

DEFINING PROJECTIONS AND THEIR PARAMETERS; ADDING XY DATA; ANALYZING THE SHAPE OF BUFFERS

"How do I add xy data to ArcMap and make the data line up with other data?"

"Why do buffers created with the tools in ArcGIS for Desktop end instead of round?"

In addition to answering the questions above, this chapter describes in greater detail the parameters of a projection. Parameters are variables that define a particular coordinate system. Let's put this into context and be very clear: why parameters are important. In doing up data in ArcMap, all data is created in some coordinate system. When you identify which coordinate system your data is in, you can *define the coordinate system for the data correctly – set or confirm the correct parameter values* – and it will drive in the right location in ArcMap in relation to other data. Basically, "defining the projection" for the data means selecting the coordinate system that correctly describes the coordinate extent of the data on the surface of the earth.

COORDINATE SYSTEM DEFINITIONS PROVIDED WITH ARCGIS FOR DESKTOP

Refer to appendix B for the default installation location of ArcGIS for Desktop. In previous versions of ArcGIS for Desktop, nearly 5,000 projection files were installed with the software. At version 10.1 there would have been over 6,000 projection files. The decision was made to create Microsoft Access database tables to contain these coordinate system definitions instead. This leads to a quicker installation of the software, and greater efficiency in locating the specific coordinate system definition you want. The sheer number of these available coordinate systems makes it impossible for the user to randomly select a projection to define the coordinate system for data and expect that particular definition to line up the data in ArcMap. A systematic method for identifying the coordinate system of the data is essential.

The key to this process is the extent of the data. The data extent can be viewed and analyzed when the data is added to ArcMap. Data can be created in geographic, projected, or local coordinate systems. By examining the extent of the data in ArcMap, you can identify the type of coordinate system used to create the data. That process is described in chapters 1, 2, and 3. You can then apply additional techniques to determine the precise coordinate system of the data. In special cases, you can also create custom projection files to align data, a process discussed in chapters 4, 5, 6, and 9.

COORDINATE SYSTEM PARAMETERS

The following parameters are required for all coordinate systems:

- Name
- Units of measure
- Datum

In geographic coordinate systems the units are angles. The most commonly used units are degrees; 360 degrees in a circle. Other angular units that can be used in the geographic coordinate system definition are grad, gon, microradian, mil_6400, minute, minute_centesimal, radian, second, and second_centesimal. All these measurements, including the degree, appear as a portion of a radian in the geographic coordinate system in ArcGIS.

For the mathematically inclined

A radian is equal to 2π , or

$$2 \times 3.141591530269234\dots = 6.2831830605384687\dots$$

The value of a degree in the geographic coordinate system definition, therefore, appears as

$$6.2831830605384687\dots \div 360^\circ = 0.017453292519943295$$

The values of other angular units used in the geographic coordinate system definitions are also calculated in relation to the value of the radian.

Projected coordinate systems use linear units such as meters or feet, and may require a zone number (for UTM, Gauss-Kruger, some national grids, and state plane [United States and territories only]) in addition to the name, units, and geographic coordinate system.

Other parameters may be required for some projected coordinate systems and values may be provided by the data source in units of decimal degrees. **Decimal degree units are used in ArcGIS for Desktop to define the following parameters for the coordinate system:**

- Central meridian or longitude of origin
- Standard parallel 1
- Standard parallel 2
- Latitude of origin
- Longitude of natural origin
- Latitude of natural origin
- Longitude of second point
- Latitude of second point
- Azimuth
- Rotation angle

False easting and false northing parameters are provided in linear units. The values will usually be in feet or meters, and will be the same as the units of the coordinate system.

Converting to decimal degrees

Projection files in ArcGIS for Desktop only use units of decimal degrees (DD) for parameters. If projection parameters are given in degrees-minutes-seconds (DMS), here is how to convert to DD using the Windows system Calculator:

- Open the calculator by going to Start > Programs > Accessories.
- Click View > Scientific.
- Click View again, and make sure Decimal and Degree options are selected.
- Enter the degree value followed by a decimal point, then the minutes and seconds values after the decimal.
- For example, if the DMS value is $-115^{\circ} 42' 23.75''$, enter -115.422375 (note that only one decimal point is entered).
- Check the box labeled "Inv".
- Click the button labeled "dms".
- The output in decimal degrees is $-115.70659722222222222222222222222222$. . .
- Recall that ArcGIS for Desktop stores values to 16 significant digits, so the value entered for this Central Meridian in the projection definition will be -115.70659722222222 .

Another example:

- The DMS value is $43^{\circ} 30' 48.8''$.
- Enter 43.30488.
- Check the Inv box, then click dms.
- The DD value after conversion is $43.51355555555555555555555555$. . .
- The parameter value will be entered as 43.513555555555556.

WHAT IS A GEOGRAPHIC COORDINATE SYSTEM?

A geographic coordinate system (GCS) displays data within a grid of equal size cells, and uses angular units of measure to give coordinates for longitude (x) and latitude (y). A geographic coordinate system has four components:

1. Spheroid (ellipsoid)
2. Datum
3. Prime meridian
4. Units of measure

WHAT IS A SPHEROID?

A spheroid (ellipsoid) is a mathematical representation of the shape of the earth calculated most recently from satellite measurements, although older spheroids calculated from ground measurements are also used in some cases. The terms "spheroid" and "ellipsoid" refer to the same mathematical model or shape, so to simplify the text, the term "spheroid" will be used.

The earth includes variations in elevation from the top of Mount Everest (at more than 29,000 feet) to the surface of the Dead Sea (at about 1,200 feet below sea level), plus the depths of the oceans. Methods for deriving a mathematical center of the earth and an average surface for the entire globe vary but they all result in a spheroid. Many spheroid values have been published over the years. These different spheroids can have comparatively large variations in size and shape.

A spheroid is a 3D shape created from a 2D ellipse. The ellipse is an oval, with the major axis (the longer axis) through the earth at the equator, and the minor axis (the shorter axis) from the North Pole to the South Pole, as shown in figure 10-1. A parabolic curve is drawn connecting the ends of the axes to create an ellipse. Rotate the ellipse around its minor axis and the shape of the rotated figure is a spheroid.

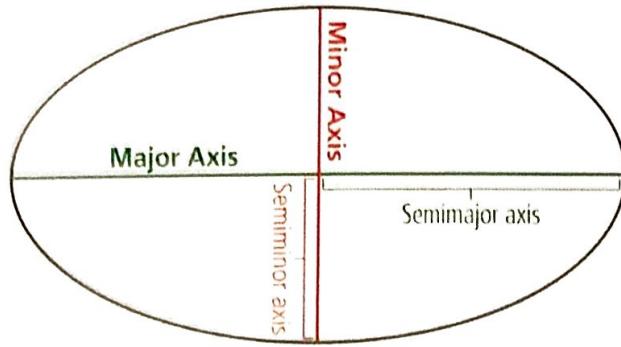


Figure 10-1 The major and minor axes of the ellipsoid and their position relative to the earth. The illustration shows how the semimajor and semiminor axes values for the spheroid are derived from the ellipsoid measurements.

The semimajor axis is half the length of the major axis. The semiminor axis is half the length of the minor axis.

One particular spheroid is distinguished from another by the lengths of the semimajor and semiminor axes and by the curvature of the surface defining the spheroid. For example, compare the

Clarke 1880 spheroid with the GRS 1980 and the WGS 1984 spheroids, based on the following measurements (in meters):

Spheroid	Semimajor axis	Semiminor axis
Clarke 1880	6378206.4 m	6356583.8 m
Geodetic Reference System (GRS) 1980	6378137 m	6356752.31414 m
World Geodetic System (WGS) 1984	6378137 m	6356752.31424518 m

A particular spheroid can be selected for use in a specific geographic area because that spheroid does an exceptionally good job of modeling the curvature of earth's surface *for that part of the world*. For North America the spheroid of choice is GRS 1980, on which the North American Datum 1983 (NAD 1983) is based.

WHAT IS A DATUM?

Datums—the collection of points of known accuracy used to georeference map data—can be horizontal or vertical. (A vertical datum provides a zero control point for elevations or depths and will not be discussed further in this book.) A horizontal datum is a reference for measuring longitude and latitude for a particular area of the earth's surface. A horizontal datum can be local, representing the average surface for an area as small as a single island; for example, St. Lawrence Island, part of Alaska. It can be a datum representing a country, such as the Japan Geodetic Datum 2000 (JGD 2000); a continent, such as the European Datum 1950 (ED 1950), the South American Datum 1969 (SAD 1969), or the North American Datum 1983 (NAD 1983); or the entire world, such as World Geodetic System 1984 (WGS 1984).

The underlying datum and spheroid to which coordinates for data are projected change the coordinate values. The following example uses coordinates for a location within the city of Bellingham, Washington, USA.

Compare the coordinates in decimal degrees for Bellingham in the NAD 1927, NAD 1983, and WGS 1984 datums. It becomes apparent that the coordinates expressed by the latter two are nearly the same, but the first one varies significantly: the coordinates of Bellingham on NAD 1983 and WGS 1984 are less than 3 meters apart for the same point, while the coordinates for the same place on NAD 1927 are quite different from the other two. This is because the underlying shape of the earth is expressed differently by the datum and spheroid. For comparison, the point on NAD 1927 is almost 100 meters or about 318 feet away from the point on the NAD 1983 datum.

Datum	X-coordinate Longitude	Y-coordinate Latitude
NAD 1927	-122.466803687	48.744049072
NAD 1983	-122.468183538	48.743879854
WGS 1984	-122.468198672	48.743885575

The x-coordinate is the measurement of the angle from the prime meridian at Greenwich, England, to the center of the earth, then west to the longitude of Bellingham, Washington. The y-coordinate is the measurement of the angle formed from the equator to the center of the earth, then north to the

WHAT IS A PRIME MERIDIAN?

A line of longitude extends north to south from the North Pole to the South Pole. In a geographic coordinate system, the prime meridian is the line of longitude where the x-coordinate is 0 (zero). Longitude values east of the prime meridian are positive numbers; longitude values west of the prime meridian are negative numbers (figure 1-12 on page 12 illustrates this).

The prime meridian most often used is the line of longitude, extending from the North to the South Pole, through the Greenwich Observatory in England. Other prime meridians are also used in geographic coordinate systems: longitudes for points in Paris, Oslo, Beijing, and Jakarta are some of these alternative prime meridians. These alternative prime meridians center the data at that location, and in that geographic coordinate system the alternative prime meridian will have a value of 0 degrees longitude.

WHAT IS A PROJECTED COORDINATE SYSTEM?

A projected coordinate system (PCS) is a type of coordinate system used for data if a precise location, distance measurements between features, lengths of linear features, areas of polygons, or the direction between points must be calculated. This is because a projected coordinate system is a 2D Cartesian system that simplifies calculations. A PCS is also used if the exact compass bearing between features must be measured.

WHY USE A PROJECTED COORDINATE SYSTEM INSTEAD OF A GEOGRAPHIC?

In a geographic coordinate system, locations are measured in angles from the known point of origin of the GCS. Because the earth is about 12,756,274 meters (12,756.274 kilometers or 7,926 miles) in diameter and 40,075,017 meters (40,075.017 kilometers or 24,901 miles) in circumference at the equator, 1° at the equator is about 111,319.5 meters (111.32 kilometers or 69.17 miles). Coordinates in decimal degrees do not provide very accurate placement of a point location, unless the value is carried out to many decimal places.

Because the units for a GCS are angles, the angle cannot tell you anything about distance on the ground. If you say a line is 1° long on the surface of a ball, it does not matter if the diameter of the ball is 1 meter or 12,756,274 meters. The "length" of the line is still 1° , even though on our one-meter ball 1° measures about 8.7 millimeters, whereas on the earth's equator the 1° angle measures 111,319 meters on the ground. The angular measurement is still only 1° and doesn't tell the user anything about distance on the surface. (For an illustration, refer to figure 9-3 on page 150.)

Area is length multiplied by width, and the length and width have to be measured in linear units. An area calculated in decimal degrees multiplied by decimal degrees gives an "area" in square decimal degrees or squared angles. Mathematically this makes no sense. That is why you sometimes need to use projected coordinate systems for your data. A GCS cannot be used when measuring distances or calculating areas because the length of a degree has no relation to surface distances.

Geographic coordinate system angles also introduce an additional complication. The equator circles the earth halfway between the North and South Poles. Being a circle, it is 360° around, and measures about 24,901 miles or about 40,075 kilometers. This is called a "great circle," a circle of maximum distance around the earth.

Any circle drawn around the earth from the North Pole to the South Pole and back is called a **great circle** and measures 360°. These circles are lines of longitude and the **equator** is a great circle for the position of data.

Say we have two lines of longitude that are 1° apart (111 km) separated, one at 0° and the other at 1° latitude, at the equator. As the lines of longitude are drawn north toward the North Pole, the distance **increases** because the North Pole is a point. Near the North Pole, these two lines of longitude are still 1° apart but have almost no distance between them.

The length of a degree in the *x* direction, measuring north to south, decreases the closer you are to the measurements in the *y* direction along the line of longitude you are trying to go. While the length of a degree of longitude on the ground gets smaller as you move away from the equator, the length of a degree of latitude is always the same. This unequal length of a degree in the *x* and *y* directions on the ground is the other reason why lengths of areas cannot be calculated with just a **DEGREE**.

Since the convergence of the lines is continuous from the equator to the pole, 1° east to west at 45° latitude is 78,847 meters; at 80°, that degree is 10,193 meters and at 90°, 1,000 meters. You can see from these numbers that coordinates in degrees cannot possibly provide the needed dimension measurements.

