
Introduction

We are living on a spherical earth and the location of any feature can be determined by using a coordinate system.

The latitude and longitude is a 3-D coordinate system or spherical coordinate system that describes the location of features on the earth surface. Another type of coordinate system which can be used is called “Projected” or “Plane” coordinate.

There are various types of plane coordinates systems, which is expressed in x and y coordinate. The plane coordinates is the projection of the sphere from 3-D view into 2-D plane view. The latitude and longitude coordinate can be converted directly into different plane coordinates. The conversion from one coordinate to another is extremely important in any GIS work. The conversion from latitude longitude to any plane coordinate is called projection. Conversion from one plane coordinate to another plane coordinate is called re-projection. ArcGIS is an advanced software and can accommodate and handle any projections and coordinate conversions (Fig. 5.1).

Geographic Coordinate System (GCS)

The GCS is used to locate and measure the location of any feature on the earth surface in terms of latitude longitude and it's based on 3-D sphere. The earth is divided into two types of lines, **meridians** and **parallels**. Longitude is the line of meridians that run from north to south and measure the East-West locations. The prime meridian is running straight from the North Pole to South Pole and passing through Greenwich in England. The rest of the meridians are moving away from the prime meridian and are spaced farthest apart on the equator and converge to a single point at the North and South Poles.

Latitude are lines of parallels and run from East-West and measure location in North-South direction (Fig. 5.2). Parallels are equally spaced between the equator and the poles and always parallel to one another, so any two parallels are always the same distance apart all the way around the globe. Parallels and Meridians cross one another at right angles 90°.

The longitude ranges from 0° to 180° east and 0° to –180° west, while the latitude ranges from 0° to 90° north and 0° to –90° south. The East-North orientation is positive and the West-South orientation is negative.

The latitude longitude is used the same way the x, y coordinate is used in any plane coordinate. It is used as a reference grid to find location of features. The origin of the GCS is the point where the prime meridian intersects the equator.

Latitude and longitude can be measured either in degree minutes and second or decimal degree. One degree equals 60' minutes and one minute equals 60" seconds (see Chap. 4).

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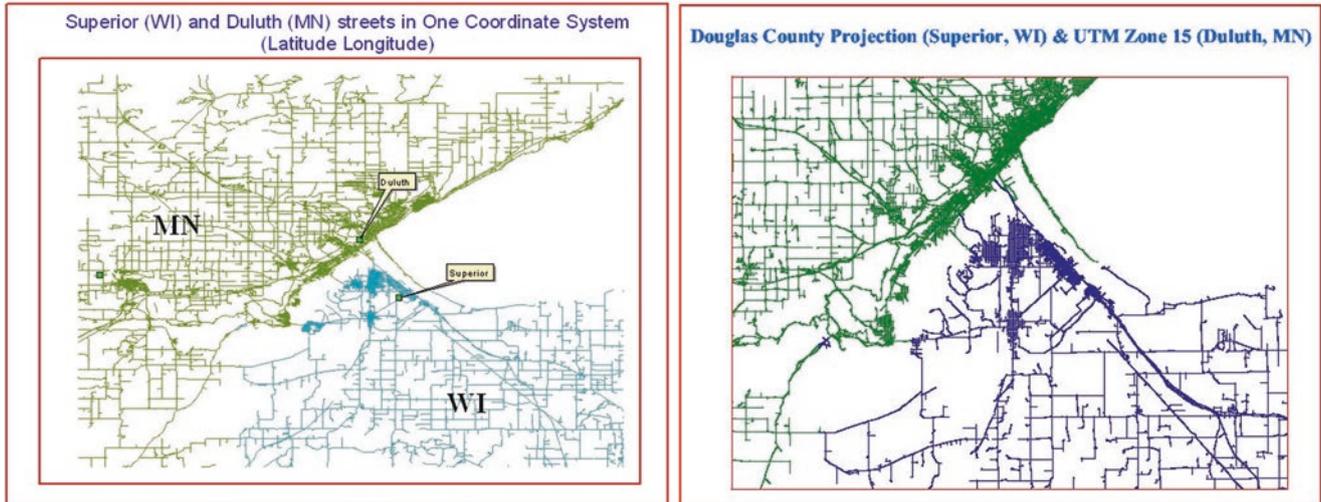
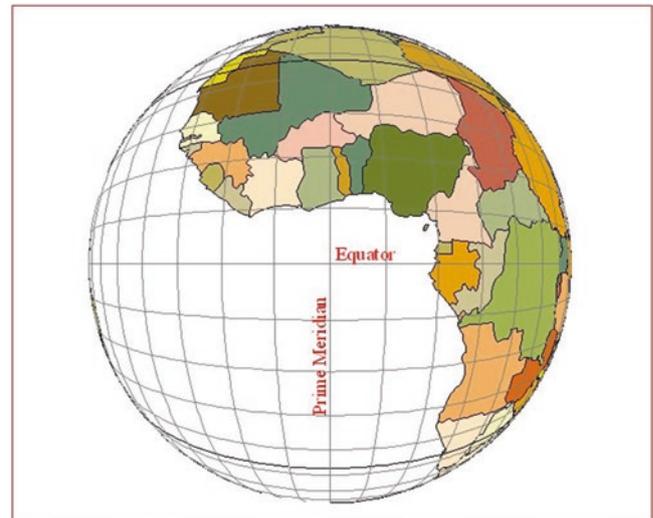


Fig. 5.1 The left map shows the streets of Superior (WI) and Duluth (MN) registered in latitude longitude. The right map shows the same file is registered in projected coordinate

Fig. 5.2 Line of latitude and longitude



Map Projections

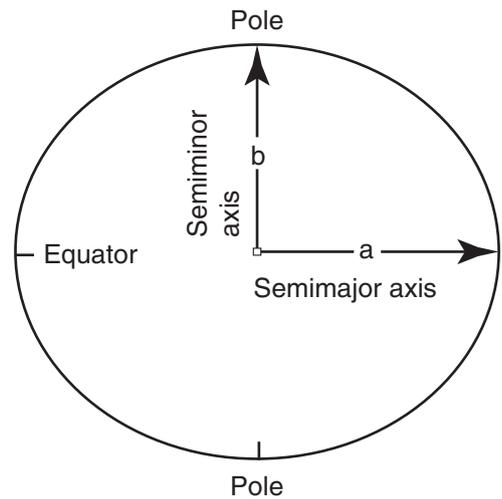
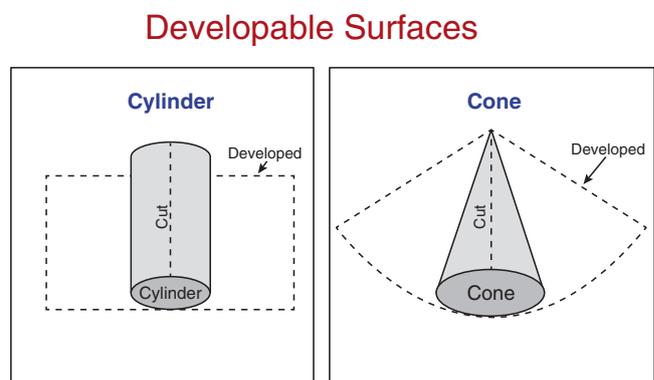
Map projection is a mathematical formula where the 3-D earth's transform into a 2-D or plane surface. A map projection is simply a systematic representation of a graticule of lines of latitude and longitude on a flat sheet of paper. The progress in computer technology and mapping mathematics makes the projection a challenging research.

