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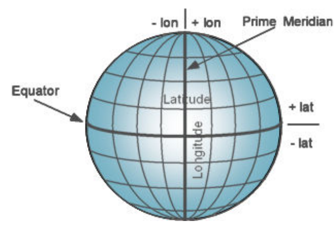
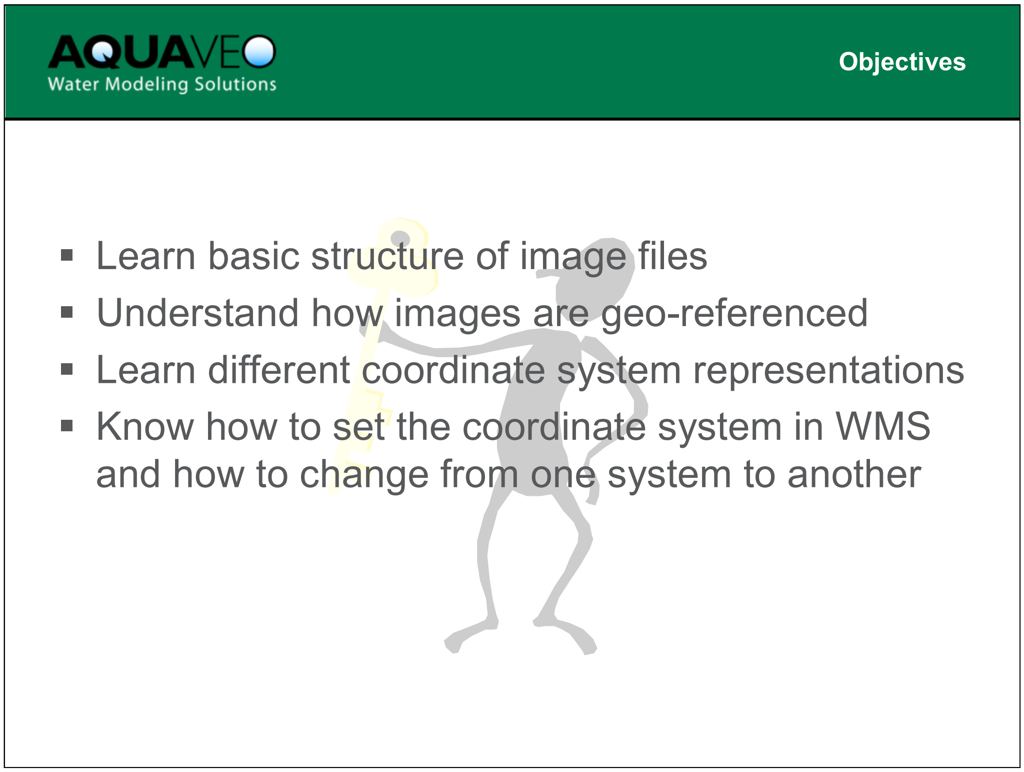
Images and Coordinate Systems

Lesson 2



NHI



OBJECTIVES

Upon completion of this lesson, participants will be able to do the following:

1. Learn the basic structures of image files.
2. Understand how images are geo-referenced.
3. Learn different coordinate system representations.
4. Know how to set the coordinate system in WMS and how to change from one system to another.

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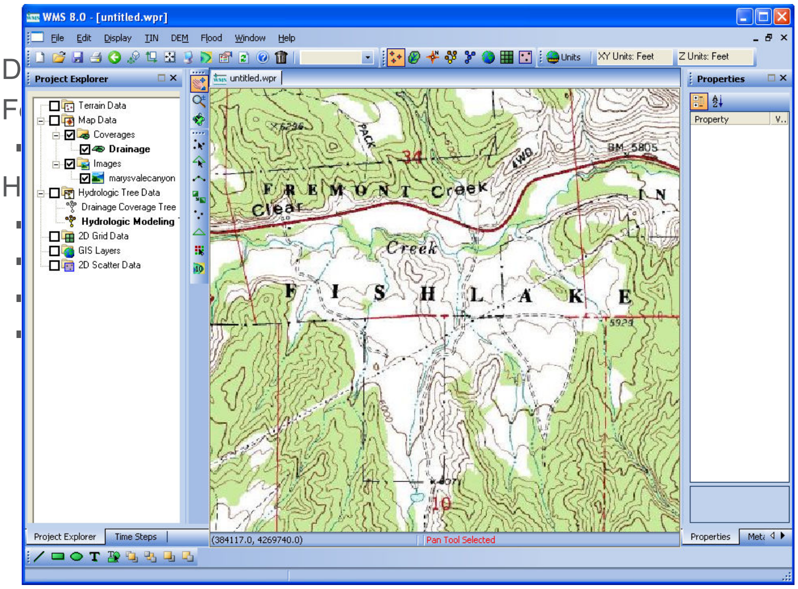
What is an image?



Images are digital pictures, or for our use, they are a digital picture of a map (most of the time). A map contains many useful features that can help us create data, or at least reference our study to a certain location.