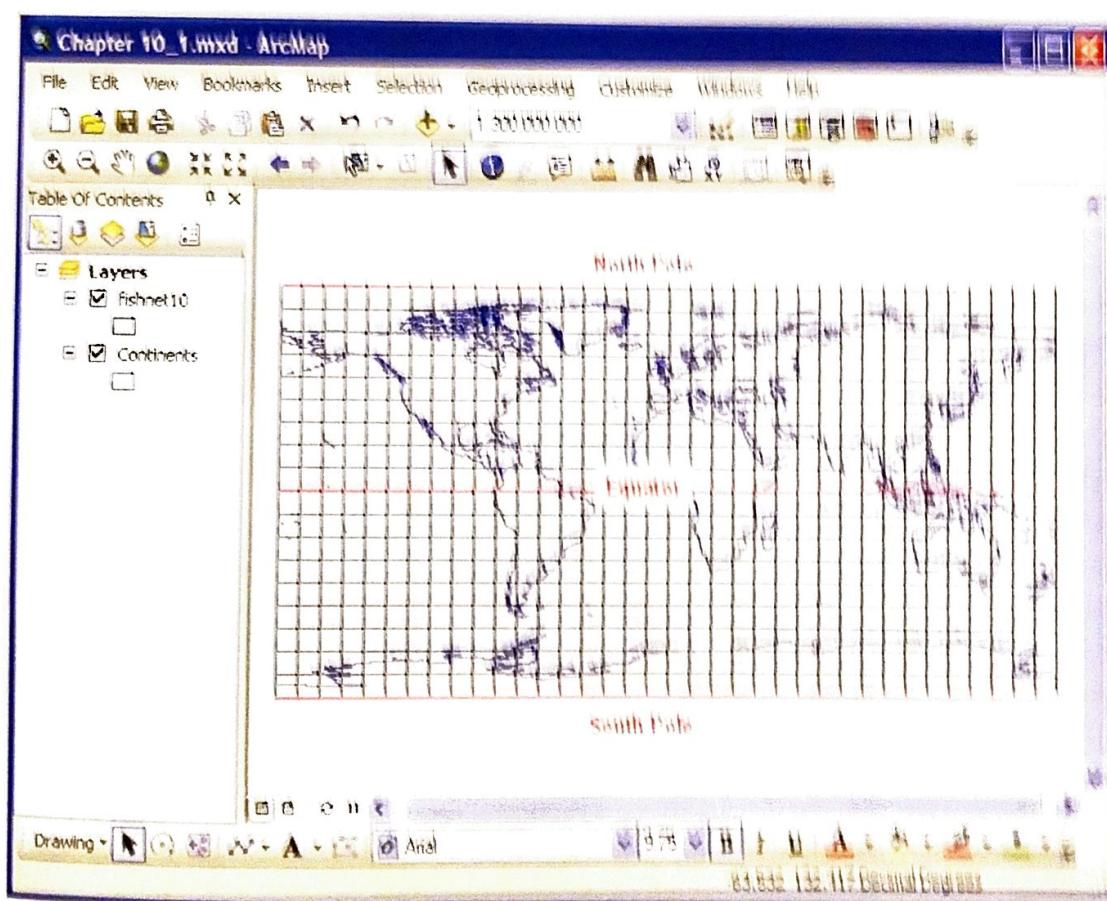


Figure 10-2 A $10^\circ \times 10^\circ$ grid covering the entire earth's surface, displayed over the continental map.

Figure 10-2 represents a $10^\circ \times 10^\circ$ grid of the earth's surface. This data is being displayed in a pseudo-plate carrée projection, which treats the angles as if they are linear units. The *meridians* are angles, each square is 10° on a side, even though the North Pole and South Pole, across the top and bottom of the grid, are supposed to be points.

PROPERTIES OF PROJECTED COORDINATE SYSTEMS

When projecting the rounded surface of the earth onto a flat piece of paper, different properties of the data will be preserved. When one of these properties is preserved in a particular projection, the other properties will be distorted. The **properties of map projections** are usually classified as

- Shape (Conformal)
- Equal area
- Equidistant
- True direction

Because each of these properties can be important for certain projects, many map projections have been created to preserve each of these specific properties for data: for certain purposes, for specific extents, for specific areas of the world, and for data that has a particular shape. These properties are mutually exclusive. You cannot have a map projection that preserves both the shape of data and distance. If the area being mapped is small (large scale) like a city, the distortion of the data may not be obvious, but the distortion will exist. If the area shown in the map is the entire world (small scale), the distortions inherent in different types of map projections will be very visible.

If preserving the **shape** of the data is most important, you would select a **conformal** projection. You have probably seen a map of the world where Greenland looks nearly as large as South America. Figure 10-2 illustrates an example. The shape of the data is preserved, but distance and area are very much distorted—Greenland is actually about one-tenth the size of South America.

If your project requires that **area** be measured most accurately, you would select an **equal area** projection for the data. Figure 9-7 on page 154 illustrates an equal area projection, Behrmann, for the entire world. Other equal area projections are suitable for smaller geographic areas.

If your project requires that **distance** be measured most accurately, you would select an **equidistant** projection for the data, although not all distances can be preserved. Generally, all east-west or north-south distances are preserved, or all distances from the origin point of the projection. No equidistant projection can be calculated for the entire world.

If you are flying a plane or sailing a boat and need to **plot your course**, you would select a **true direction** projection so that the angle of the line drawn on the map would be the course you fly or sail to get to your destination. The azimuthal equidistant projection, illustrated in figure 9-8 on page 155, approximates true direction on a world scale.

WHAT IS A LOCAL COORDINATE SYSTEM?

Local coordinate systems are very often used when creating computer-aided design (CAD) files. An arbitrary point is selected on the ground, often at a street intersection, property boundary corner, a survey monument, or other point. That point will become the 0,0 point for survey measurements. In the CAD program, bearings and distances for parcel data would then be drawn based on survey measurements from that point location. For detailed instructions on working with data in local coordinate systems, refer to chapters 4, 5, and 6.

ADDING X,Y DATA TO A TABLE AND CONVERTING TO FEATURES IN A SHAPEDFILE AND GEOREFERENCING FEATURE CLASS

Latitude and longitude coordinates are often more frequently provided in CSV files in digital form. The coordinates can be stored in a geodatabase or tabular table, in a space-delimited text file, or a comma-delimited text file. The coordinates in the file are most often in units of degrees, but may be in degrees, minutes, and seconds (DMS) rather than decimal degrees (DD).

Coordinates provided in CSV need to be converted to DD before the points can be displayed in ArcMap.

In ArcGIS 10.8 for Desktop, coordinate conversion can be performed using the Convert Coordinate Nodalities tool in Arc Tools > Data Management Tools > Projections and Transformations. The tool describes the supported file and coordinate formats, and instructions for executing the tool. This tool will write the output coordinates to a shapefile or geodatabase feature class.

Knowledge Base article 9074 on the Esri Support Center includes a Python script and instructions for converting coordinates to DMS to DD. Here is the link to the article: <http://support.esri.com/knowledgebase/techarticles/detail/9074>.

To convert these point coordinates to data in your CSV, you also need to make sure that the signs for the values are correct. The image in Figure 10-12 on page 112 shows the distribution of positive and negative longitude and latitude values for locations across the earth. For x,y data in North America, the x coordinate (longitude) values must be negative, while the y coordinates (latitude) values are positive numbers.

ADDING THE X,Y DATA TABLE TO ARCMAP

There are two methods for adding the table containing x,y data to ArcMap. One good one is to click Add Data, navigate to the directory where the table is stored, and add the table directly to the ArcMap session (see Figure 10-11).

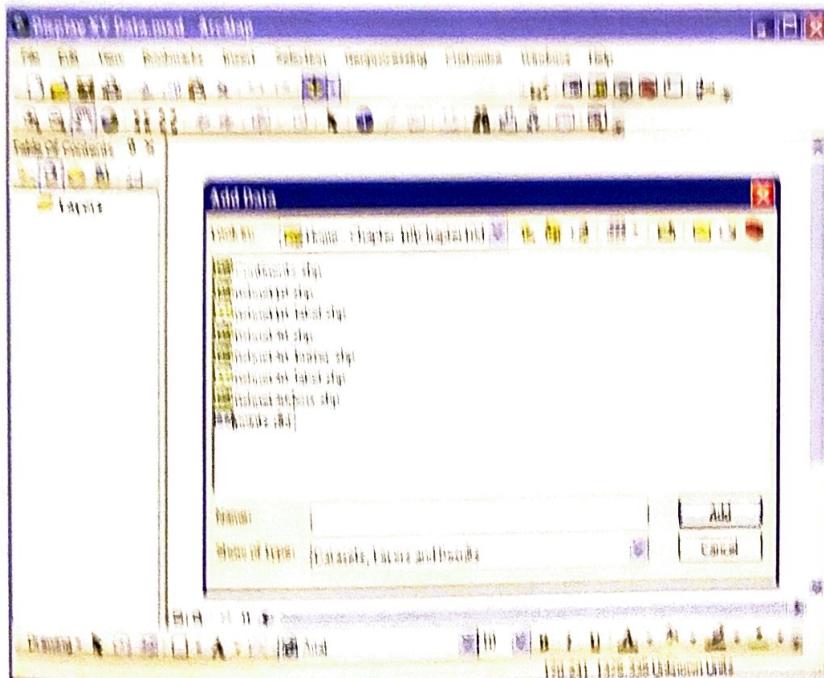


Figure 10-3 Select the table containing the point data through the Add Data dialog box in ArcMap and add the table to ArcMap.

As noted previously, the table coordinates may be given in decimal degrees or in units of DMS. They might even be in feet or meters, using a projected coordinate system such as state plane or UTM. Adding the table to ArcMap, then opening the table—*before* defining the projection—will allow you to examine the table, find the names of the fields that contain the coordinate values, and decide on the most likely coordinate system definition for the values.

In this example the coordinates are in decimal degrees, as displayed in figure 10-4. The names of the fields containing the x- and y-coordinates are conveniently named POINT_X and POINT_Y.

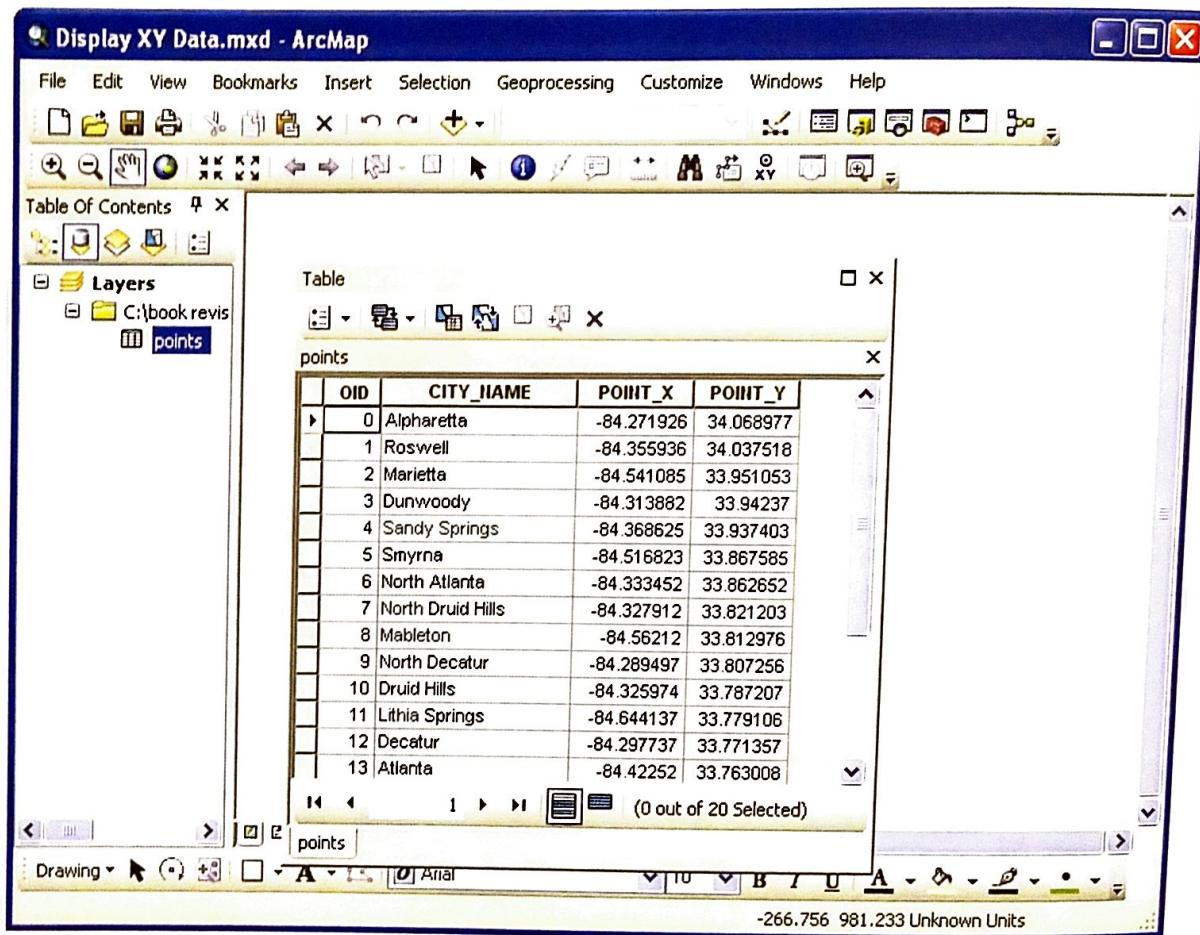


Figure 10-4 These coordinates are in decimal degrees and show points for cities in the state of Georgia, in the United States.

To display the points in ArcMap, right-click the name of the table and select Display XY Data. In this dialog box, populate the X Field and Y Field boxes with the field names that contain the x- and y-coordinates, as shown in figure 10-5.