Projection is used widely in cartography, land information system, remote sensing and GIS. The map projections generate different types of plane coordinates which are easier to use and work with than the spherical coordinate.

Projection and Distortion

The shape of the earth is so complicated and for the map projection, the earth is considered ellipsoid or sphere. The earth is rotated about its minor axis and has semimajor (a) and semiminor (b) axes (Fig. 5.3).

The shape, area, distance and direction of the features on the earth surface are correctly shown on a globe. The transformation from earth surface onto a flat plane surface involves distortion. Parallels, meridians, and the perpendicular intersection of parallels and meridian cannot be duplicated. The major alteration has to do with the angles which will affect the area, shape, distance and directions. There is no ideal projection that retains the major globe properties. This leads scientist to

Fig. 5.3 The shape of an ellipsoid**Fig. 5.4** Projection surfaces the cylinder and the cone

generate hundreds of map projections in order to minimize the distortion and retain at least one of the earth's properties. Therefore, cartographer classified the map projection into major and minor properties. The major is the conformal and equivalent, the minor is the equidistant and azimuthal. Here are some examples about the major world projection.

1. **Conformal or orthomorphic projection** retains the angle and the shape of a small area. When this condition happens, the parallels and meridians will intersect at 90° .
2. **Equivalent or equal-area projection** will retain the correct relative size. Thus in such projection, the parallels and meridians will not intersect at 90° .
3. **Equidistant projection** conserves the distance between two points in a map. The scale must be the same as the principal scale on the reference globe from which the transformation was made.
4. **Azimuthal or true-direction projection** represents the part of the earth's directions correctly with straight line. But no projection can show direction so that the latitude and longitude are straight lines.

Many map projections include more than one property, which is extremely important in a small scale map.

Geographers use three physical surfaces for the construction of map projections. Developable surfaces (Fig. 5.4) such as the cylinder and cone and non-developable surface such as the plane. The cylinder and cone are not flat at the time the projection is created but can be flattened later by making an appropriate cut in the surface and unrolling it. Without stretching or tearing no distortion, when unrolled, distortion of the developable surface or of the pattern drawn on it occur.

Map projection may be produced by a light from three viewpoints: at the center, from infinity, and on the surface of the globe. For example, a light can be used to project the globe on a cylinder. The light also can be placed at any desired location and this gives rise to variations of the map projection.

Changing the location of the light source, modifies the characteristic of the resulting projection to the tangent or secant intersect on the cylinder and the cone. The first is the simple (tangent) case and the second is the secant case. The simple case results in one line and the secant case results in two lines. With the simple case, the projection surface (azimuthal plane, cylindrical or

Fig. 5.5 Use the cone to construct a map projection

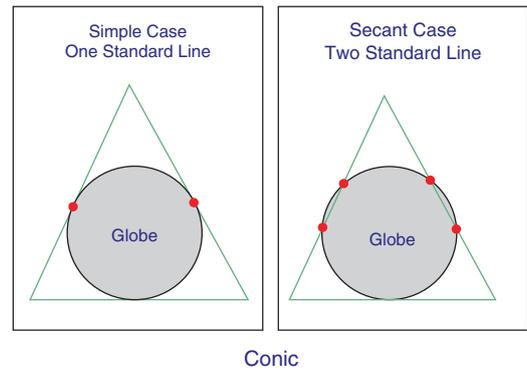
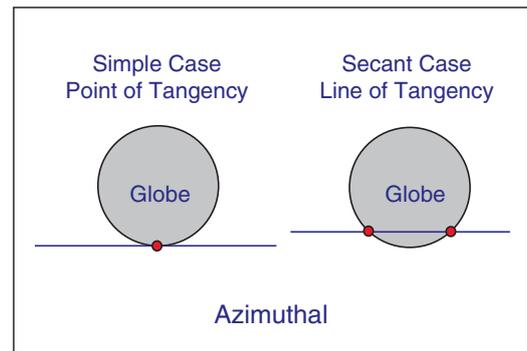


Fig. 5.6 Point and line of tangency



conic surface) touches the globe at one point or along one line. In secant case, the projection surface cuts through the globe to touch the surface at two lines (Fig. 5.5). The line of tangency is called a standard line in map projection. For cylindrical and conic projection the simple case has one standard line, whereas the secant case has two standard lines. If the standard line along the parallel is called standard parallel, and if it follows a meridian, it is called standard meridian. Along the standard line there are no distortions because there is a relationship one to one between the projection surface and the reference globe. The standard line is the identical to the reference globe, and away from the standard line a distortion occurs.

An azimuthal projection has only one point of tangency in the simple case and a line of tangency in the secant case. Therefore a plane may be tangent at any point on the globe (Fig. 5.6).

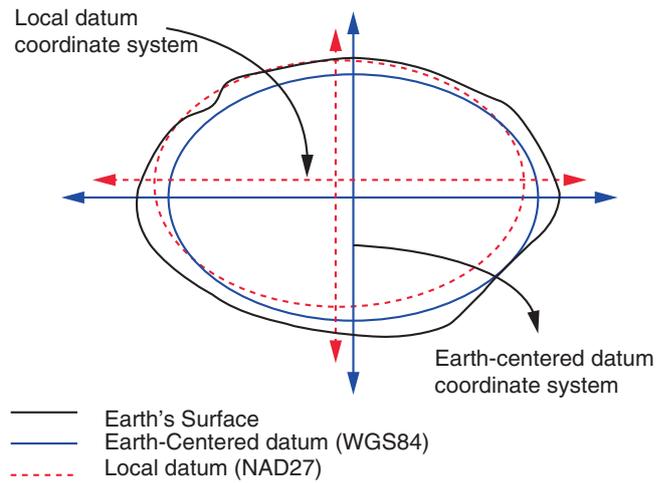
The orientation of the cylinder and the cone may be changed as desired and it can be normal, transverse and oblique. The normal orientation is when the cylinder can be placed so its tangent is along the equator and in the case of the cone its tangent along the parallel. Transverse Projection is when the cylinder or the cone is turned 90° from normal orientation. Oblique Projection is when the cylinder and cone lie between normal and transverse position.

Concept of the Datum

Datum is sets of parameters and ground control points defining local coordinate systems. Because the earth is not a perfect sphere, but is somewhat “egg-shaped,” geodesists use spheroids and ellipsoids to model the 3-dimensional shape of the earth. Although the earth can be modeled by an egg-shaped solid, local variations still exist, due to differential thickness of the earth’s crust, or differential gravitation due to density of the crustal materials.

A datum is created to account for these local variations in establishing a coordinate system. Figure 5.7 shows that the earth is irregular surface (thick black line). A generalized earth-centered coordinate system is called World Geodetic System 84 (WGS84). WGS84 provides a good overall mean solution for all places on the earth. However, for specific local measurements, WGS84 cannot account for local variations. Instead, a local Datum has been developed. For example, the local North American Datum of 1927 (NAD27, in dashed red line) more closely fits the earth’s surface in the upper-left quadrant of the earth’s cross-section. NAD27 only fits this quadrant, so to use it in another part of the earth will result in serious errors in measurement. For mapping North America, in order to obtain the most accurate locations and measurements, NAD27 is updated to NAD83 and NAD83 is adjusted in 1991. Any new map created in the U.S. will be based on NAD83.