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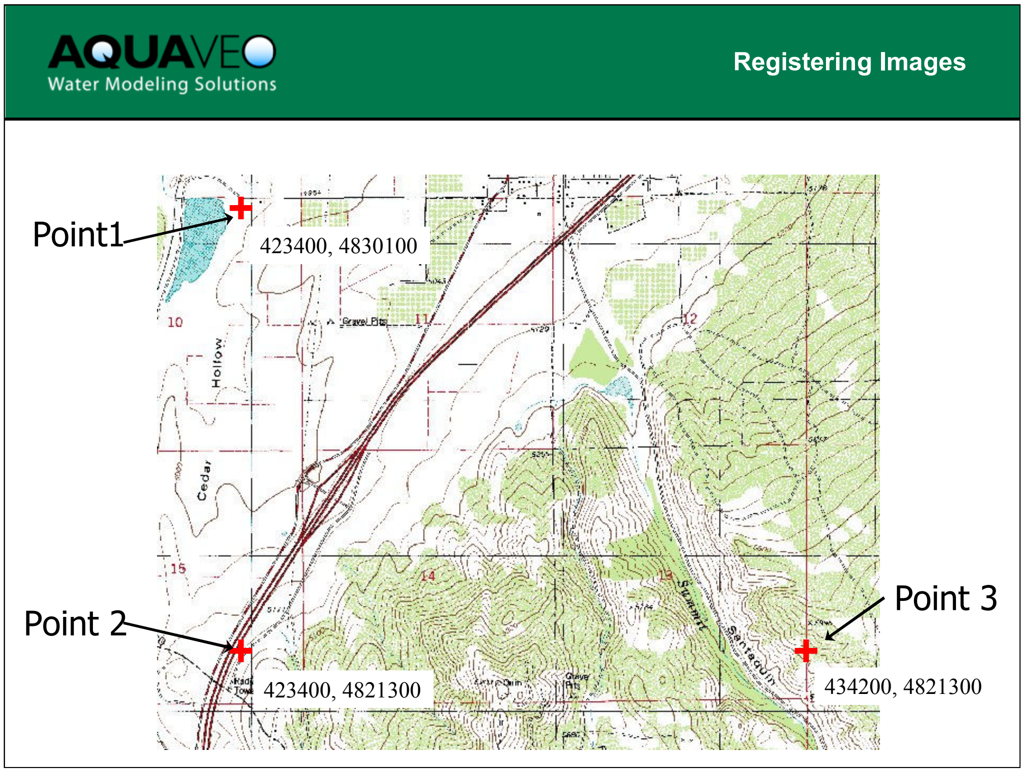
Images – Details

- 2D array of pixels
- Color code for each pixel (red, green, blue)
- Each pixel has a size
- More pixels means…
  - More detail
  - Larger files
- File types
  - TIFF
  - JPEG
  - MrSID

If you "look under the hood" a little you will see that inside an image file is a two-dimensional array of pixels. A pixel represents a picture element. Pixels are defined as components of red, green, and blue. The more colors you want to have, the more bits that are required to represent the colors.

In the real world the pixel has some dimensions (or resolution). The smaller the pixel size the greater the detail in the image, but the smaller the area you can cover (without increasing the size overall of the image file). So, more pixels means more detail, but also larger file sizes or smaller coverage for the same file size. There are many file types for images, but those commonly used in engineering, and the ones supported by WMS, include TIFF, JPEG, and MrSID.



In order to be useful in engineering projects, images must be registered to the coordinate system of the model you are working in. Providing a proper coordinate system is referred to as registering or geo-referencing the image. The basic idea behind geo-referencing is to define the world or ground coordinates of two or three points (pixels) on the image. This in turn allows the position anywhere on the image to be calculated. From positions, distances and areas can easily be calculated.

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Registration Options

- GeoTiff
  - Registration information embedded in file
- World Files
  - Separate text files with registration information (.tfw, .jpgw)
- Manual
  - Scanned images, downloaded from the internet

Many TIFF images now contain the registration information embedded as part of the file type. Other images come with a corresponding world file that is used by WMS to automatically geo-reference the image. As long as the world file has the appropriate extension it is automatically used, otherwise it can be read in as part of the registration process. If no geo-referencing information exists then you must provide the registration points manually.

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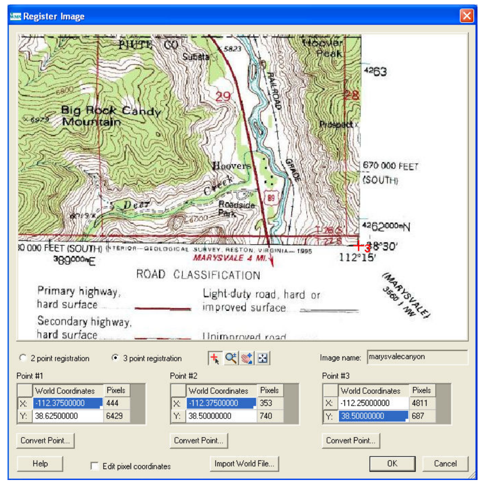
World File

2.000000	pixel size in x (meters)
0.000000	rotation term
0.000000	rotation term
-2.000000	pixel size in y (meters)
443600.00	
4456800.00	upper left coordinate

The world file contains the size of the pixels in the x and y directions and the coordinate of the upper left corner. The y value is negative because y coordinates decrease from the upper corner as you move down the image (x values increase to the right of the upper corner). The rotation terms are always zero if you download from the TerraServer and the image is oriented towards north, but they could be something different.