In this figure, notice that ArcMap populated the X Field and Y Field boxes automatically, *but the value selected for the Y Field is wrong*. This is fixed by clicking the Y Field drop-down list and selecting the correct field name that actually contains the y-coordinate values.

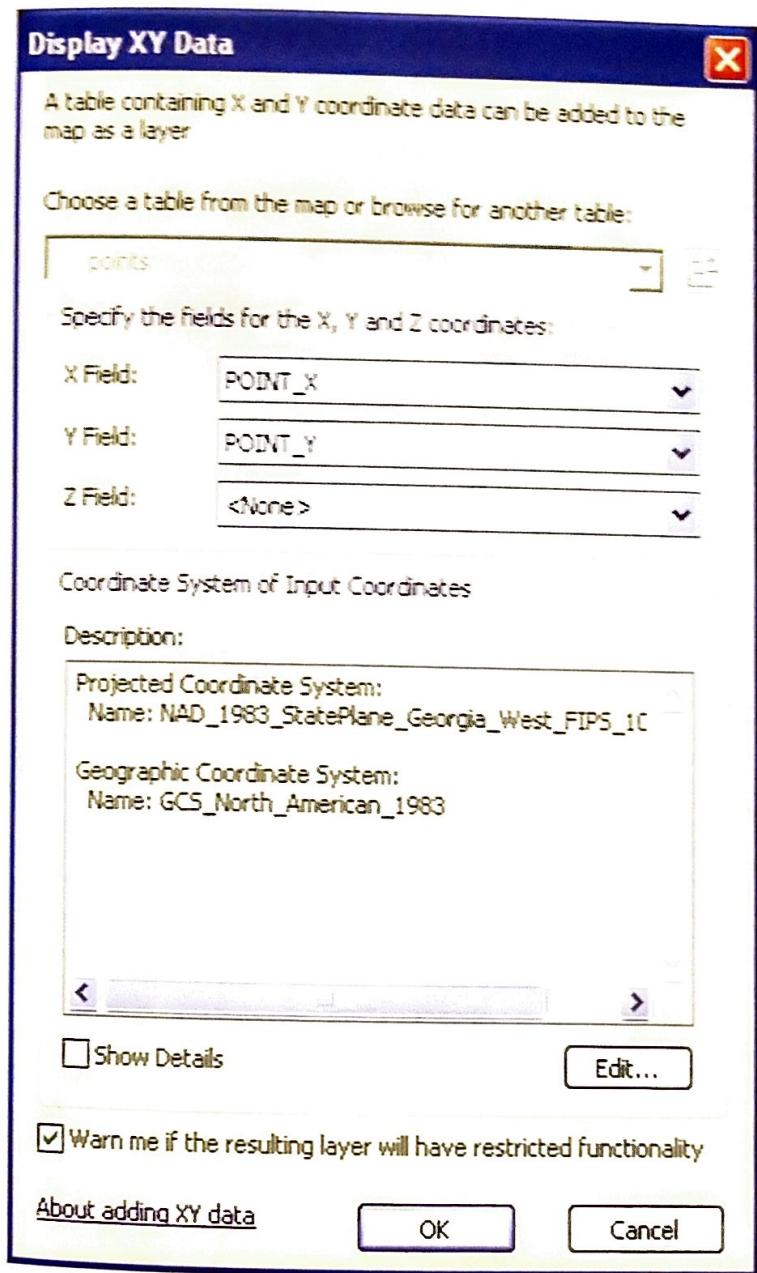


Figure 10-5 The fields containing the coordinates x (longitude) and y (latitude) are selected to populate the X Field and Y Field boxes in the dialog box. Note that the projection of the ArcMap data frame is assigned to the XY data by default, but that projection definition is incorrect for these data. These point coordinates, as shown in figure 10-4 are in a geographic, not in a projected coordinate system.

In ArcGIS 10.x for Desktop the software automatically assigns the projection of the ArcMap data frame to the point data, **but this coordinate system is often incorrect**. Based on your examination of the coordinate values, click Edit to open the Spatial Reference Properties dialog box, then click Select. In this example, since the data has coordinates in decimal degrees, we will open the Geographic Coordinate Systems folder > North America. The data source informed us that the coordinates were on North American Datum 1983, so we will select the coordinate system definition NAD 1983 from the available options. If we did not have that information from the data source, we would still begin by selecting this option for data within the United States. (Other techniques for identifying the geographic coordinate system for data are discussed in detail in chapter 2.)



Coordinate System

Type here to search



- Mexican Datum of 1993
- NAD 1927
- NAD 1927 (CGQ77)
- NAD 1927 (Definition 1976)
- NAD 1983**
- NAD 1983 (2011)
- NAD 1983 (CORS96)
- NAD 1983 (CSRS)
- NAD 1983 (NSRS2007)
- NAD 1983 (WGS84)



Current coordinate system:

GCS_North_American_1983

WKID: 4269 Authority: EPSG

Angular Unit: Degree (0.0174532925199433)

Prime Meridian: Greenwich (0.0)

Datum: D_North_American_1983

Spheroid: GRS_1980

Semimajor Axis: 6378137.0

Semiminor Axis: 6356752.314140356

Inverse Flattening: 298.257222101



OK

Cancel

Figure 10-6 The correct coordinate system definition has been selected for the point data. Click OK on the properties dialog box.

In figure 10-7, the coordinate system definition for the XY points now matches the coordinate system of the data. Click OK in the Display XY Data dialog box.

The point data will display in ArcMap, listed as an Events theme in the ArcMap toolbar. In addition to the surrounding state plane FIPS zones in figure 10-8, you can see the location in the Georgia West StatePlane FIPS zone 1002. This is the correct location for the

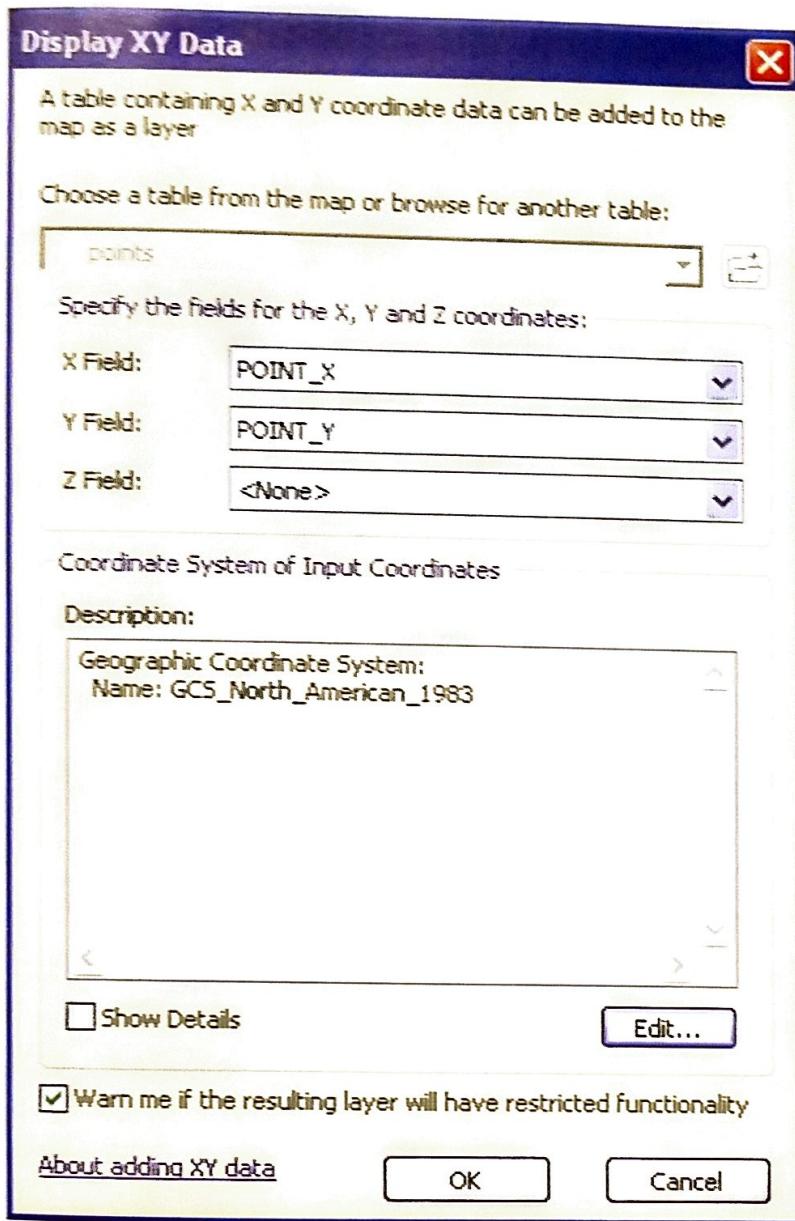


Figure 10-7 Display of the corrected coordinate system definition for the city points, which are in decimal degrees.

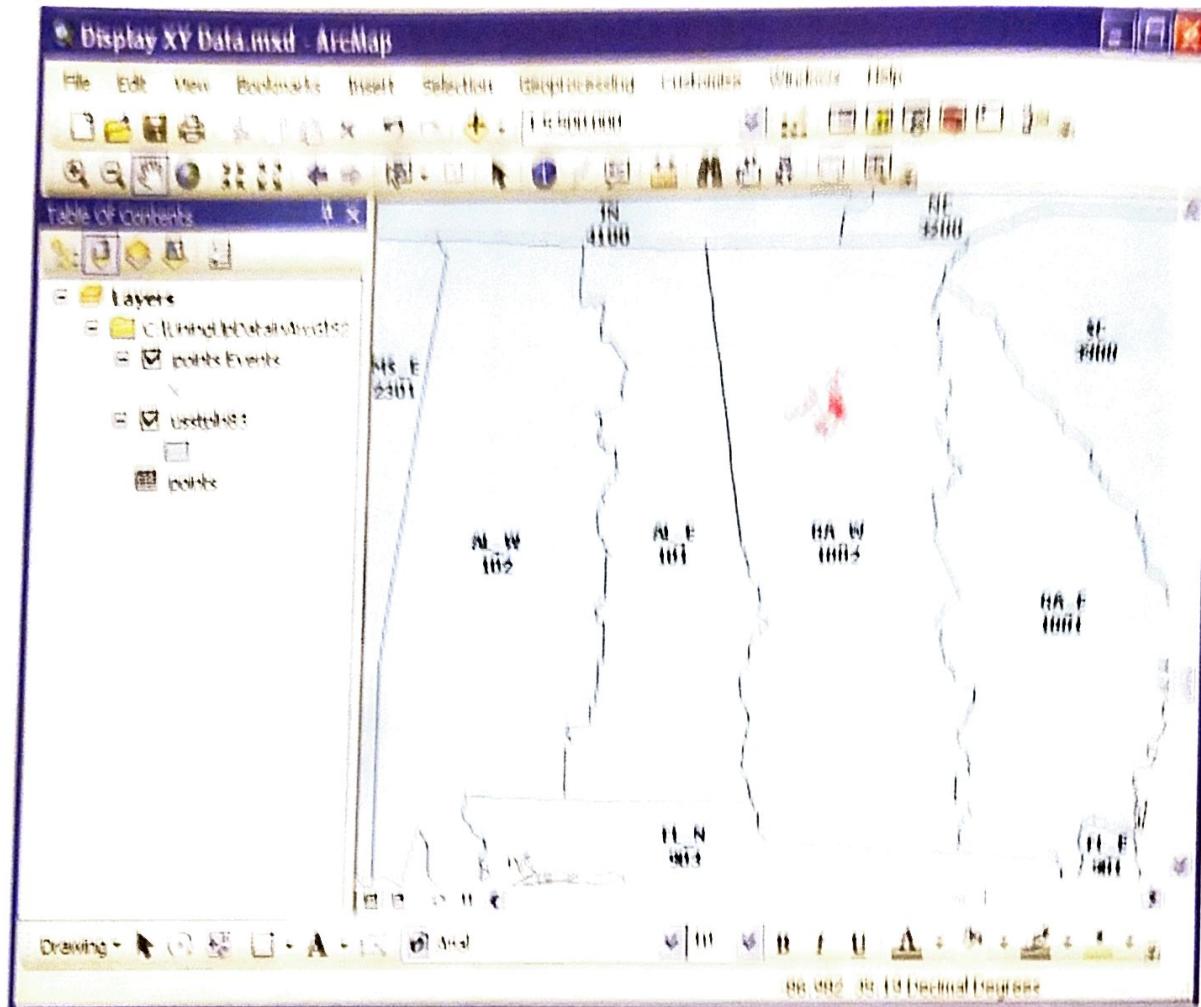


Figure 10-8 Display of the 'Points Events' theme in ArcMap, overlaying the *disaster.shp* file.

CONVERTING THE X,Y DATA TO SHAPEFILE OR GEODATABASE FEATURE CLASS

The Events theme shown in figure 10-8 has not yet been converted to a shapefile or geodatabase feature class. The data can be maintained as a table, but each time the data is added to ArcMap, the coordinate system would have to be defined again. It is much more useful to convert the data from the table to a shapefile or geodatabase feature class. Here are the steps:

- Right-click the name of the Events layer, and select Data > Export Data from the drop-down menu, as shown in figure 10-9.

