shapefile to create features from our image. Now you will start working with the new shapefile.

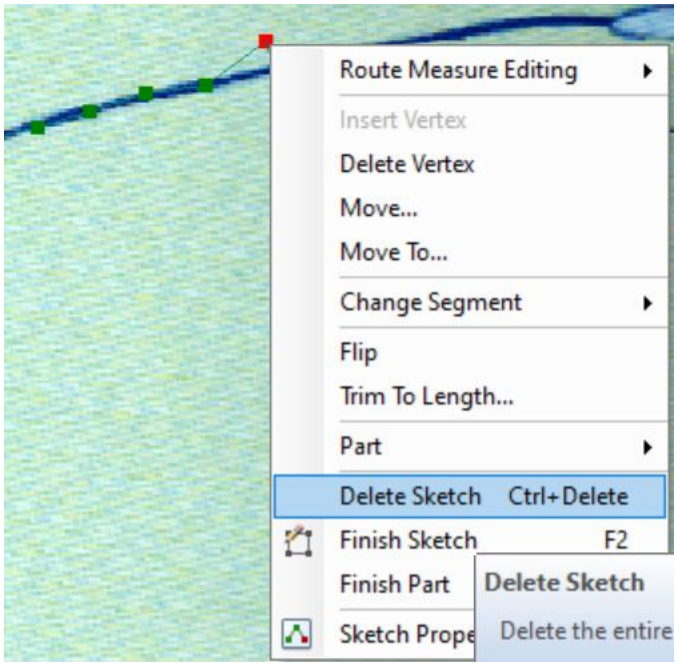
Before you start editing, first **open its Attribute Table**. Click on the **Table Options** button (first icon on Table menu) and **Add Field**… First create a text field called Name, where the river name will be entered later.

3. Digitizing rivers and entering tabular data

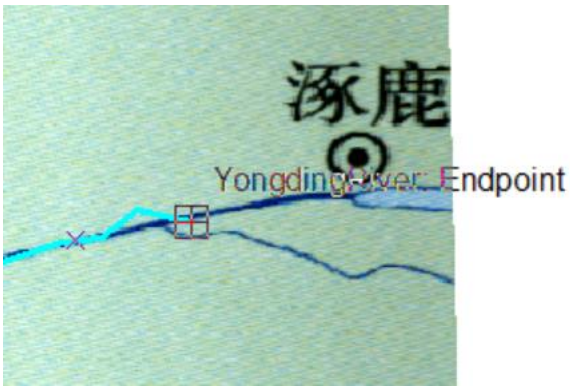
You will need the **Editor** Toolbar. Customize → Toolbars → Editor. On the Editor Toolbar, click on the Editor tool and **Start Editing**. In the **Create Features** window (on the right, where the catalog window opens), click on the YongdingRiver, you will see different types below. Now select **Line**. You are going to create a polyline for individual rivers; it is probably easiest to start with the main river. By clicking at the line you are digitizing you will create a continuous line of it.



If you wrongly add one point, you can **right** click on that point to delete this sketch. Of course, you can also delete the whole line you have wrongly created. One you finished, you can double click to finish sketch or right click on the last point to choose “Finish Sketch”. Now you can open the Attribute Table, and there is one feature there. Now you can write something in the Filed “Name”.



Of course, you can stop at any point along the river. No need to finish the whole river in one feature. You can see continue the digitizing from where you stopped. Put you mouse near the end point; you should be able to snap to the point.



4. Digitizing river boundary and other features

Similarly, you can create a new polygon shapefile, and digitize the river boundary which is the red dashed lines.

Also, create new shapefile for major lakes and reservoirs. They can be saved in one shapefile but with different types, say, Lake and Reservoir.

Assignment: After this exercise, you are able to make a digital map of the Yongding river basin. In the end, you need to **submit three shapefiles** (one polyline shapefile for rivers, one polygon shapefile for river basin, and another polygon shapefile for lake/reservoir) and **one thematic map** (including all the features you have digitized).