Manual Registration

- 2 point or
- 3 point
- Move point to known location
- Enter coordinates
- Define coordinate system



To register your image, locate two or three points on your image where the coordinates are known and enter the coordinates for these points. This is done in the registration dialog. A preview of the image is shown and you can drag the registration point (red cross mark) to the appropriate location on the image and then enter the known coordinates for that point. A world file can also be imported if it was not recognized automatically when opening the image file.

It might seem improbable that you can register an image with just two points. In fact this is only possible if the image is uniform in scale (all pixels are the same size). Since most of the maps we work with are of this nature, or when you scan a map it is done at a uniform resolution then for most cases it will be okay. The first point “pins” the map to the world and the second point “stretches” the map (scales) and defines any rotation that may exist. It should be obvious that the pixel sizes in the world file seen in the last slide are generated by calculating the distance between the two registration points and dividing by the number of pixels between them. If three points are used then an “average” can be taken in the x and y directions. Points should be spaced as far apart as possible in order to reduce errors.

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Where to Get Images?

- USGS
  - Digital Raster Graphics (DRG) are the USGS map series saved as images
    - Available at many local locations
  - Digitial Ortho Photo Quads (DOQ, DOQQ)
- MSR Maps
  - USGS Maps, and satellite imagery
  - Now has Web Service capability
- Google Earth Satellite Imagery
- NFF has state equation region maps
- Use a desktop scanner and register any map

Because of their utility, images are becoming widely available for purchase or free download from the Internet.

The USGS provides their Digital Raster Graphics (DRG) from many different web sites that are free for download. A DRG is a scanned image of a standard USGS map. Digital Ortho Quads, or aerial photographs that come in quadrangle or quarter-quadrangle sizes, are also available from some web sites.

MSR Maps is useful for finding both USGS maps and aerial photographs for almost all locations in the US. You can zoom in/out and crop just the area you are interested in from this site.

Google Earth satellite imagery for anywhere in the world can be accessed and saved at no charge from inside the Google Earth client.

Maps of the NFF regions can be found at the USGS site by searching for USGS NFF from Google. These maps can be downloaded, registered in WMS, and then used to create NFF Region coverages.

Any map can be converted to a digital representation and read/registered in WMS using a desktop scanner. Be sure to scan the entire area you need, and also be sure to save the image as either a TIFF or JPEG file.

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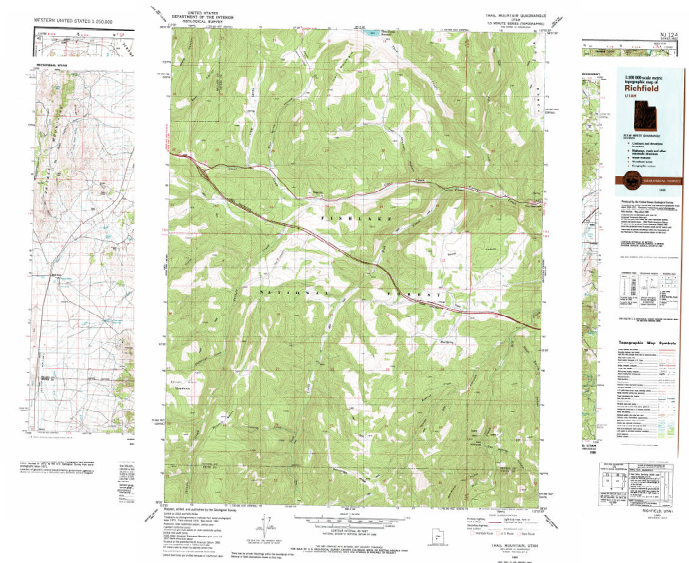
USGS DRG Maps

- 1:250,000
- 1:100,000
- 1:24,000



USGS DRG Maps are typically available for the 1:250,000, 1:100,000, and 1:24,000 (quadrangle) map series. The 1:250,000 maps cover a larger area, but provide less detail, than the 1:100,000 maps which cover more area but less detail than the 1:24,000 map series. You can load all of the maps at once into WMS and then choose the map that displays the best and provides the most detail for your particular purpose.

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DOQs

An aerial photograph is useful for many projects because of all the features they identify (roadways, homes, land uses, lakes and waterbodies, etc.).

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MSR Maps

- File size is small = JPEG
- Can save a World File
- UTM Coordinates (NAD ’83)
- Can be loaded automatically from WMS with web services

Microsoft® Research Maps

http://msrmaps.com

MSR Maps is useful for finding and downloading (for free) both DRG maps and aerial photographs. The images are downloaded in the JPEG file format and an accompanying world file can also be saved that registers the image in UTM, NAD 83 coordinates (more on coordinates later in this lesson).