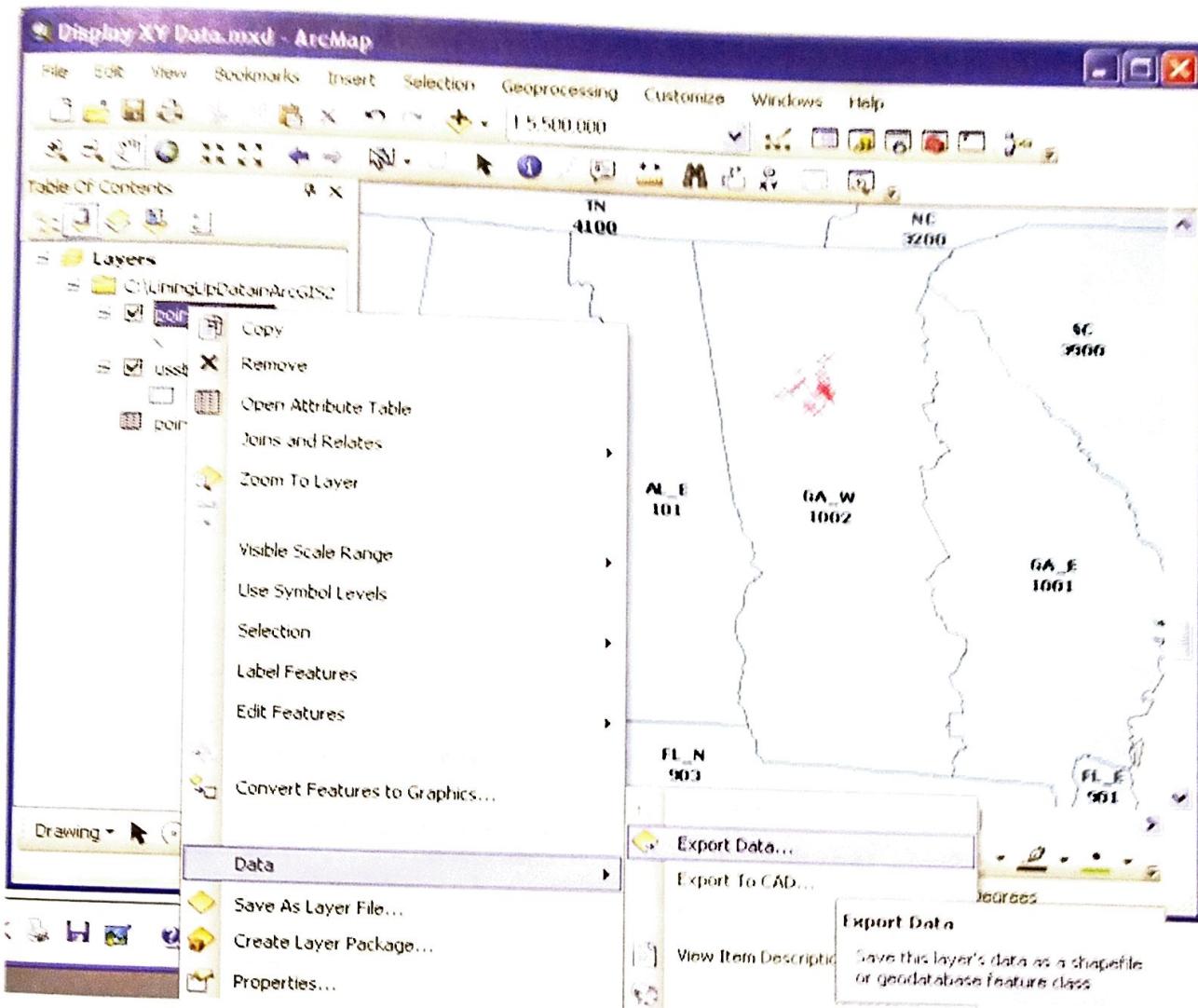


Figure 10-9 Accessing the Export Data dialog box in ArcMap to export the Events theme to a shapefile or geodatabase feature class.

- In the Export Data dialog box, click on the Browse button at the bottom of the dialog box to open the Saving Data dialog box. In that dialog box you can select the path to the location where the output data is to be saved, and select the format for the output data. The data can be saved as a shapefile or as a feature class in an existing geodatabase. It is useful to assign a sensible name to the output data instead of the default Export_Output. In this case a name like "georgia_cities_gdb83" indicates the kind of data in the output dataset and also provides information about the spatial reference of the data. See figure 10-10 for an example.

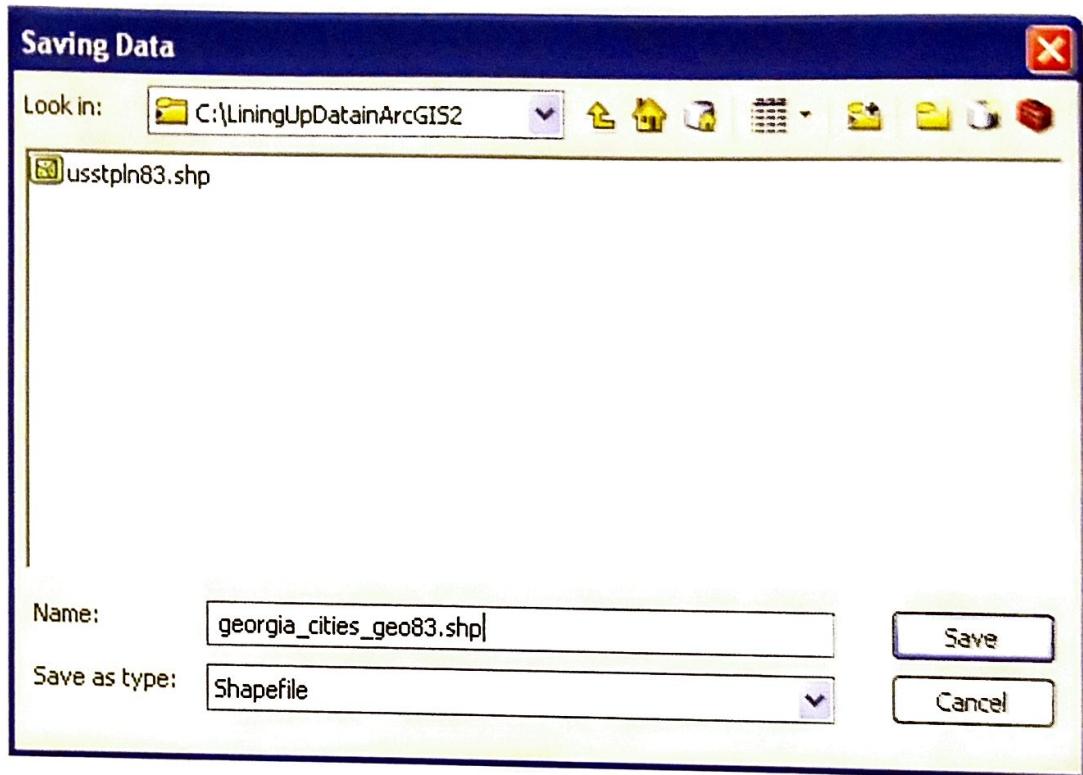


Figure 10-10 In the Saving Data dialog box, you can browse to the location where the output data will be saved and also select the format—shapefile or geodatabase feature class—for the output dataset.

- Click Save on the Saving Data dialog box, and then click OK on the Export Data box. A message will appear asking, “Do you want to add the exported data to the map as a layer?” Click Yes and the new shapefile or geodatabase feature class will be added to the map document.
- You can then remove the Events layer and the original table from the ArcMap data frame by right-clicking those layer names on the Source tab and selecting Remove.

The new dataset is now available for use in this and other map documents.

WHY BUFFERS DISPLAYED IN ARCMAP ARE NOT ROUND

When creating buffers around point features, then displaying the buffers in ArcMap, the buffers may not appear round or may not actually be circular. The shape of buffers around points in ArcMap is determined by two factors:

- The coordinate system assigned to the ArcMap data frame, which may be either geographic or projected.
- The units specified as the buffer radius, which may be linear (feet, meters, etc.) or angular (decimal degrees).

Best practice for creating geometrically correct buffers in ArcGIS for Desktop using the Buffer tool

When buffering point features with the Buffer tool (available in ArcToolbox > Analysis Tools > Proximity toolbox), project the points to a geographic coordinate system, and specify a linear buffer distance—feet, meters, miles, kilometers, or other linear units. The tool will create geodesic buffers, as measured across the curved surface of the earth. Buffers created in this way will be geometrically correct.

When buffering line or polygon features, create the output buffers in an equidistant projection suitable for the area of interest, by specifying that output coordinate system in the Environments dialog box.

For best results, particularly when buffering large, complex datasets, execute the Buffer tool first. If the buffers must be dissolved, run the Dissolve tool separately, after the buffer process has been completed.

In the following example, points are being buffered. It is important to remember that the same factors apply when the features being buffered are lines and polygons.

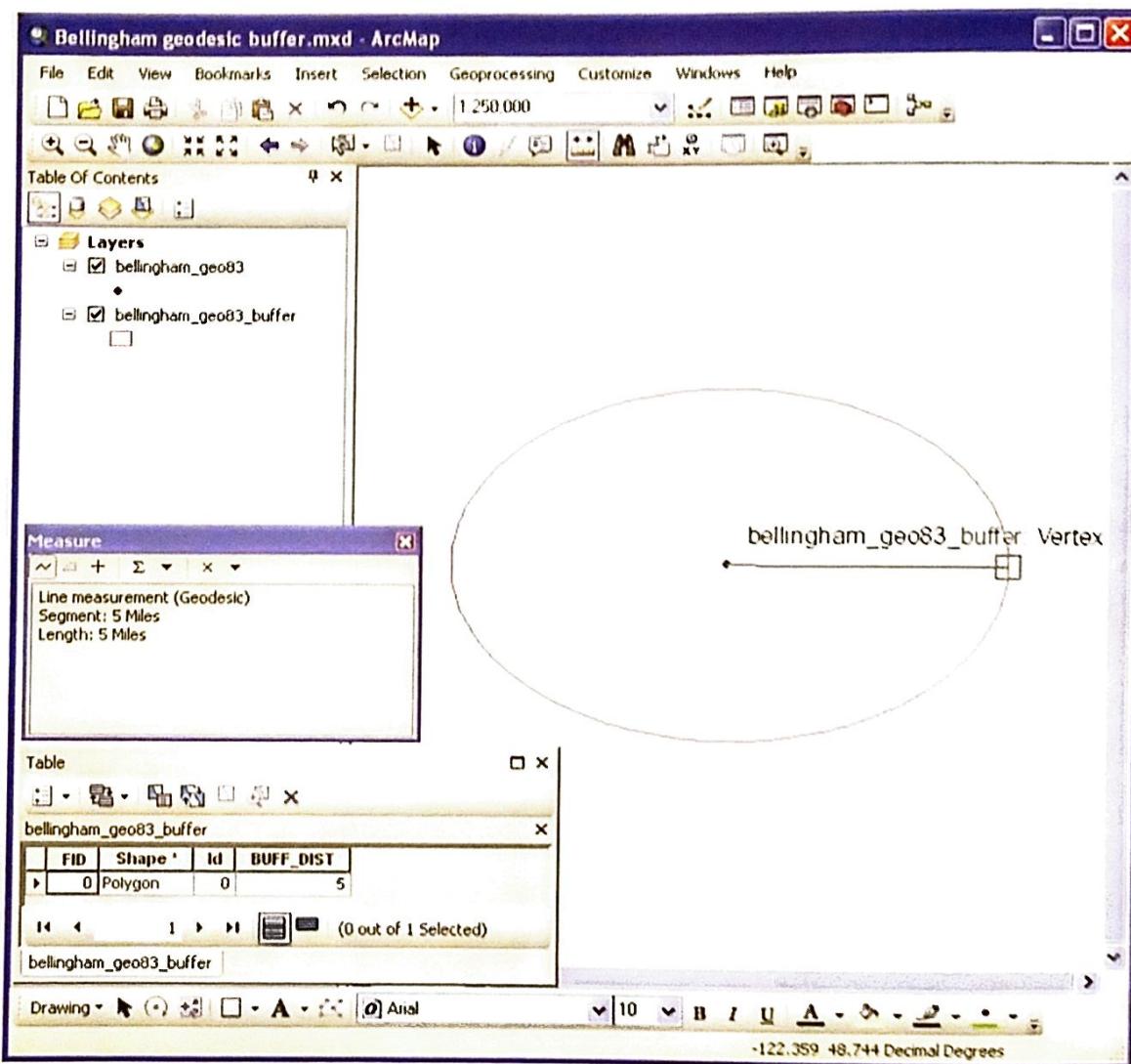


Figure 10-11a, Figure 10-11b The ArcMap display is set to GCS_North_American_1983 and the buffer distance is five miles. Measuring in any direction, the distance from the center point to the buffer is five miles even though the buffer appears oval.