Fig. 5.7 Datum (Image from ESRI)



Projection Parameters

A datum specifies the dimensions of a specific spheroid, a point of origin, an azimuth from the origin to a second point, and the spatial orientation of the spheroid relative to the earth. A GCS assigns unique coordinate values to locations on the surface of a spheroid. The system is usually based on latitude and longitude and is fully specified by a unit of measure (typically degrees), a prime meridian and a datum (e.g. NAD83). A Projected Coordinate System (PCS) is a combination of a map projection, projection parameters, and an underlying GCS that determines the set of X, Y coordinates assigned to a map.

When a map projection is used as a basis of coordinate system an origin should be established first. The point of origin is defined by the central parallel and the central meridian. The central parallel and central meridian in some literatures is called the latitude of origin and longitude of center respectively. For example Douglas County has the following projection parameters:

Douglas county of Wisconsin has the following parameters

Base Projection:	Transverse Mercator
Central Meridian:	-91.917
Central Parallel:	45.8833
False Easting:	194000
False Northing:	0.013 U.S. Survey feet
Scale Factor:	1.00004
Unit:	Foot US
Datum:	NAD83

Once map data is projected onto a planar surface, features must be referenced by a planar coordinate system. The latitude-longitude coordinate, which is based on angles measured on a sphere, is not valid for measurements on a plane. Therefore, a Cartesian coordinate system is used, where the origin (0, 0) is toward the lower left of the planar section. The true origin point (0, 0) may or may not be in the proximity of the map data you are using.

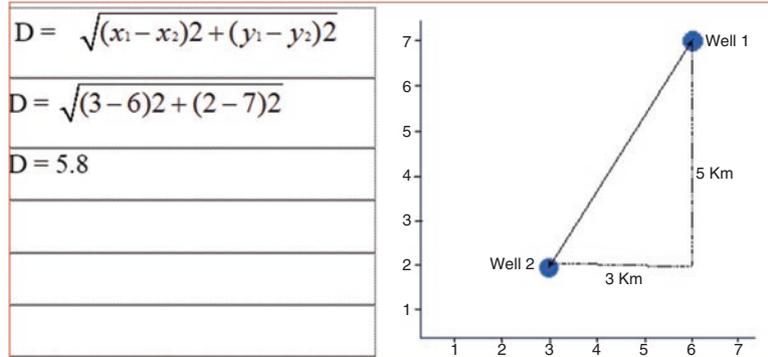
The following lessons will be performed in this chapter

1. Working with GCS
2. Projection on the Fly
3. Projection the GCS into UTM Zone 15
4. Georeferencing
5. Raster Projection
6. Datum Conflict

Working with GCS

The following two examples show how to calculate the distance in latitude-longitude coordinate.

Application 1: Distance calculation between two points on the map using the Pythagorean Theorem. The theorem is used to find the length of the hypotenuse of a right triangle, a calculation which affords many practical uses in various fields such as land surveying and navigation.



Application 2: Distance calculation between Superior and Eau Claire in Wisconsin using the latitude longitude. The location of the two cities are as follow:

1. Superior: -92.06 longitude and 46.70 latitude.
2. Eau Claire: -91.52 longitude and 44.80 latitude.

Formula of calculation: $\cos d = \sin a * \sin b + \cos a * \cos b * \cos c$

$a = 46.7$ latitude of Superior

$b = 44.8$ latitude of Eau Claire

$c = 0.54$ this is longitude of Superior – Longitude of Eau Claire

$\cos d = \sin 46.70 * \sin 44.80 + \cos 46.70 * \cos 44.80 * \cos 0.54$

$\cos d = 0.7277 * 0.7046 + 0.6858 * 0.7095 * 0.9999$

$\cos d = 0.999237$

$d = 2.237$ distance in degree

$2.237 * 69.17$ miles = 154.7 mile or $(2.237 * 111.32 \text{ km} = 249 \text{ km})$

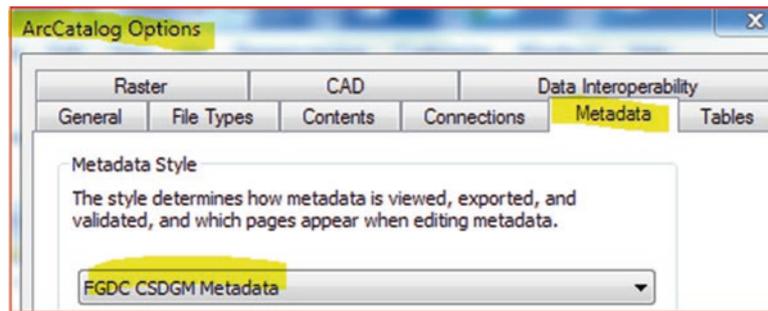
Projection on the Fly

On-the-fly projection is a powerful approach in GIS environment that allow users to combine data from any projection into a common projection for viewing and analysis. ArcGIS is armed with mathematics that can transform spherical coordinates to projected systems and vice versa on the fly without difficulties. The most important step to make the projection on the fly successful is to make sure that your file (if you are working with shapefile only) includes the *.prj file.

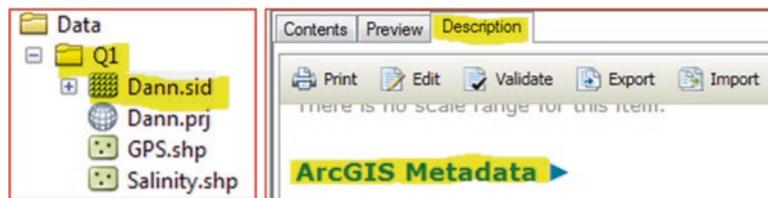
Scenario 1: You are an ecologist working to define certain species in Lake Menomonie. You have used the GPS and integrated the GPS file into ArcGIS. Your duty is to align the GPS data which is in latitude longitude with the image that has UTM coordinate system. In this exercise you are going to do two functions: (1) projection on the fly (2) project the GPS file permanently into UTM Zone 15N.

Define the Coordinate System and Datum

1. Start ArcCatalog
2. Click Customize menu points to ArcCatalog Options
3. Click Metadata tab / change Metadata Style into **FGDC CSDGM Metadata**

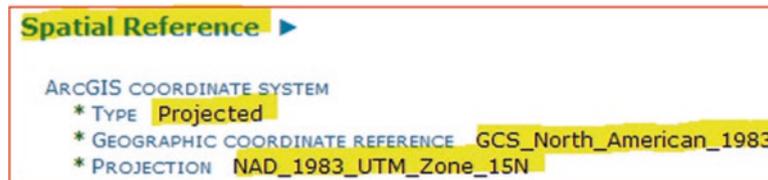


4. Click Apply and then OK
5. Hit F5 to refresh
6. Connect to your folder \\Ch05\Data\Q1 folder
7. Highlight in the Q1 folder "lake.tif"
8. Click the "Description" item in the right panel



9. Scroll down and click "ArcGIS Metadata"
10. Click "Spatial Reference"

Result: lake.tif is an image projected into UTM ZONE 15 and its DATUM is NAD83.



11. Highlight the GPS.shp in Q1 folder
12. Click Description Tab
13. Scroll down and click "ArcGIS Metadata"
14. Click "Spatial Reference"

Result: GPS.shp file is registered in GCS and its DATUM is NAD83.