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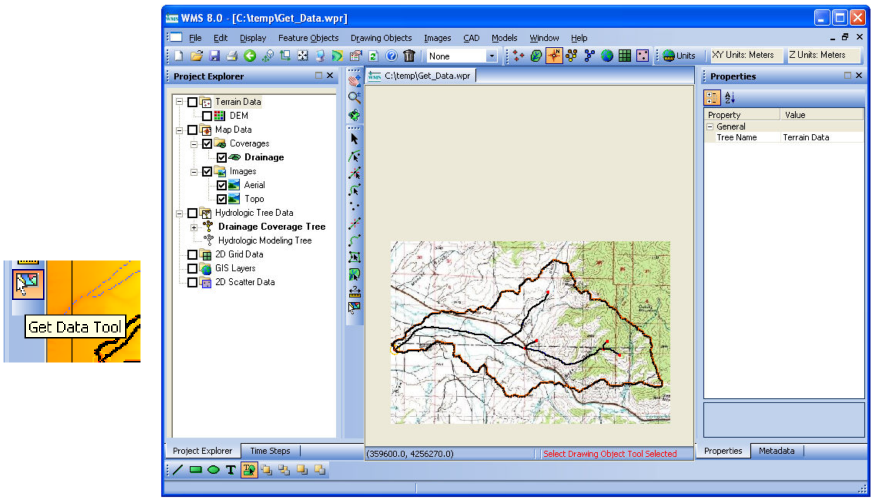
Web Services - A Better Way



Web services provide a way to call programs that reside on remote computers via the Internet. This works the same way as a DLL, only the dynamic link takes place over the Internet. MSR Maps now provides such a service that allows WMS to pass bounding box coordinates (the current coordinate system must be either geographic NAD 83, or UTM NAD 83) for which the topographic or aerial photography image is returned. In addition to the complete image being returned, the world file geo-referencing information is also returned. Unlike the MSR Maps website, you can specify the exact boundary you wish to have. WMS will suggest an appropriate resolution based on the geographic size of the bounding box, but you can specify a higher (takes more time to download) or lower (faster download but not as “crisp”) resolution.

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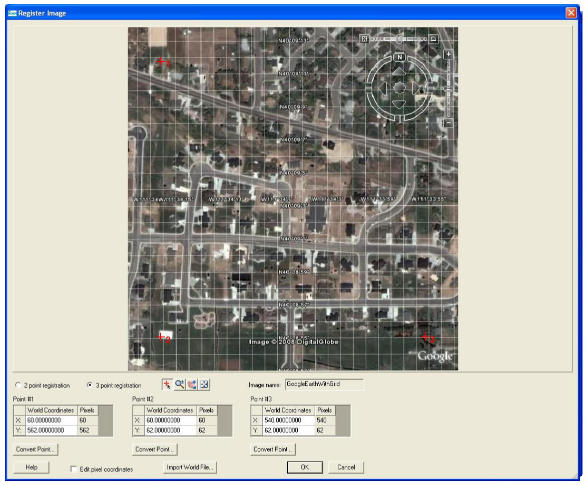
Google Earth Satellite Images

- Must be georeferenced in WMS



Google Earth is a free software program that offers satellite imagery for anyplace on the globe. Though saving images in Google Earth is easy, the software doesn't currently provide an option to export a world file. An easy way to georeference an image from Google Earth is to save two satellite images, one with latitude and longitude grids turned on and one with the grids turned off. Open the image with the latitude-longitude grids in WMS and use the grids to register the image. Once the image is registered, export a world file from WMS. Now just rename the world file to the same name as the grid-less Google Earth image you saved earlier and you've got a georeferenced image ready for use in WMS.

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Scanned Image

- Scan using a Desktop Scanner
- Save as JPEG or TIFF
- Register in registration dialog
- Save as a WMS Image File
  - Text file with image file name and registration points

A Desktop scanner can be used to convert a paper map to a digital format that can be registered and used within WMS.

A WMS Image file is a text file that contains the name of the TIFF/JPEG/MrSID image file and the registration coordinates. When registering an image manually it is a good idea to save an image file so that if you wish to use the image again you do not have to re-register it.

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Coordinate Systems

- Data must be in a consistent coordinate system in order to overlay correctly
- Different data sources provide data in different coordinate systems
- WMS allows you to convert most data from one coordinate system to another

When you are dealing with multiple data sets (e.g. images, land use, DEMs) for a study you need to ensure that all are defined from a consistent coordinate system if you want to be able to overlay.