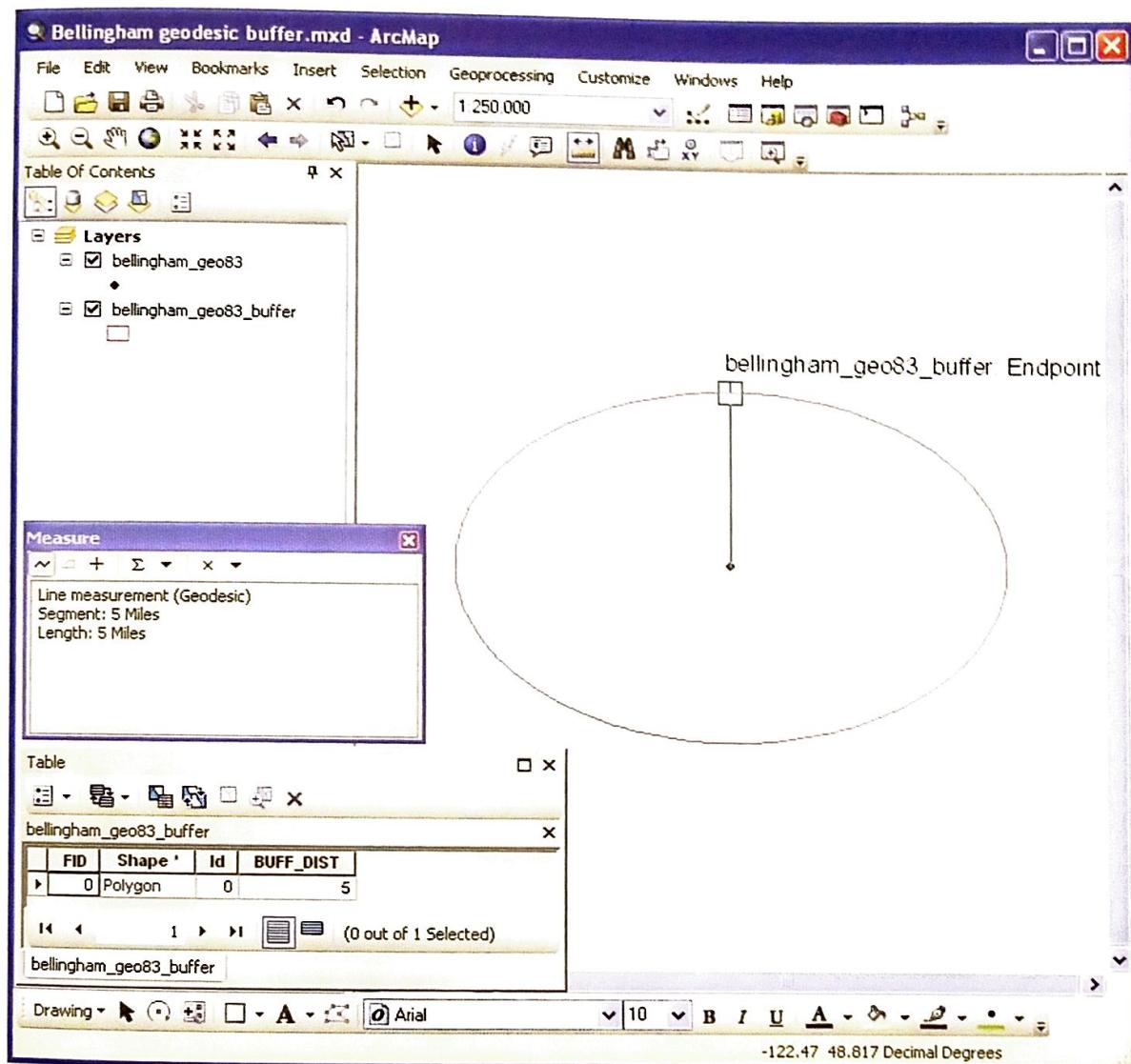


Figure 10-11a, Figure 10-11b (continued)

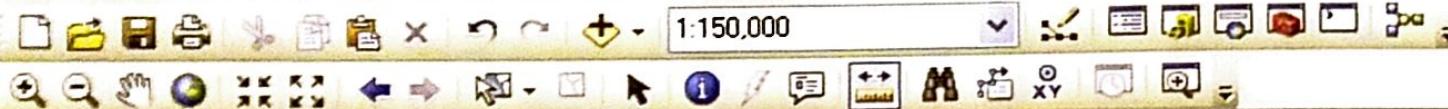
Examining figures 10-11a and 10-11b, you see that the point feature from the shapefile that is in geographic coordinates on the NAD 1983 datum and is displayed in the ArcMap data frame in GCS_North_American_1983 has been buffered using a buffer distance of five miles. The buffer does not appear round; the shape of this buffer is decidedly oval. However, using the Measure tool and setting the distance units to miles, you can measure from the buffered point to the buffer, in any direction, and the distance always measures five miles.

Looking back at figure 10-2 (page 173), you recall that data displayed in a geographic coordinate system is progressively more "stretched" in the east-west direction, the farther north or south the data is from the equator. The North and South Poles are points, but a geographic coordinate system displays distances in angular units—degrees—that do not reflect linear surface distances in the

Bellingham geodesic buffer.mxd - ArcMap



File Edit View Bookmarks Insert Selection Geoprocessing Customize Windows Help



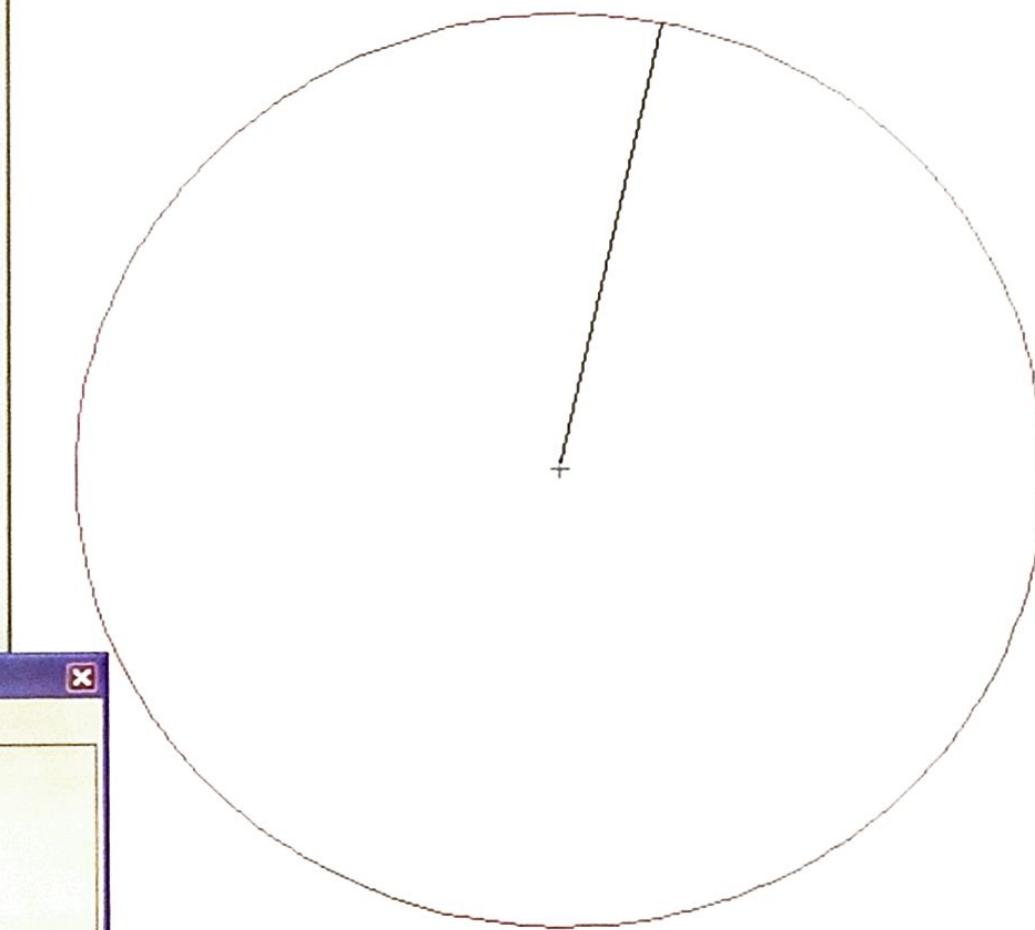
1:150,000

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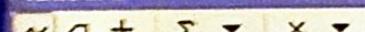


Layers

- bellingham_geo83
 - + |
- bellingham_geo83_buffer



Measure



Line measurement (Planar)
Segment: 5.001923 Miles
Length: 5.001923 Miles



Drawing



Arial

10

B

I

U

A



east-west direction properly. Since Bellingham, Washington, the location of this point, is far north of the equator, there is substantial east-west stretch of the data. This results in the oval appearance of the buffer.

Now take a look at figure 10-12. This is the same ArcMap document shown in figure 10-11 but the projection of the ArcMap data frame is now set to NAD 1983 UTM zone 10N. Because the data frame is now set to a projected coordinate system, the same buffer has assumed a round shape.

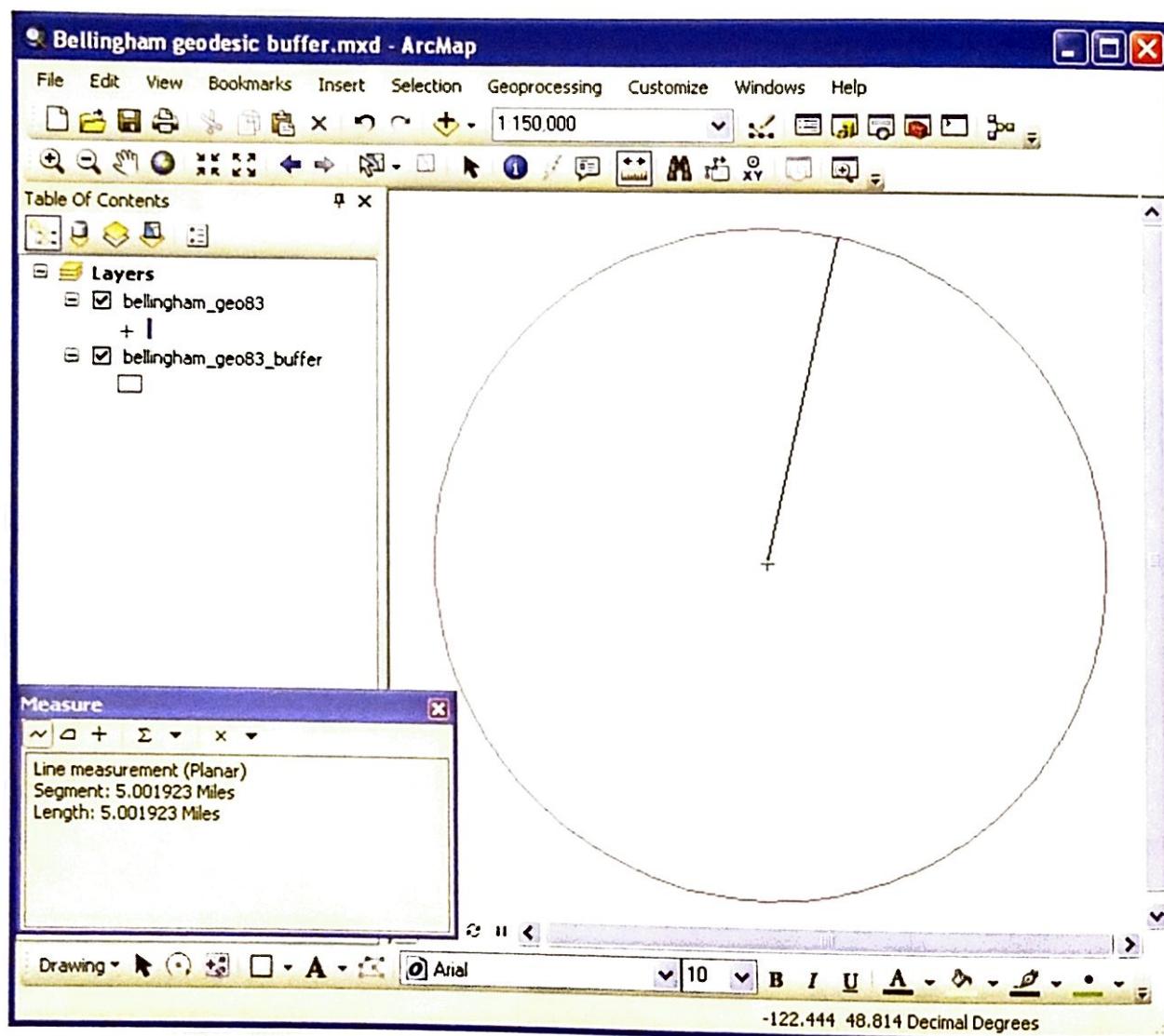


Figure 10-12 When the projection of the ArcMap data frame is changed from the GCS in figures 10-11a and 10-11b to NAD 1983 UTM Zone 10N as shown here, the oval buffer from the previous figure assumes the expected round shape, and the measured distance from the point to the buffer is still five miles. The measured distance does appear slightly different due to a change from geodesic to planar distance in the Measure tool.

In figure 10-13, the point shapefile bellingham_geo83.shp is buffered again, this time using an angular distance of 0.1 decimal degrees, so the buffer distance units match the units of the projection. Figure 10-13 displays this buffer, with the data frame set to GCS_North_American_1983.