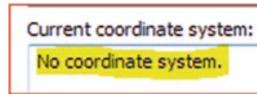


Note: lake.tif is projected and GPS.shp is not projected, but both represent the same area. ArcGIS can display both files on the fly.

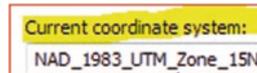
Apply the Projection on the Fly

Projection on the fly means that you want to align two files from the same area together despite a difference in their coordinate system.

15. Launch ArcMap
16. R-Click the **Data Frame** “**Layers**”/Properties/Coordinate System
17. What is the coordinate of the Layers data frame? No coordinate system



18. Integrate **lake.tif** into ArcMap from \\Data\Q1 folder
19. Now, what is the coordinate of the Layers data frame? NAD_1983_UTM Zone_15N



Comment: This means that the Data Frame inherited the coordinate system of the first layer integrated into ArcMap, which is the **lake.tif**.

20. Integrate the file **GPS.shp** into ArcMap from \\Data\Q1 folder
21. R-click the **GPS.shp** in the TOC
22. Point Zoom To Layer



Result: The two files are aligned with each other despite the **lake.tif** coordinate systems is different than GPS layer coordinate system.

Define the Projection

23. Click the **Add Data**  button and add **Salinity.shp** from \\Data\Q1 folder
24. Click Ok to accept that the **Salinity.shp** has missing spatial reference information

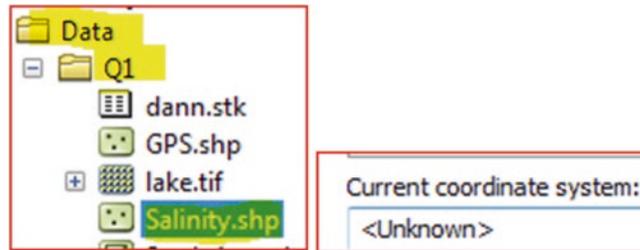


Result: The **Salinity.shp** is not displayed in the extent of the **lake.tif** and **GPS.shp**, because the Salinity layer is missing spatial information. This means that the “**Salinity.shp**” is missing the file “**Salinity.prj**.”

25. Click the Symbol of the **Salinity.shp**/chose Circle 2, size 12, cyan color, then click OK
26. Click the **Full Extent** button  on the **Tools** toolbar to see all the data in your map

How to Check That?

27. Open Catalog window
28. R-click Salinity.shp in \\Data\Q1 folder/Properties/click XY Coordinate System



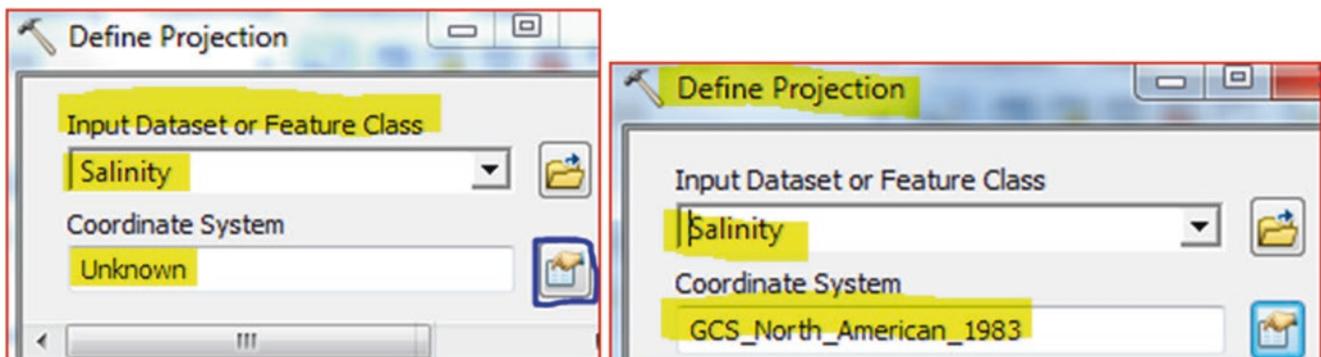
Result: Current coordinate system: <Unknown>. This means, the only information available is that the file has a latitude longitude but no spatial information (*.prj).

Open in window explorer the folder of \\Data\Q1, do you see the file “**Salinity.prj**”? The answer NO, therefore, you have to create it

29. Launch ArcToolbox by clicking ArcToolbox Window button  found on the Standard toolbar and duck it to the left of ArcMap (or click Geoprocessing menu/ArcToolbox)

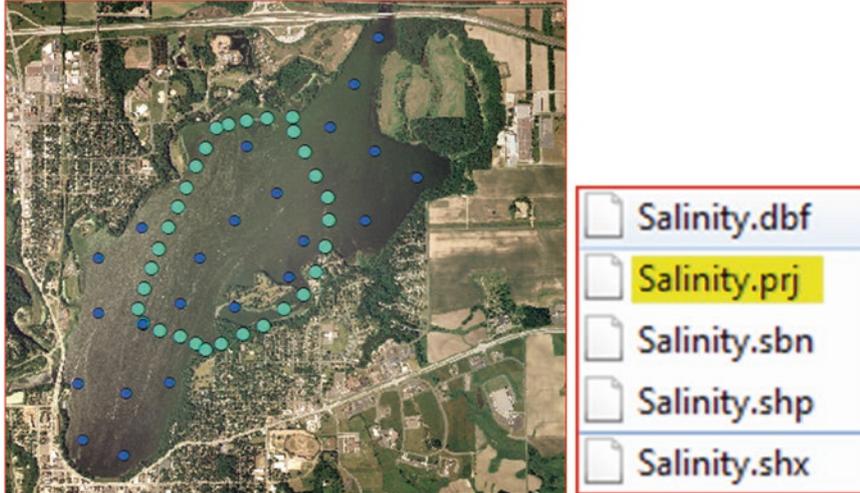
Set the Environment

30. R-click an empty space in ArcToolbox
31. Environment/Workspace/
32. Current Workspace: \\Ch05\Data\Q1
33. Scratch Workspace: \\Ch05\Results
34. OK
35. In ArcToolbox, click Data management Tools/Projections and Transformations
36. D-click Define Projection
37. Browse to Salinity.shp in in \\Data\Q1 folder
38. Click the spatial reference icon to choose the coordinate system/select/D-click Geographic Coordinate Systems/North America
39. Select NAD 1983/OK/OK
40. R-click Salinity.shp point to Zoom To Layer



What is the result? Projection on the fly and the following happened:

