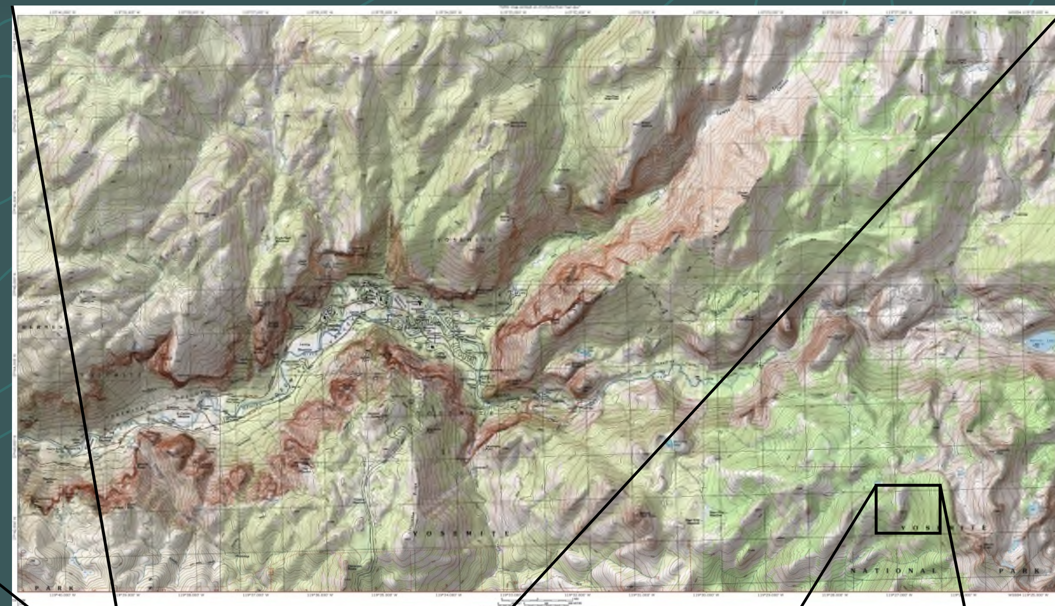
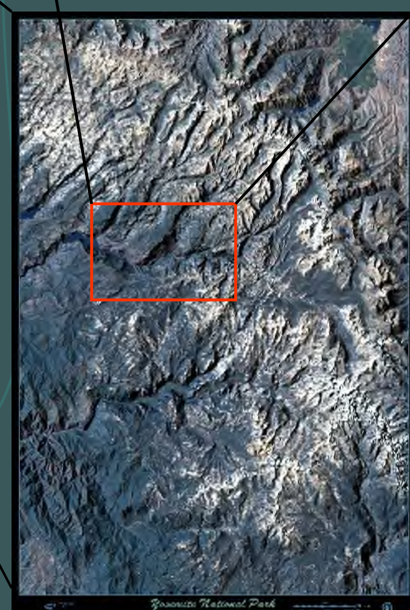
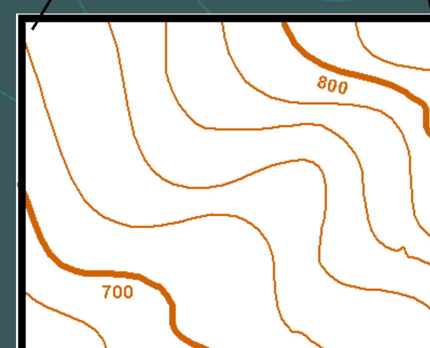
Topographic Maps and Landforms







Geology Lab

Ray Rector: Instructor

Topics

1) Become familiar with the fundamentals of topographic maps and landforms

2) Preparation for next week's lab on Structural Geology and Using and Making Geologic Maps

Learning Outcomes

When you are finished today, you should be able to:

1) familiar the concepts of scale, location (latitude and longitude), elevations, depths and contour lines.

2) identify the type, shape, and steepness of landforms

3) create s simple contour map from elevation point data

4) draw a cross-section profile

Many Types of Maps

1) Topographic Maps
2) Bathymetry Maps
3) Nautical Charts

Surface Height Maps

4) Geology Maps
5) Road Maps
6) Political Maps
7) Climate Maps
8) Ecosystem Maps

What is a Topographic Map?

1) An abstract, 2-dimensional, scaled-down graphic representation of the shape of the land.

2) “Topo” maps illustrate location, scale, width, length, and height of land surfaces.