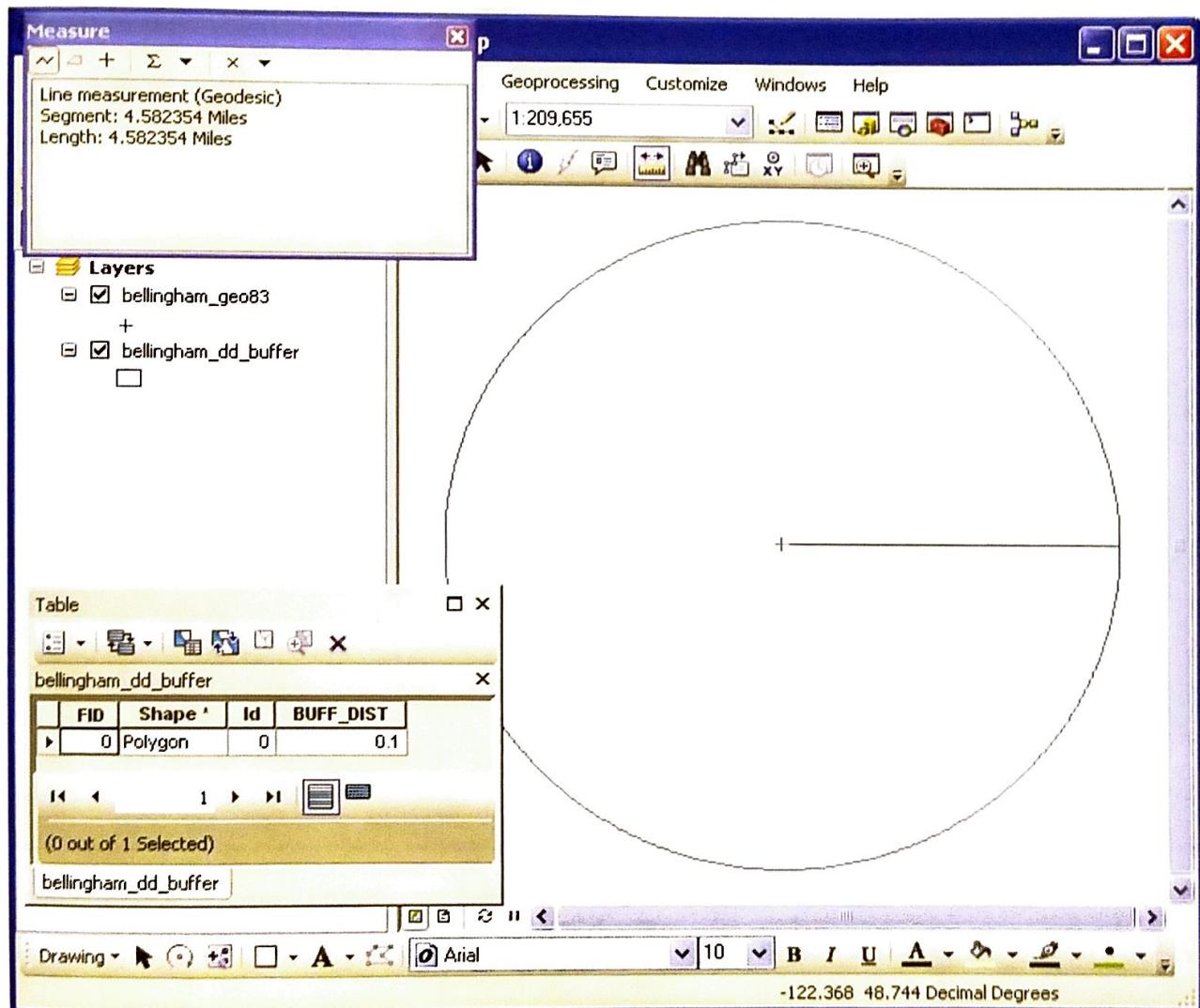


Figure 10-13 Using a buffer distance of 0.1 decimal degrees, the measurement from the center point east to the buffer measures 4.582354 miles. The measurement from the center point north to the buffer measures 6.909991 miles. Even though the display of the buffer is round, the buffer is not geometrically correct as it is displayed in figures 10-10 and 10-11a.

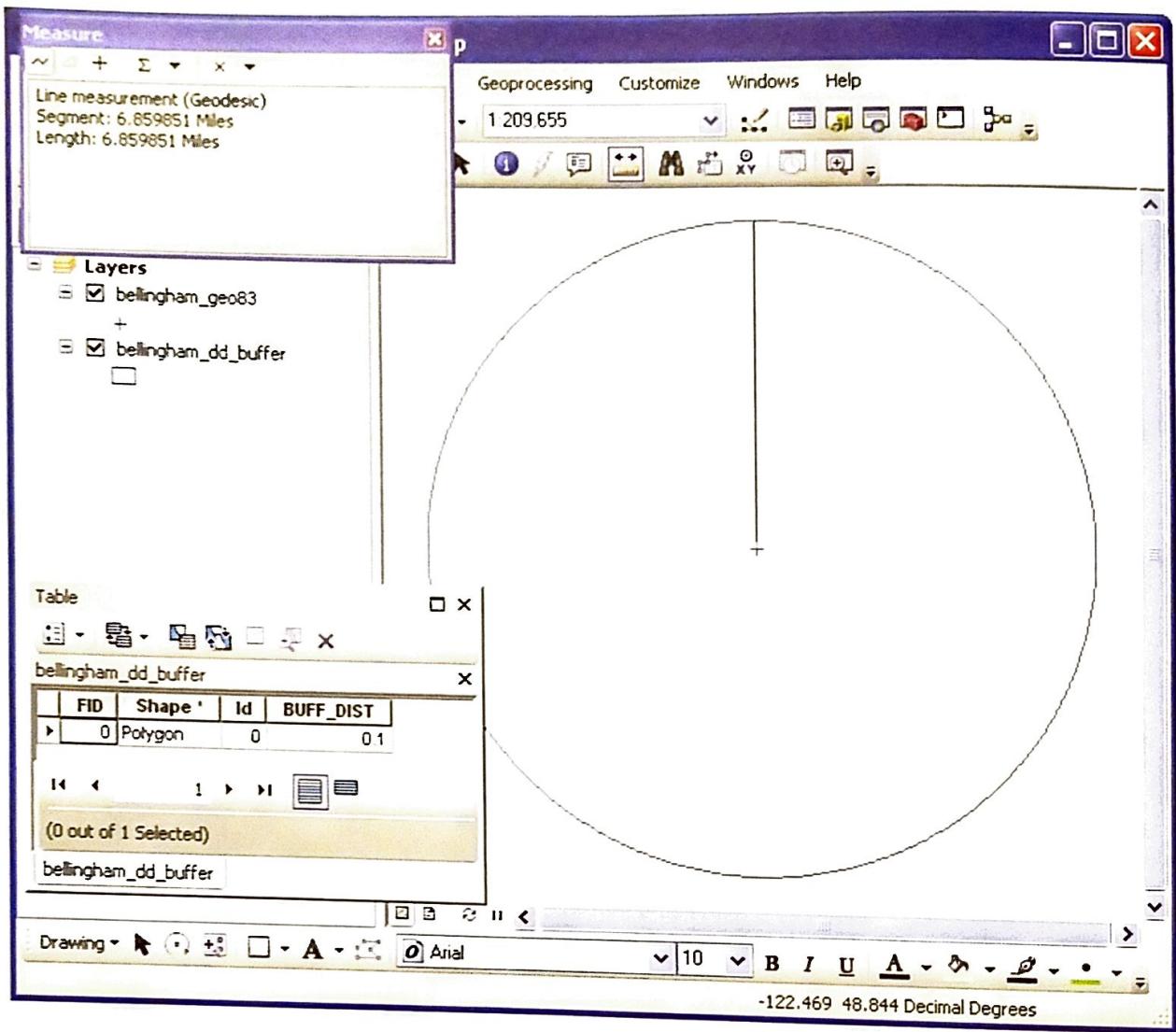


Figure 10-14 Measuring the same buffer as shown in figure 10-13, the distance from the center point to the northern edge of the buffer is 6.859851 miles. This demonstrates the difference in linear distance measured in the east-west direction versus north-south, when angular units of measure, decimal degrees, are used to create the buffer.

In figure 10-15, both the buffer created with linear units of miles and the buffer created with an angular unit of 0.1 degrees are displayed together in a geographic coordinate system. Compare this with figure 10-11b, in which the five-mile buffer (red) is also displayed in a GCS. The red buffer that is geometrically correct displays as an oval, while the 0.1 degree buffer (blue) displays as a circle, even though we verified that the east-west buffer distance is not the same as the distance in the north-south direction shown in figures 10-13 and 10-14.

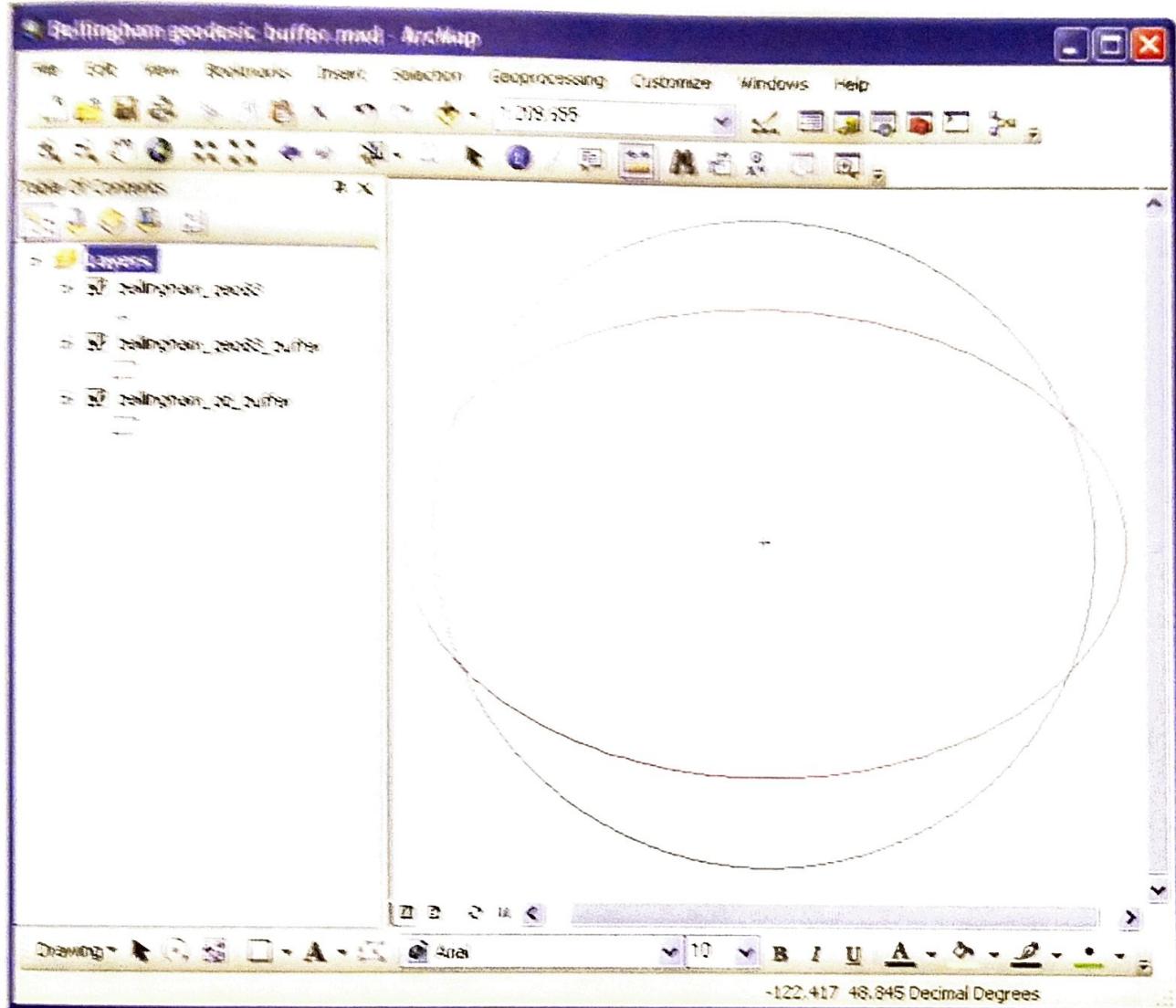


Figure 10-15 The coordinate system of the ArcMap data frame is set to a GCS. The red buffer, created with a linear buffer distance of five miles, appears as an oval even though this buffer is geometrically correct and measures five miles from the center point to the buffer in all directions. The blue buffer, created with the angular distance of 0.1 degrees, appears round even though the distance from the center point to the buffer varies in all directions.

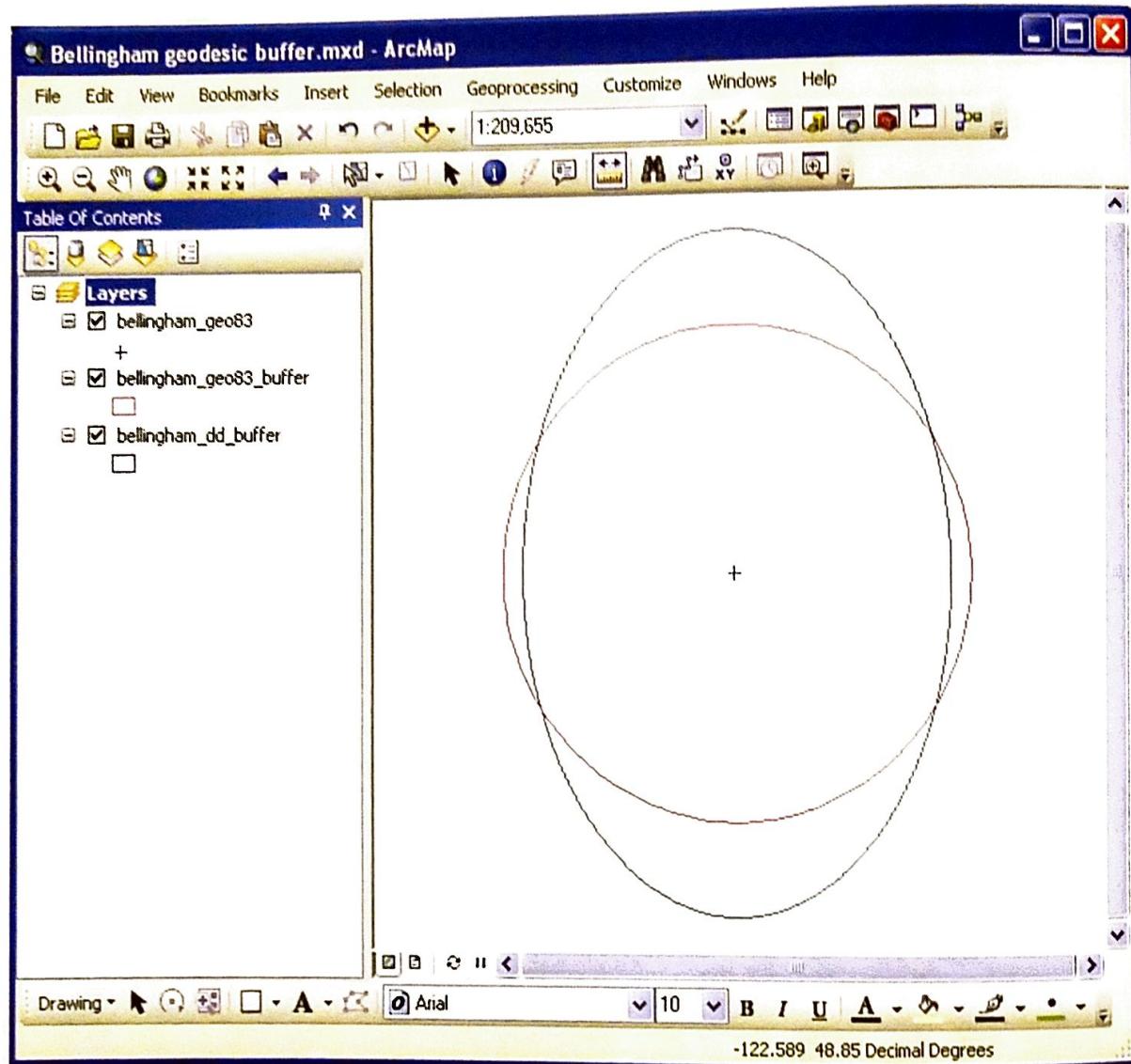


Figure 10-16 Both the five-mile buffer (red) and the 0.1 degree buffer (blue) are displayed with correct proportions when the coordinate system of the ArcMap data frame is set to a projected coordinate system, in this case NAD 1983 UTM zone 10N. Notice that the blue buffer, which was created with a “distance” in degrees, is compressed east to west. Since we know that lines of longitude converge toward the poles, this is correct behavior.