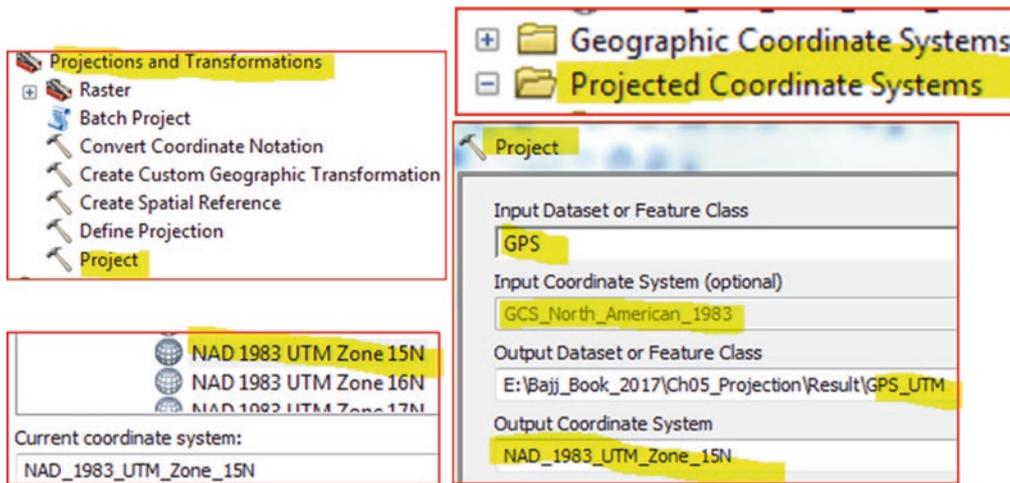
- a. The Salinity.shp is aligned with the **lake.tif** and **GPS.shp**
- b. **Salinity.prj** a new file is created and added to the \\Data\Q1 folder
- c. The Salinity.shp points are located inside Lake Menomonie



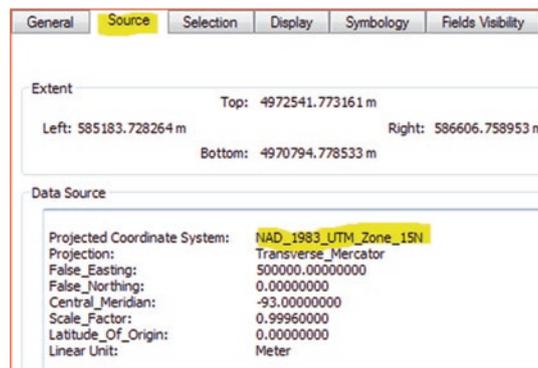
Projection the GCS into UTM Zone 15

The **lake.tif** and **GPS.shp** have different coordinate system. **lake.tif** has a UTM projection zone 15N and **GPS.shp** has a geographic coordinate system (latitude and longitude). You are interested in projecting the **GPS.shp** from latitude-longitude coordinate system onto UTM zone 15 N.

1. Insert new Data Frame and call it “**Projection**”
2. Integrate the **lake.tif** and **GPS.shp** into ArcMap from \\Data\Q2 folder
3. Activate ArcToolbox if it is not active from the previous exercise
4. In ArcToolbox, click Data management Tools/Projections and Transformations
5. D-Click Project
6. Drag **GPS.shp** from the Table of Content and place it into the Input Dataset in the Project Dialog Box
7. Output Dataset **GPS_UTM.shp** and save it in \\Result folder
8. Output Coordinate System: Click the button for the coordinate system to open the Spatial Reference Properties Dialog box
9. D-Click ‘Projected Coordinate Systems’/UTM/NAD 1983
10. Click NAD 1983 UTM Zone 15N
11. Click OK/OK



- 12. **GPS_UTM.shp** added from \\Result folder into the TOC
- 13. R-click **GPS_UTM.shp** in the TOC/Properties/Source



Result: the **GPS_UTM.shp** is now registered in **NAD_1983_UTM_Zone_15N**.

Georeferencing

Raster data is commonly obtained by scanning maps or collecting aerial photographs and satellite images. Scanned maps and some downloadable images don't usually contain information as to where the area represented on the map fits on the surface of the earth; the locational information delivered with aerial photos and satellite imagery is often inadequate to perform analysis or display in proper alignment with other data. Thus, in order to use these types of raster data in conjunction with your other spatial data, you often need to align or georeference it to a map coordinate system.

When you georeference your raster, you define how the data is situated in map coordinates. This process includes assigning a coordinate system that associates the data with a specific location on the earth. georeferencing raster data allows it to be viewed, queried, and analyzed with other geographic data.

Scenario 2: You are an ecologist and you are interested in the wetland in eastern Wisconsin. One of the critical issues in your research is to determine the hydraulic relationship between the groundwater of the Silurian dolomite aquifer and the wetland. In order to conduct the research, you have to collect any type of data to support your research. You have found on the internet an image representing Silurian aquifer in east Wisconsin. The image has a false coordinate and the rest of your digital data is registered to a geographic coordinate (Latitude-Longitude). Your first target is to georeference the image using the State of Wisconsin file.

You can obtain the state of Wisconsin file using the **ESRI database** that come with ArcGIS software. In this exercise you will be given the file.

GIS Approach

1. Insert Data Frame and call it “**Georeference**”
2. Add **State48.shp** from the folder \\Ch05\Data\Q3

Set Environment

3. Click Geoprocessing menu and point to Environment and click Workspace
 1. Current Workspace: \\Ch05\Data\Q3
 2. Scratch Workspace: \\Result
4. Click OK
5. R-click **State48.shp**/Properties/Source

Result: the *coordinate* & *datum* of the **State48.shp** is *GCS_North_American_1983*.

Geographic Coordinate System:	GCS_North_American_1983
Datum:	D_North_American_1983

6. After viewing the coordinate close the **Layer Properties** dialog box
7. R-click States48 layer in the TOC/Label Features

Result: The states is now labeled by the name field.

8. Use the **Select Features** tool  on the **Tools** toolbar
9. Click state of Wisconsin to select it
10. R-click **State48.shp** point to **Data** select **Export Data**
11. Save it as **WI.shp** in \\Result folder



12. **OK/Yes** to add **WI.shp** to the **TOC**
13. R-click **State48.shp** in the **TOC** point to **Remove**
14. R-click **WI** layer in the **TOC/Zoom To Layer**
15. Click Add Data and integrate the raster “**WI_Aquifer.jpg**” from \\Data\Q3 folder
16. Click Ok on the note saying that

The following data sources you added are missing spatial reference information. This data can be drawn in ArcMap, but cannot be projected

Result: The “WI_Aquifer.jpg” display’s far from the WI layer, because the image has false coordinate system.



17. Click Customize/Toolbars and check Georeferencing



The Georeferencing tool displays and the **WI_Aquifer.jpg** shows in the Layer drop down.

Note: if you have more than one raster, click the **Layer** drop-down arrow and click the raster layer you want to Georeference.

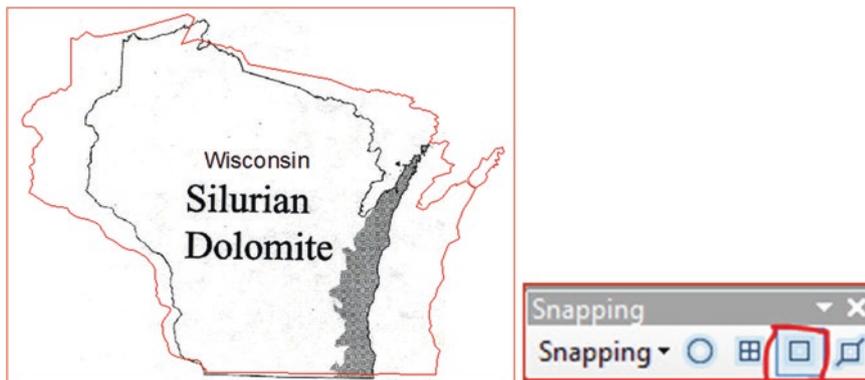
18. Click Georeferencing in the Georeferencing tool and click **Fit To Display**. This will display the raster in the same area as the **WI** layers.