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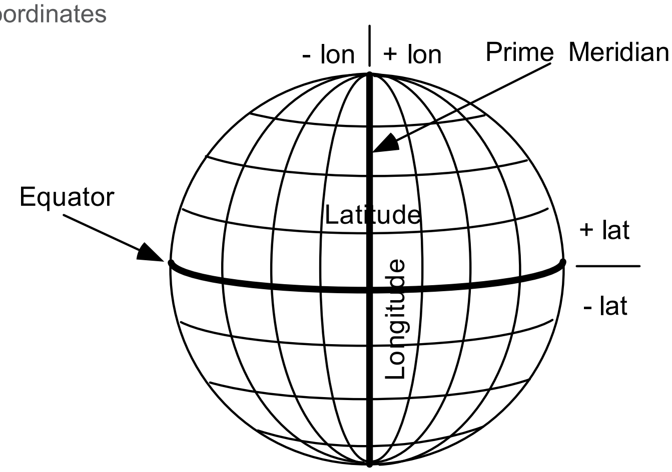
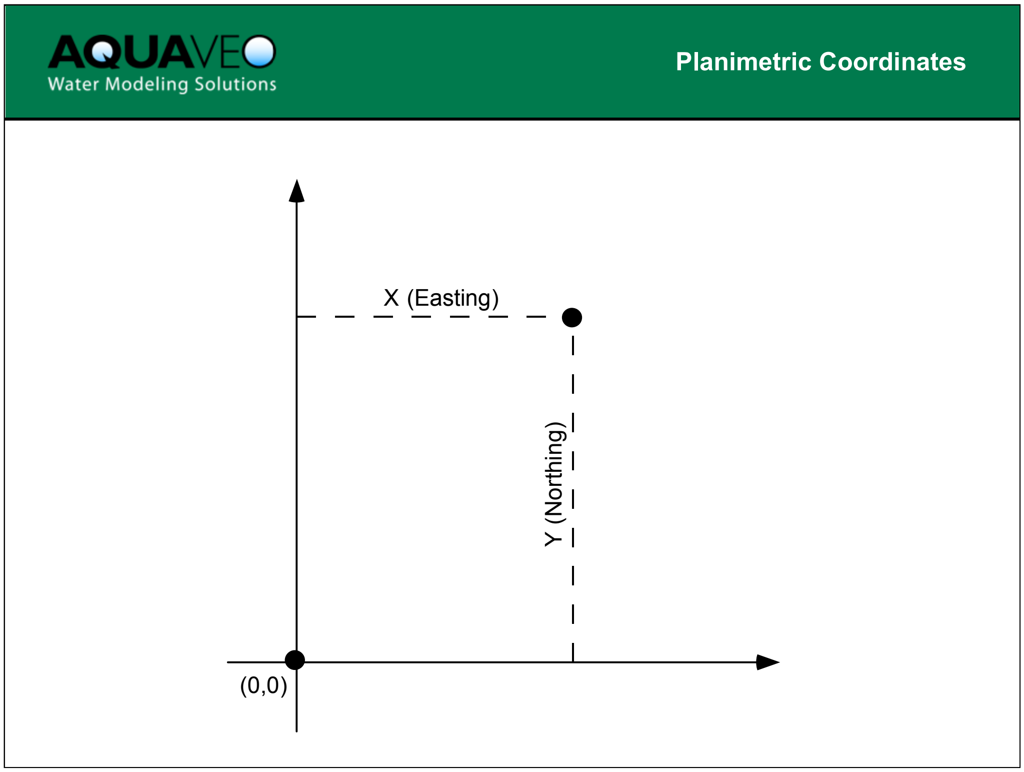
Geographic Coordinates

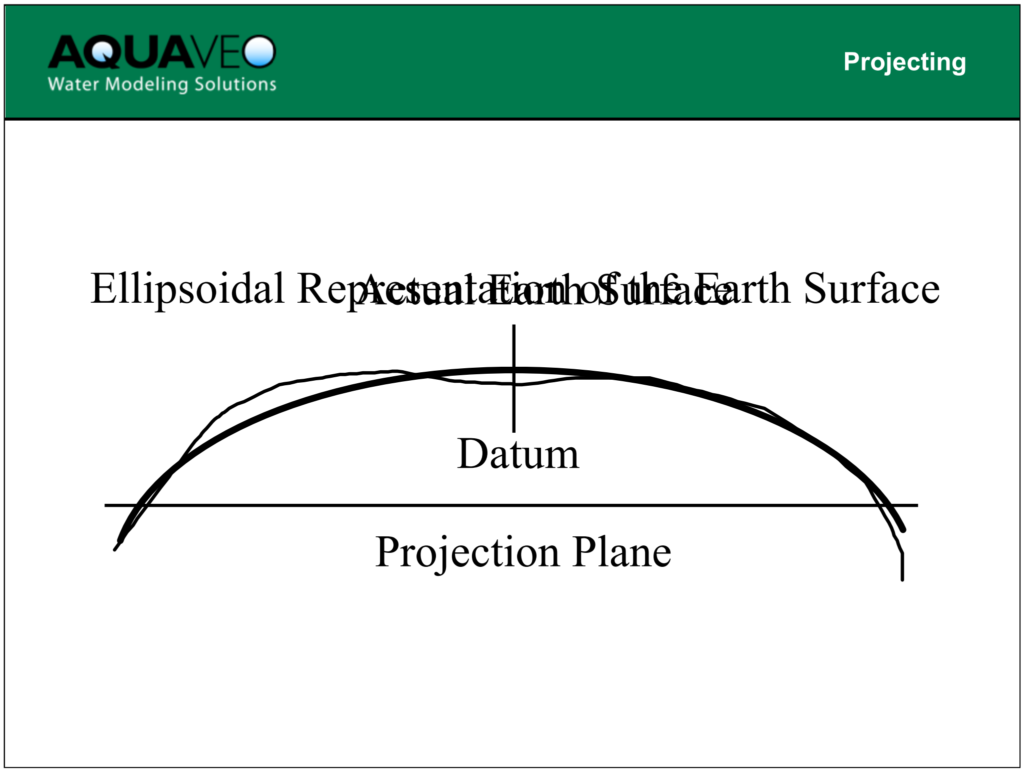
- Latitude and Longitude
  - Spherical coordinates
  - Geographic Coordinates