When buffering data, there are some issues to consider so that the buffers being created will properly serve their purpose.

The coordinate system selected to display the data can cause distortion in buffers. People unfamiliar with that fact often expect buffers to be round. As we have just seen in the figures above, buffers that are geometrically correct can look like ovals if displayed in a GCS. Buffers created with angular units, which are not geometrically correct, appear round when displayed in a GCS.

In order to realize the expectations for round buffers while at the same time creating buffers that are geometrically correct and can be used to analyze data, the best practice is to buffer features with a linear distance unit—feet, miles, meters, kilometers—and to display the buffers in an appropriate projected coordinate system.

In the following illustration, buffers were created around points in a geographic coordinate system (WGS_1984) and the points are 30° apart east to west as well as north to south. The buffer distance, the radius of the buffers, was specified as 15°.

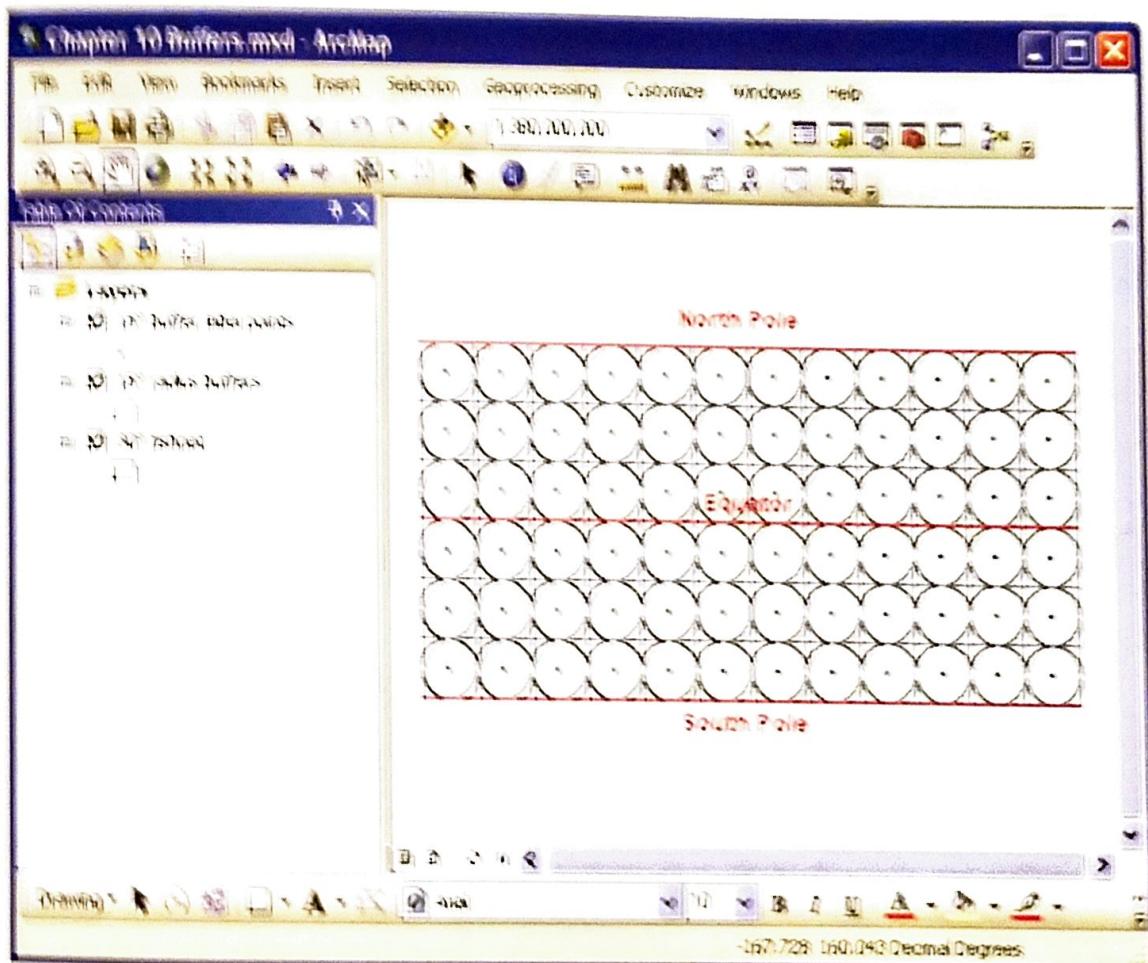


Figure 10-17 A 30° grid covering the entire earth's surface. Each grid "square" is filled with a circle having a radius of 15° and a diameter of 30°.

With the ArcMap data frame set to WGS_1984 as shown in figure 10-17, the buffers appear round, and all the buffer "circles" appear to be the same size. Recall, though, that when displaying data for the world in a geographic coordinate system, the North and South Poles, which are points, are stretched until both points appear as long as the equator. The buffers north and south of the equator are also stretched in the east-west direction.

To illustrate this, the Measure tool, set to distance units of miles, is used to measure the east-west distance across one grid cell at the equator. This measurement is shown in figure 10-18.

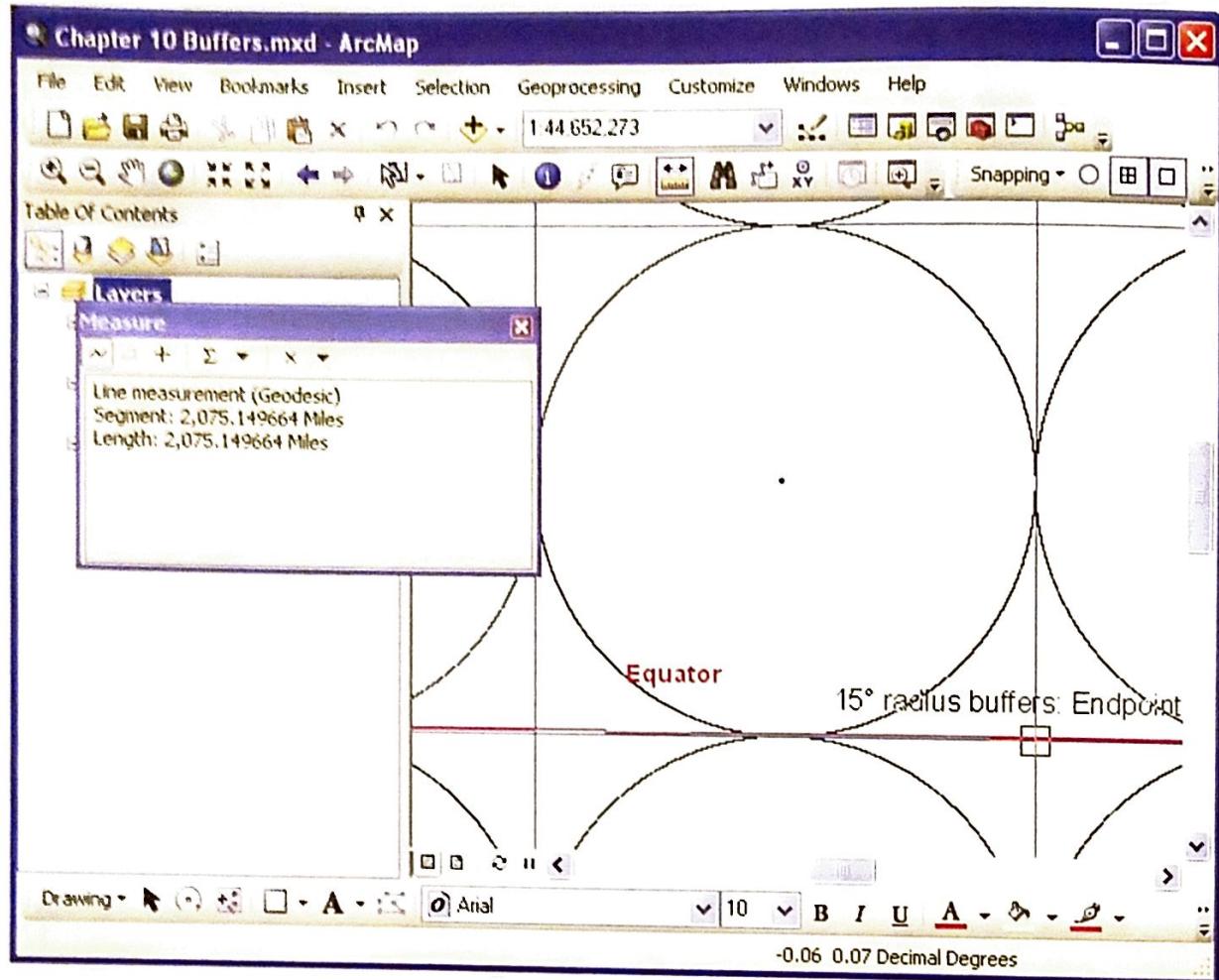


Figure 10-18 Distance measurement of 30° east to west at the equator is about 2,075 miles, as shown in the Measure tool output.

Now, in figure 10-19, let's measure the east-west distance across the buffers close to the North Pole.

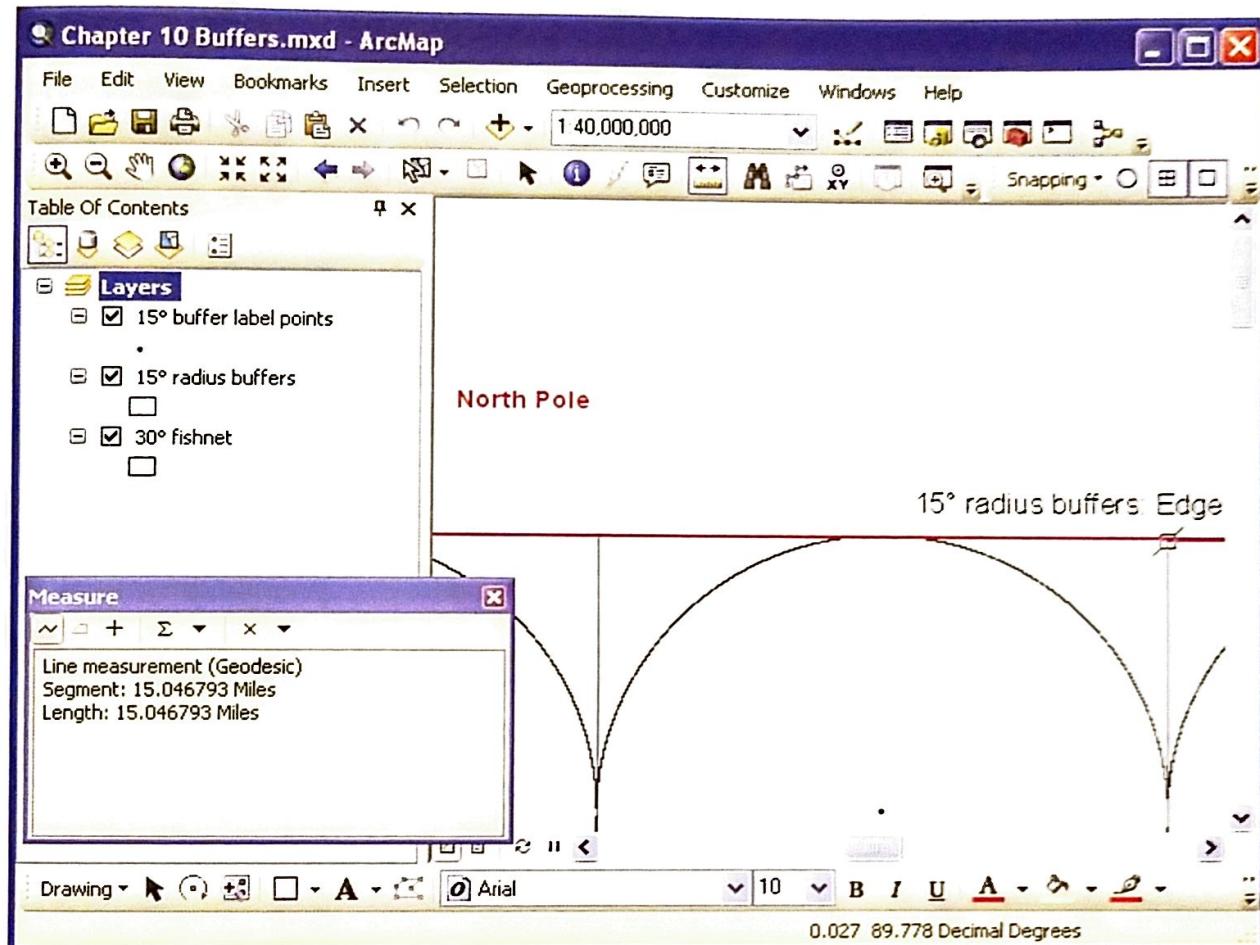


Figure 10-19 The linear distance covered by 30° east to west close to the North Pole is only about 15 miles.