19. Click on the **WI** layer symbol color and choose “Hollow” and red to outline color

Note: This displays the raster dataset in the same area as the target layers. You can also use the **Shift** 

and **Rotate**  tools to move the raster dataset as needed. To see all the datasets, adjust their order in the table of contents.

Results: You see now both the image and vector together.



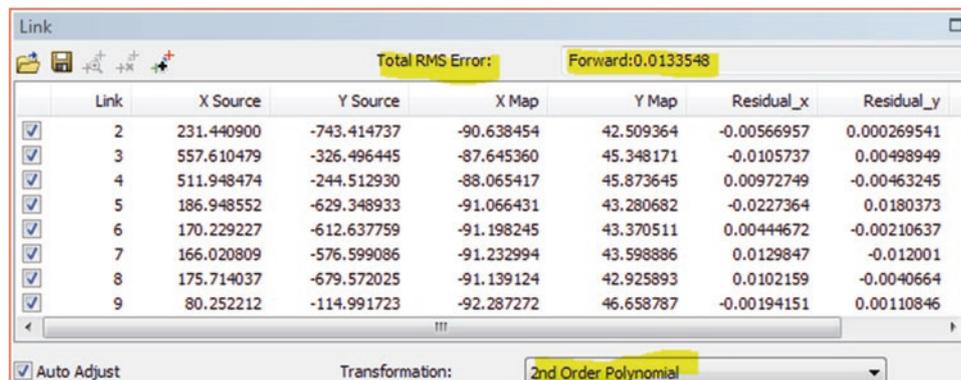
20. Click Editor toolbar/Snapping/Snapping toolbar

21. Activate Snapping tool in Snapping toolbar (this snap to the vertex of WI layer)

22. In the Georeferencing tool click the Add Control Points tool  to add control points.
23. To add a link, click the mouse pointer over a known location on the raster, then over a known location on the target data.
24. Add enough links for the transformation order. You need a minimum of three links for a first-order transformation, six links for a second order, and 10 links for a third order

Note: It is recommended to add at least 8 points, from south, east, north and west of the image. Try to use a known location such as corner or intersection. Try also each time you add a control point to zoom in, in order to achieve more accuracy (9 points selected).

25. Click View Link Table in Georeferencing toolbar 
26. Change the transformation into second Order Polynomial
27. Make sure Auto Adjust is checked



Link	X Source	Y Source	X Map	Y Map	Residual_x	Residual_y
2	231.440900	-743.414737	-90.638454	42.509364	-0.00566957	0.000269541
3	557.610479	-326.496445	-87.645360	45.348171	-0.0105737	0.00498949
4	511.948474	-244.512930	-88.065417	45.873645	0.00972749	-0.00463245
5	186.948552	-629.348933	-91.066431	43.280682	-0.0227364	0.0180373
6	170.229227	-612.637759	-91.198245	43.370511	0.00444672	-0.00210637
7	166.020809	-576.599086	-91.232994	43.598886	0.0129847	-0.012001
8	175.714037	-679.572025	-91.139124	42.925893	0.0102159	-0.0040664
9	80.252212	-114.991723	-92.287272	46.658787	-0.00194151	0.00110846

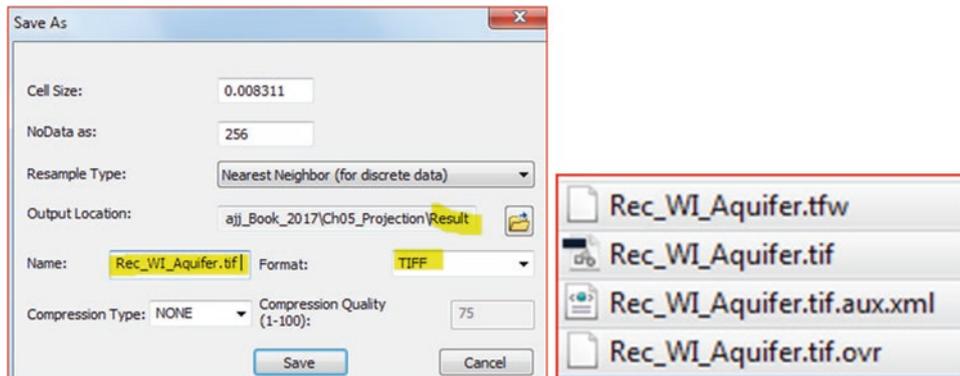
Root Mean Square (RMS): The error report includes two different error calculations: a point-by-point error and a root mean square (RMS) error. The point-by-point error represents the distance deviation between the transformation of each input control point and the corresponding point in map coordinates. The RMS error is an average of those deviations.

28. If you're satisfied with the registration, you can stop entering links.
29. If you're not satisfied with the registration, you can delete the control points or some of the points
30. To do that click Georeferencing Menu/Delete Control points
31. Repeat the previous steps to start Georeferencing once more time
32. Once you finished and you are satisfied with the RMS
33. The Total RMS Error is **0.013** (this is acceptable)



34. Click Georeference menu **Rectify** (This creates a new file with the same name as the raster but with an .aux file extension).
35. Browse and save the image in the \\Result folder

36. Call the image **Rec_WI_Aquifer.tif** and click Save
37. Click Georeferencing toolbar and click **Update Georeferencing** to save the transformation information with the raster.



38. R-click **WI_Aquifer.tif** in the **TOC** and **Remove**
39. Click Add Data and add **Rec_WI_Aquifer.tif** from \\Result folder

Result: The **Rec_WI_Aquifer.tif** aligned with WI layer.



Exercise: it is recommended to perform the georeferencing using a projected layer. Therefore, you have been asked to project **WI.shp** into WI Transverse Mercator (**NAD 1983 Wisconsin TM (Meters)**) and call it **WI_TM**, and then use the projected layer to Georeference the **WI_Aquifer.jpg** once again.

Raster Projection

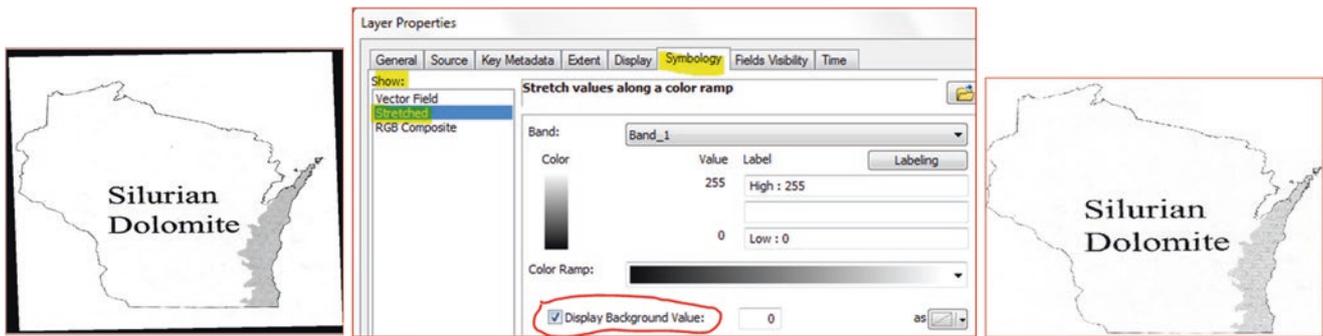
This exercise allow you to project the raster “**Rec_WI_Aquifer.tif**” that you have georeferenced in the previous section.