The earth is approximately in the shape of a sphere and therefore points on the surface of the earth are accurately described in a spherical coordinate system. Latitude ranges from 0 to +90 from the equator to the north pole and 0 to –90 from the equator to the south pole. Longitude is 0 at the prime meridian, which passes through Greenwich, England and ranges to positive 180 going east and –180 going west.



The problem with geographic coordinates is that while they can accurately describe a position on the surface of the earth, they are not very useful for calculating distances and areas—two important parameters for hydrologic analysis. Therefore, we need to have geographic coordinates converted to a planimetric coordinate system. Planimetric coordinate systems are defined using (x, y) coordinate pairs (also called eastings and northings) from an origin of a local coordinate axis.



Actually, the earths surface cannot be described everywhere with the mathematics of a sphere or even ellipsoid. So a combination of an ellipsoid definition together with a datum (a point on the earth's surface for which the ellipsoid has a "good fit") are used to determine latitude and longitude values. These values are then projected, or "flattened" onto a projection plane. The problem is that as we "flatten" the ellipsoid onto a flat surface from which we can define a planimetric coordinate system, there will be some distortion. This "flattening" process is referred to as projecting. The farther we move from the origin, the more distortion there will be. In order to minimize the distortion in a given area there are many different coordinate reference frames in use. Each tries to ensure that coordinates will all be defined with positive values relative to the origin and that the distortion from projecting will be minimized. Some of the most common systems are described on the next few slides.

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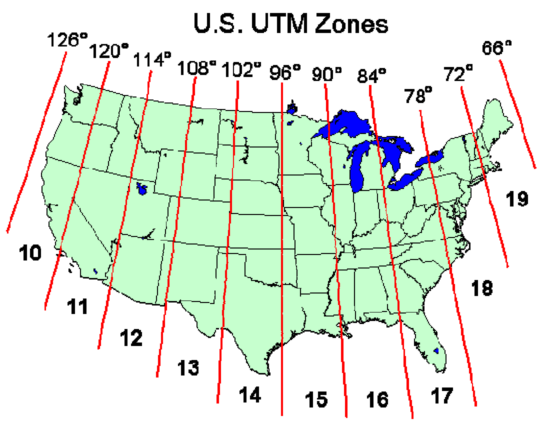
UTM

- Universal Transverse Mercator



A UTM (Universal Transverse Mercator) system is a world-wide system defined in meters. The world is divided into 60 zones, 6 degrees of longitude each, running from 84°N to 80°S latitude. It is worth noting that in the western hemisphere the UTM zone numbers increase as the magnitude of longitude decreases. Actually, zone one begins at the smallest value of longitude or –180. But we often refer to –180 as 180 degrees west, so there can be some confusion. This map shows the zone boundaries for the United States.

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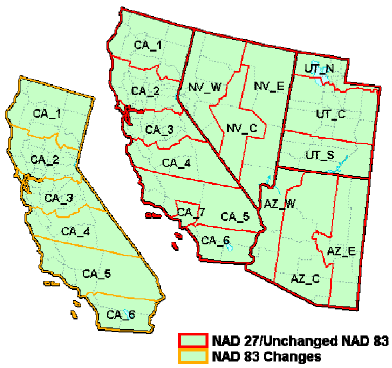
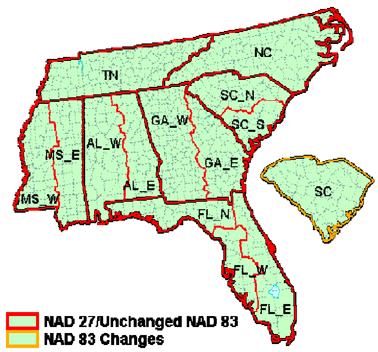
State Plane

- Commonly used in the U.S.





The definition used for State Plane coordinates vary from state to state and within states. This figure illustrates how states in the west (this is similar for eastern states, although many smaller states may have only a single coordinate zone) are divided into separate zones within a state. As with UTM coordinates, XY values (eastings and northings) are defined uniquely only within a given zone and therefore you may be required to convert data from one zone to another to have a consistent coordinate definition within a project area.