Note the position of the snapping control, and notice that the actual linear distance is now about 15 miles instead of 2,075 miles.

Now change the coordinate system of the ArcMap data frame to a projected coordinate system that illustrates the North and South Poles as points. Applying a sinusoidal-based coordinate system to the ArcMap data frame, and zooming in to a smaller area, you can see the compression of the buffers (as shown in figure 10-15). Instead of displaying as round circles, the buffers now look egg-shaped. The east-west compression of the buffers now illustrates the linear east-west distance across the buffers much more accurately, in figure 10-20.

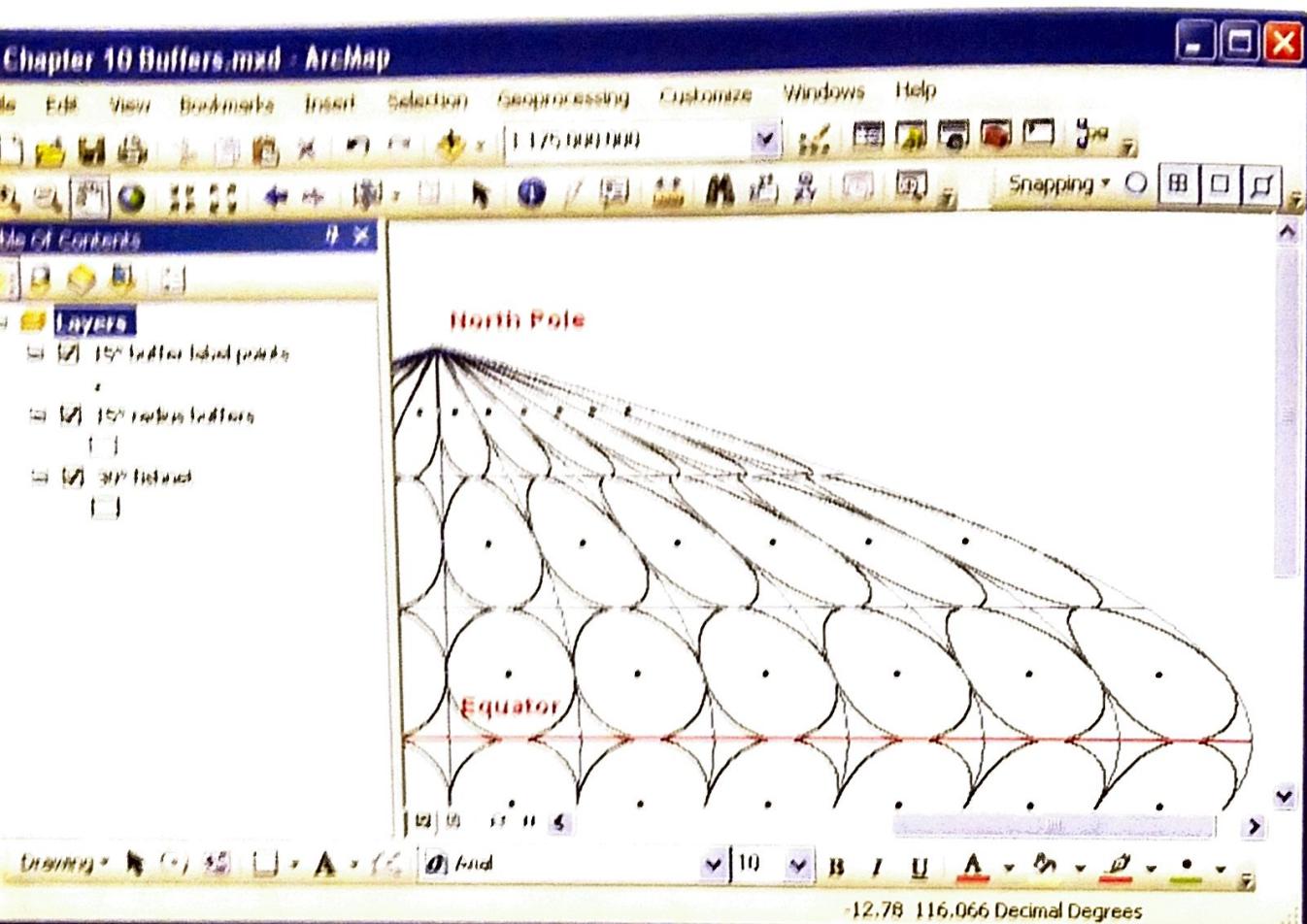


Figure 10-20 Circles with 30° diameters displayed in the sinusoidal projection. Sinusoidal approximates equal area for the entire world. Note that the areas covered by the buffers now show a more realistic representation of each area on the ground, but the buffers appear egg shaped.

Aitoff (figure 10-21) is a compromise projection, but can represent areas for the entire world with reasonable accuracy. Again note the change in shape of the buffer circles when zooming in to a quarter of the globe. The North Pole is again represented as a point, although the representation is not as extreme as with the sinusoidal projection. (View the latter representation of the data in figure 10-13.)

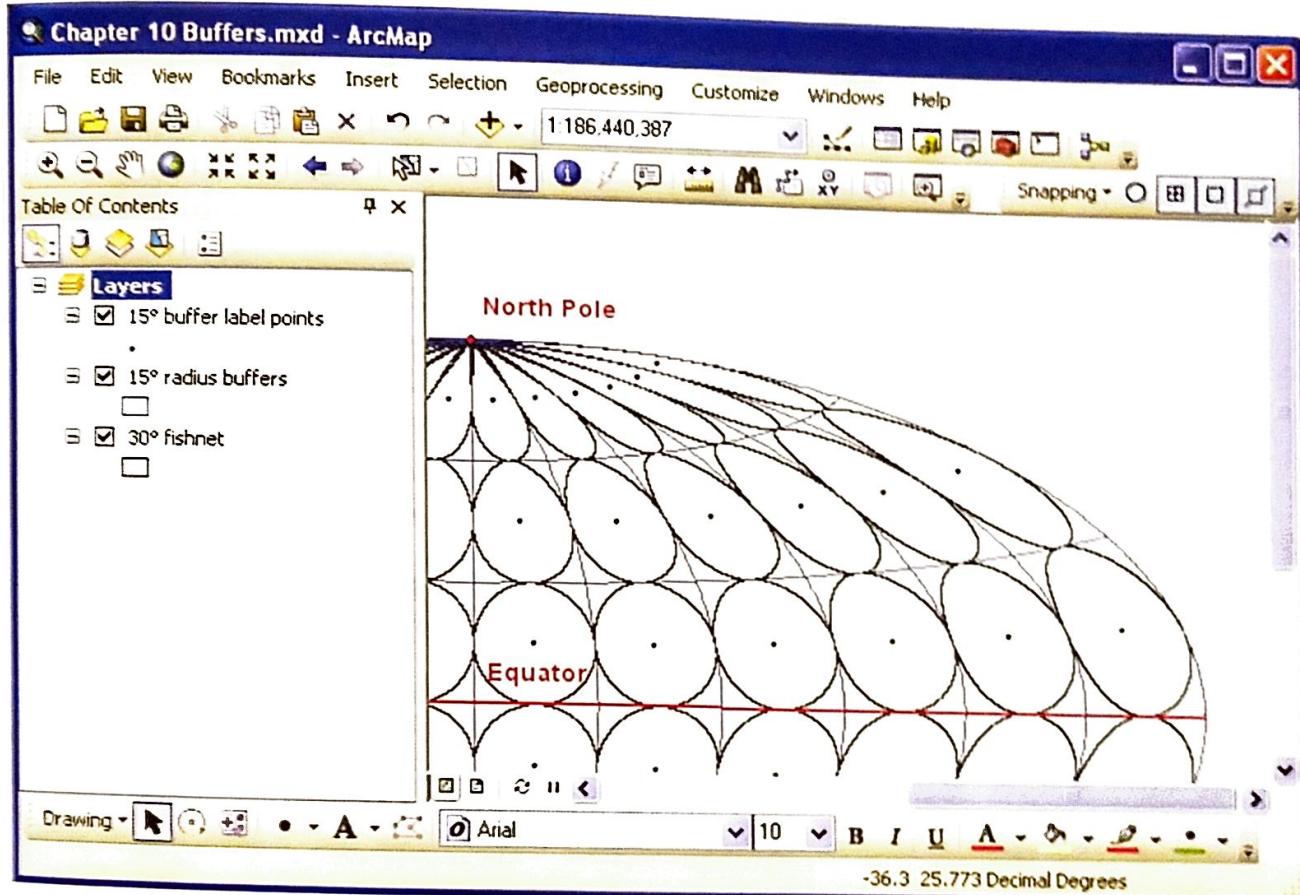


Figure 10-21 Here, the Aitoff projection is used to illustrate the true proportionate areas of the buffers.

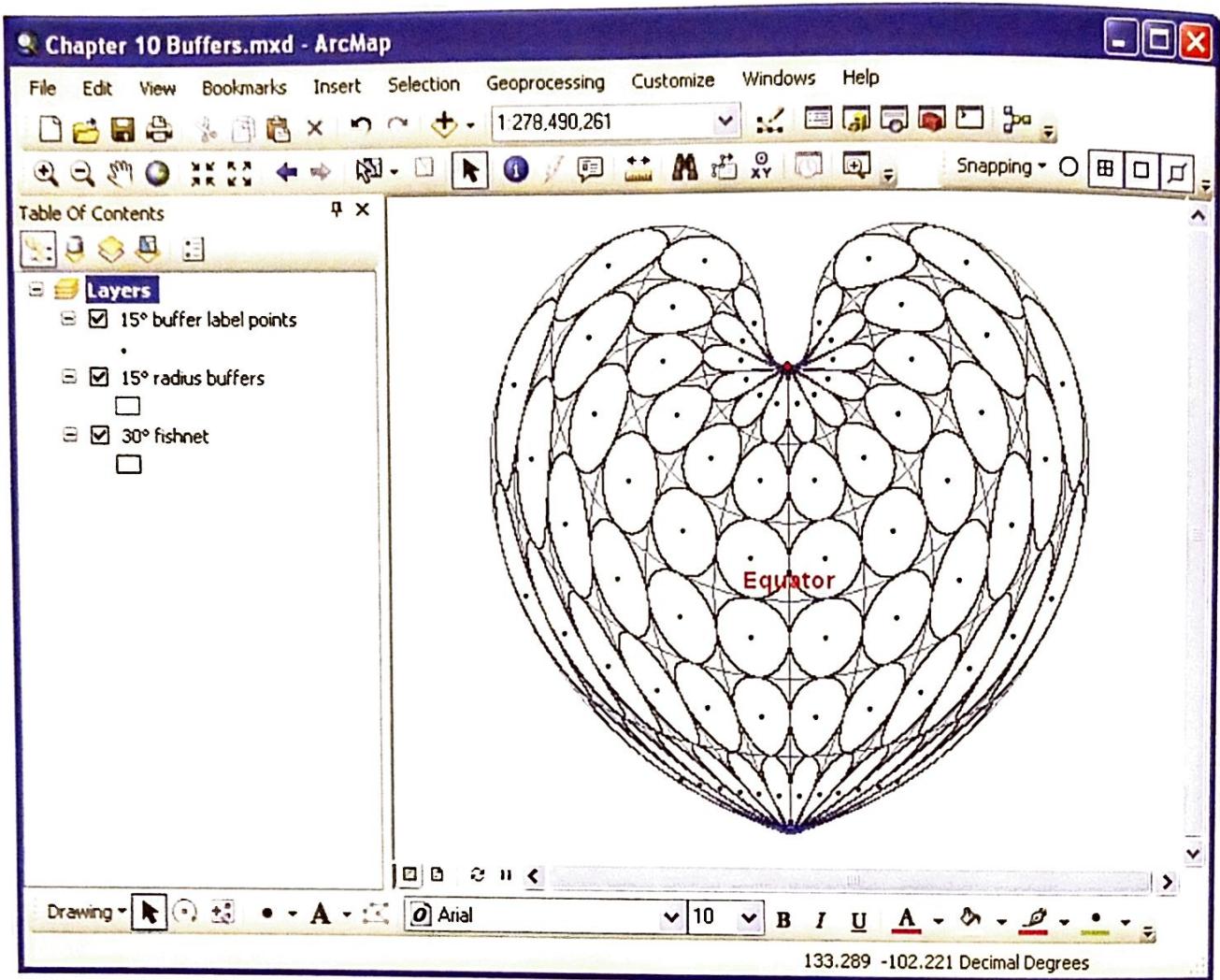


Figure 10-22 Bonne is an equal area projection suitable for use in continental areas.

SUMMARY

This chapter addresses the construction of projection files and explains their parameters in greater detail. The chapter also answers two very common questions:

How do you add x,y data to ArcMap and make the data line up with other data?

Why are buffers created with the tools in ArcGIS for Desktop oval instead of round?

Those of us who work in the field of GIS go to our jobs every day, doing our best to make the world a better place. We hope the information presented in this book will be useful to you and will contribute to our shared goal.