Scenario 3: You have decided to use the raster **Rec_WI_Aquifer.tif** to manage the groundwater in eastern Wisconsin. In order to do this you have decided to project the file into Wisconsin Transverse Mercator (WTM).

1. Insert Data Frame and call it “Raster Projection”
2. Click Add Data and add **Rec_WI_Aquifer.tif** from \\Data\Q4 folder

Result: The **Rec_WI_Aquifer.tif** displays with black background.

3. R-click **Rec_WI_Aquifer.tif** in the TOC/Properties/click Symbology tab
4. Highlight Stretched (under Show) and check Display Background Value



5. Click Source tab and scroll down to the **Special Reference**

Result: the Coordinate is GCS (latitude-longitude) and the Datum is NAD83.



6. Click OK to exit the Layer Properties dialog box

7. Launch ArcToolbox by clicking ArcToolbox Window button  found on the Standard toolbar and tuck it to the left of ArcMap (if it is not already there)

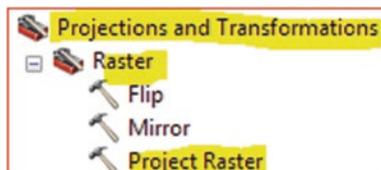
Set the Environment

1. R-click an empty space in ArcToolbox
2. Environment/Workspace/
3. Current Workspace: \\Ch05\Data\Q4
4. Scratch Workspace: \\Result
5. OK

Project the Rectified Raster

This tool will transform the raster dataset from one coordinate system to another. In this exercise, it will transform from latitude-longitude into Wisconsin Transverse Mercator.

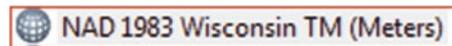
6. In ArcToolbox, click Data management Tools/Projections and Transformations
7. Under **Projection and Transformation**
8. Open the **Raster** and double click **Project Raster**



9. The Project Raster dialog box will display
10. Drag the **Rec_WI_Aquifer.tif** from TOC and place it in the Input Raster
11. Output Raster Dataset browse to \\Result and call the raster "**Aquif_WTM.tif**"

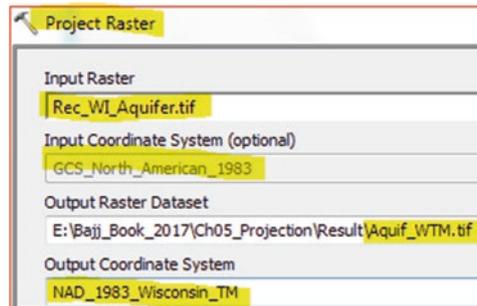


12. Click the Spatial Properties button
13. Open Projected Coordinate Systems/open State Systems/
14. Scroll down to the end and select “NAD 1983 Wisconsin TM (Meters)”



15. Click OK/OK

Result: The “Aquif_WTM.tif” is displayed in the TOC and it is now projected and has the customized Transverse Mercator of Wisconsin.



16. R-click **Aquif_WTM.tif** in the TOC/Properties/click Source tab
17. Scroll down to the **Special Reference**

Result: the Coordinate is Wisconsin Transverse Mercator (Wisconsin_TM) and the Datum is NAD83.



Datum Conflict

Some countries have more than one coordinate system and datum. Often the times when you re-project the features from one coordinate to another, the conversion is not always accurate.

Scenario 4: You are a new employee at the Water Authority of Jordan and you have given an Excel file (**Well.xls**) that include the well numbers and their coordinates in latitude-longitude from Dhuleil Area. You have been asked to do the following:

1. Integrate the Wells (**Well.xls** file) into ArcGIS and assign to it the Palestinian Datum and save it as a shapefile and call **Well_PD.shp**
2. Project the **Well_PD.shp** into “Palestine_Belt” and call it “**Well_PTM.shp**”
3. Integrate the Well.xls file into ArcGIS again and assign to it the Jordanian Datum and save it as a shapefile and call it **Well_JD.shp**
4. Project the **Well_JD.shp** into “JTM” and call it “**Well_JTM.shp**”
5. Re-project the **Well_JTM** into **Well_PTM.shp**

GIS Approach

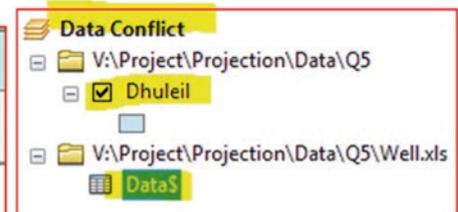
1. Insert Data Frame and call it “**Datum Conflict**”
2. Add **Dhuleil.shp** into ArcMap from \\Data\Q5 folder

3. R-click **Dhuleil.shp**/Properties/Source
4. The coordinate of the **Dhuleil.shp** is a Customize UTM Coordinate

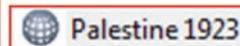
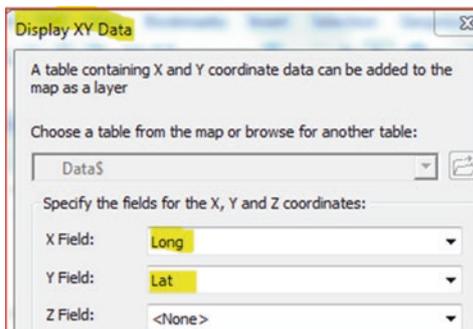
Projected Coordinate System: Palestine_1923_Palestine_Belt
Projection: Transverse_Mercator

Now, you should add the Excel file (Well.xls) that has two fields of the coordinate system in latitude and longitude.

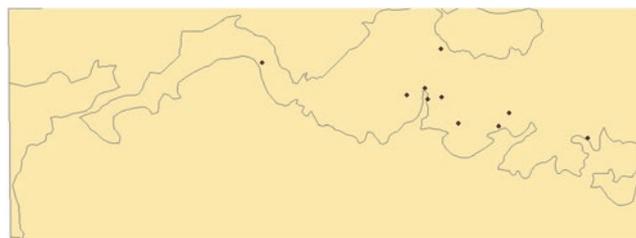
No	Long	Lat
1	36.3504	32.1415
2	36.2095	32.1674
3	36.3024	32.1543
4	36.3118	32.1736
5	36.3119	32.1499
6	36.3039	32.1488
7	36.2923	32.1511
8	36.3951	32.129
9	36.3443	32.1354
10	36.3212	32.1367



5. Click Add Data and browse to the \\Data\Q5 folder
6. D-click Well.xls/select Data\$ and click Add
7. The Data\$ added to the TOC
8. R-click Data\$/Display XY Data
 - a. X Field: Long
 - b. Y Field: Lat
 - c. Click Edit/Geographic Coordinate Systems/Asia/Palestine 1923
You are selected the **Palestine 1923** datum that associated with the latitude-longitude
9. OK/OK/Yes to create Object-ID



Result: The wells will display inside the ArcMap in the Data View.