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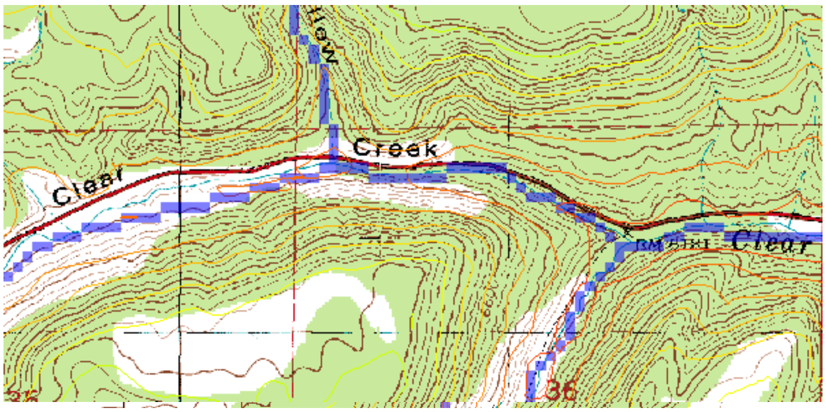
Converting Coordinate Systems

- Different UTM Systems
  - Image is in UTM NAD 83, DEM in UTM NAD 27



Another common coordinate system problem is that older data are defined in the UTM NAD 27 system and newer data in the UTM NAD 83 system. This results in a small shift that may not always be noticeable, but can become problematic for some studies (if nothing more than your credibility is gone because things do not look right) if not corrected.

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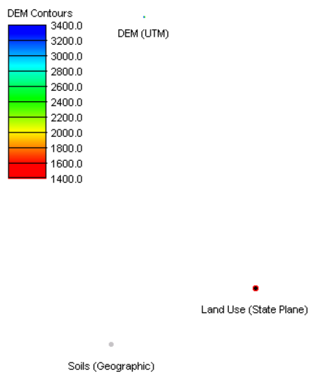
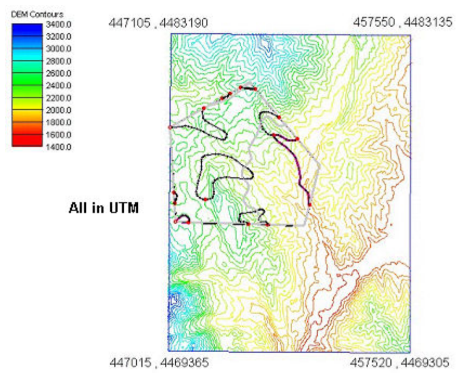
Converting Coordinate Systems

- DEM in one coordinate system and Land Use in another





Sometimes you may have different parts of your data in different coordinate systems. For example in this case we have the DEM in UTM coordinates, the soils in geographic (latitude-longitude) coordinates and the land use in state plane. In order to properly do the conversion in WMS you would need to import the soils, set the current coordinate system to geographic and then convert the soils to UTM and save. Then import the land use set the current coordinates to state plane and convert to UTM and save. Finally you can read the converted land use and soils files in and then import the DEM and all three will be in the UTM coordinate system.

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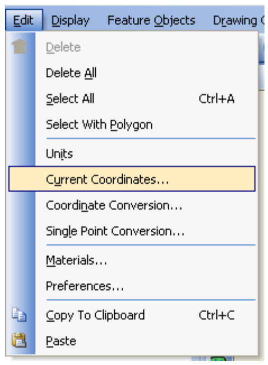
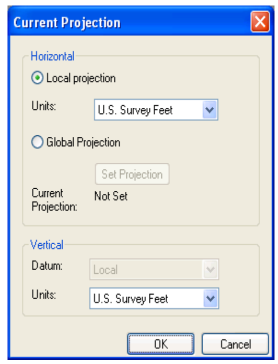
Know Your Coordinate System!

- It isn't enough to have the data, you also need know the coordinate system.
- Set the Current Coordinate System





Finding good data is important, but it is just as important that you know what coordinate system and units the data are in so that they can be correctly used in WMS. The Current Coordinates dialog allows you to tell WMS what coordinate system and units your data are in.

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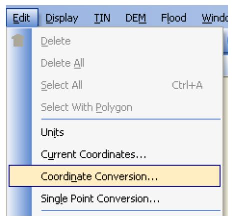
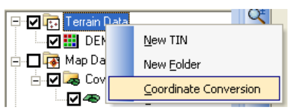
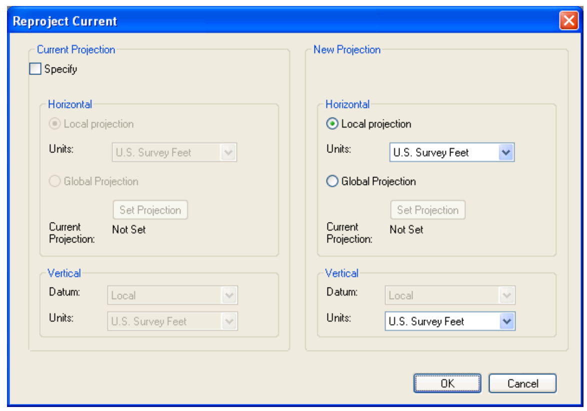
Converting Coordinate Systems

- Specify Coordinate System to Convert To
  - Globally
  - By data object from Tree







If you want to convert the coordinate system of a DEM, TIN, image, etc. you then choose the Coordinate Conversion command in the Edit menu. You can specify many different coordinate systems, datums, and units. However, you cannot mix coordinate systems for your data. For example you can't specify the current coordinates of a DEM to be UTM and the current coordinate system of an image to be state plane. You must first convert one or the other so that they can be used together. Coordinate systems for objects managed in the Data Tree Window can be individually converted by right clicking on the object and choosing the Coordinate Conversion command.

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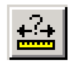
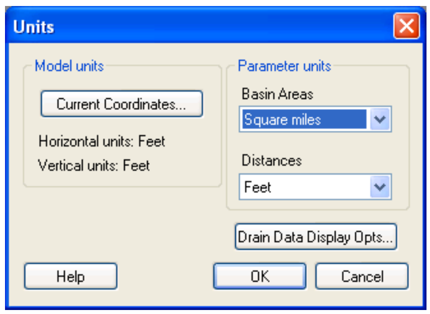
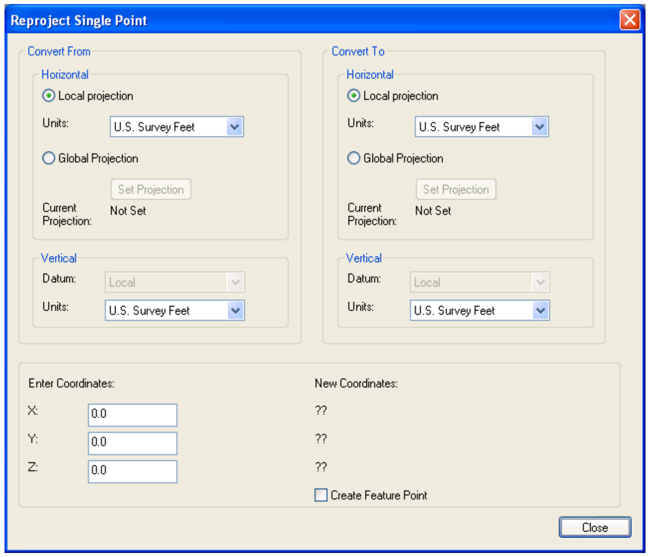
Current Coordinate System

- Measurement Tool 
- Calculations of Watershed/Stream Geometric Parameters
- Lengths/Areas of Feature Objects



The current coordinate system effects the values computed (units reported) when using the measuring tool. Units are derived from the definition of the current coordinate system so it is important that the current coordinates be defined before computing basin data. Also the horizontal (x, y) and vertical (z) units must be consistent in order for slopes to be computed properly.

Single Point Conversion



You can also use the Single Point Conversion command to convert the coordinates of any point from one system to another. This is particularly useful if you have the coordinates of a rain or stream gage in latitude/longitude and you wish to convert them to UTM or state plane in order to work with other data. Note that you can use the results of the conversion to create a feature point in the currently active coverage.

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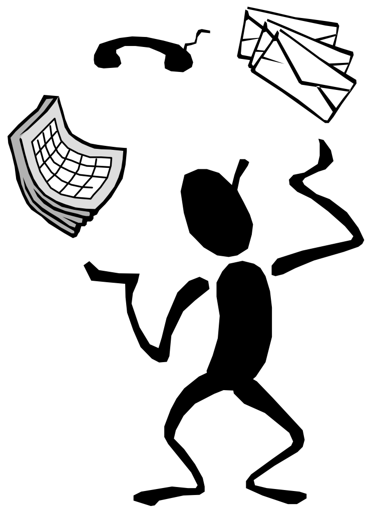
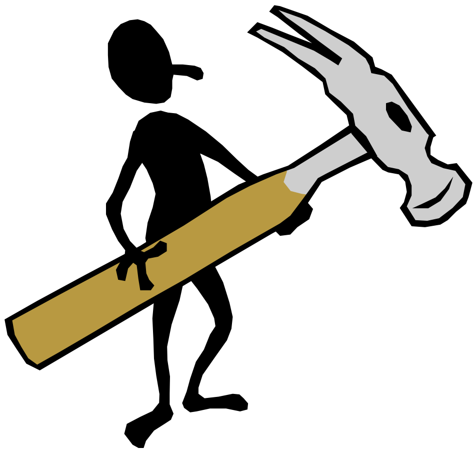
Demonstration



Workshop



The files that will be used for this workshop can be found in the tutorials directory in the folder named **images**.

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Review & Discuss

- Objectives
  - Learn basic structure of image files
  - Understand how images are geo-referenced
  - Learn Different coordinate representations
  - Know how to set the coordinate system in WMS and how to change from one system to another
- Applications