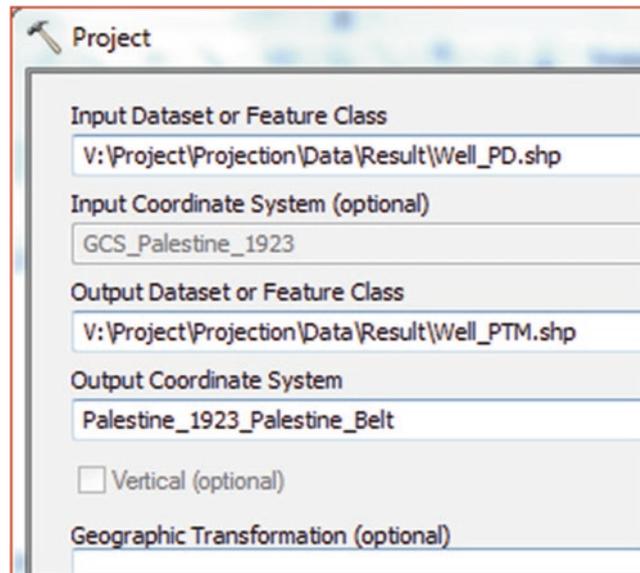


10. R-click Data\$Events/Data Export call it **Well_PD.shp** in the \\Result folder

11. Click Yes to add the **Well_PD.shp** into the TOC
12. Remove **Data\$Events** and **Data\$** from the TOC

Project the Well_PD from Latitude-Longitude into Palestinian Projection

13. Insert Data Frame and rename it Palestine Projection
14. Copy **Dhuleil.shp** and **Well_PD.shp** into the Palestine Projection Data Frame
15. Launch ArcToolbox/Set the Environment
 - a. Current Workspace \\Data
 - b. Scratch Workspace \\Result
16. OK
17. ArcToolbox/Data Management Tools/Projections and Transformations\
18. D-click Project Tool
19. Input Dataset Or Feature Class: Well_PD
20. Output Dataset Or Feature Class: \\Result\Well_PTM
21. Output Coordinate System: Projected Coordinate Systems\National Grids\Asia\Palestine 1923 Palestine Belt
22. OK/OK



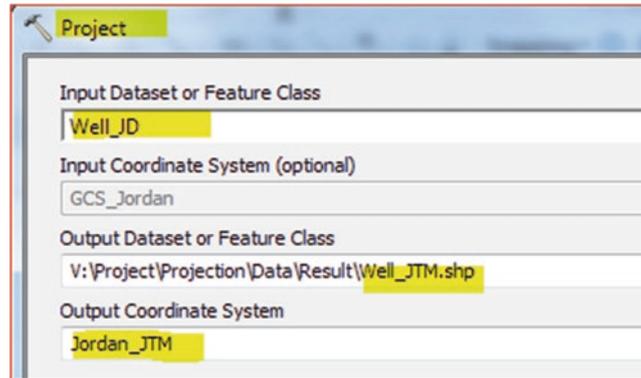
Note: The Palestine Belt Projection is based on the Transverse Mercator and its parameters are:

False_Easting:	170252
False_Northing:	1126868
Central_Meridian:	35.2121
Scale_Factor:	1
Latitude_Of_Origin:	31.7341
Linear Unit:	Meter

Project the Data into Jordanian Projection

23. Insert Data Frame and rename it Jordanian Projection
24. Add **Dhuleil.shp** and then browse to the folder \\Data\Well.xls\Data\$
25. R-click Data\$
 - a. X Field: Long
 - b. Y Field: Lat

- c. Click Edit/Geographic Coordinate Systems/Asia/Jordan
26. OK/OK/OK
27. R-click Data\$Events/Data Export \\Result\Well_JD.shp
28. ArcToolbox/Data Management Tools/Projections and Transformations\
29. D-click Project Tool
30. Input Dataset Or Feature Class: **Well_JD**
31. Output Dataset Or Feature Class: \\Result**Well_JTM**
32. Output Coordinate System: Projected Coordinate Systems\National Grids\Asia\Jordan JTM
33. OK/OK



Note: The Jordanian Projection is based on the Transverse Mercator and its parameters are:

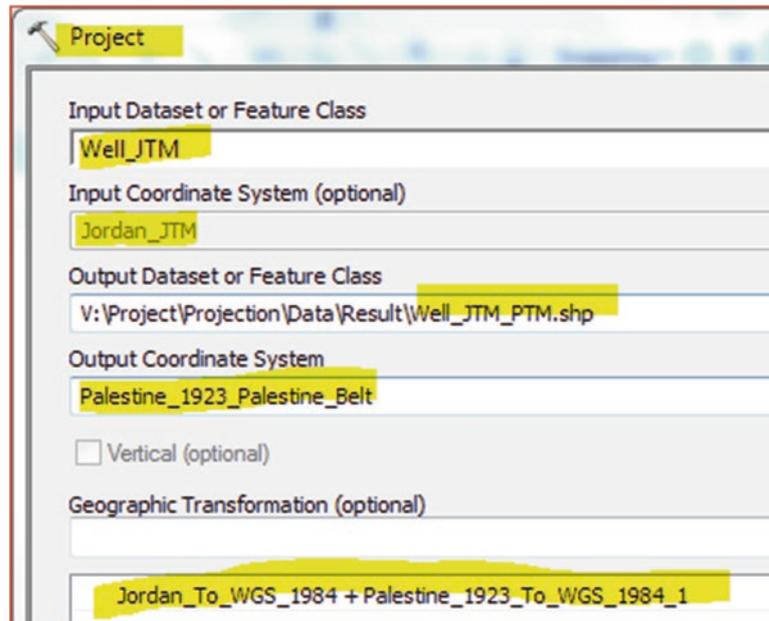
False_Easting:	500000
False_Northing:	-3000000
Central_Meridian:	37
Scale_Factor:	0.9998
Latitude_Of_Origin:	0
Linear Unit:	Meter

Project the wells from Jordanian Projection into Palestinian Projection

34. Insert Data Frame and rename it Jordanian_Palestinian
35. Copy **Well_PTM.shp**, **Dhuleil.shp** and **Well_JTM.shp** into the Jordanian_Palestine Data Frame

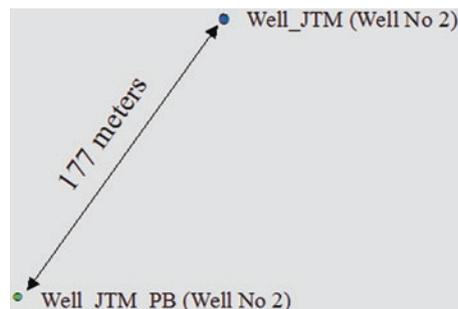
Result: Projection on the fly took place.

36. D-click Project Tool
37. Input Dataset Or Feature Class: **Well_JTM**
38. Output Dataset Or Feature Class: \\Result\Well_JTM_PTM.shp
39. Output Coordinate System: import from the file \\Result\Well_PTM.shp
40. Add\OK\OK
41. Geographic Transformation:
 - a. Jordan_To_WGS_1984
 - b. Palestine_1923_To_WGS_1984_1
42. OK



Comment: The **Well_JTM_PTM** is added to the TOC. Nevertheless, ArcGIS software can't proceed with the projection unless the following happened: The software needs to convert first the Jordanian datum into WGS84, then the Palestine datum to WGS84.

Result: the result of the projection shows that the projected **Well_JTM_PTM.shp** didn't align correctly with the location of the **Well_PTM.shp**. The discrepancies between the same well from the two files around 177 m. This could be to the accuracy of the Palestine or Jordanian datum.



How to work around the problem

The only way to work around this problem is to perform the transformation through a geodatabase approach, which will be discussed in the Geodatabase chapter.