3) Elevations of land surface are symbolized by contour lines which signify lines of equal elevation (termed isopleths).

4) Topo maps also show other features like rivers, streams, trails, roads, and buildings.

Next:

Let’s compare a “Topo” map to a Bathymetric Chart ?

Map Series Examples

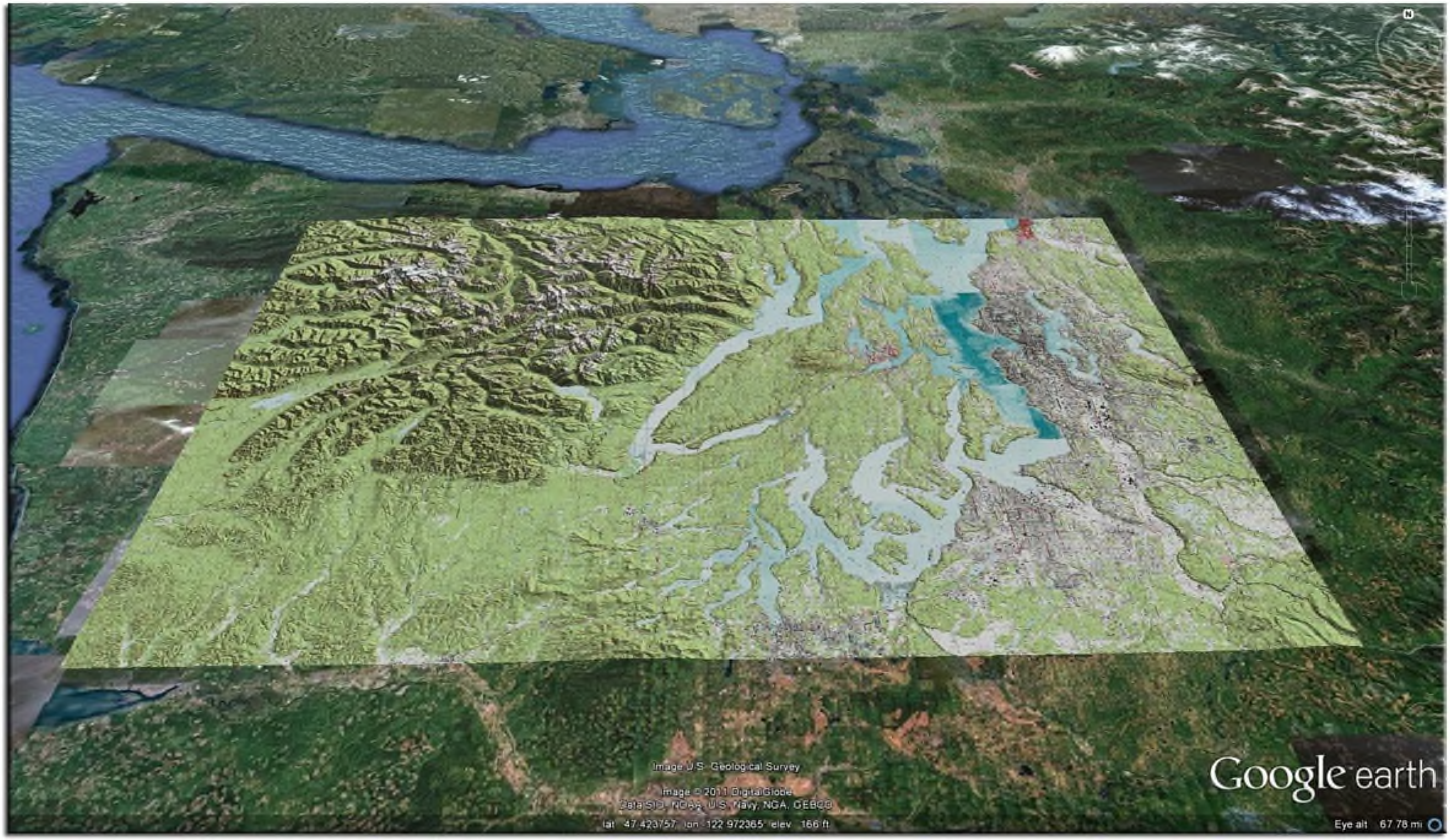
USGS Topographic Maps

|| 7.5-minute maps || 15-minute maps || 1:100,000-scale series
|| County map series || 1:250,000-scale series
|| State map series || National park map series
|| Shaded-relief maps || Topographic-bathymetric maps
|| Antarctic maps ||

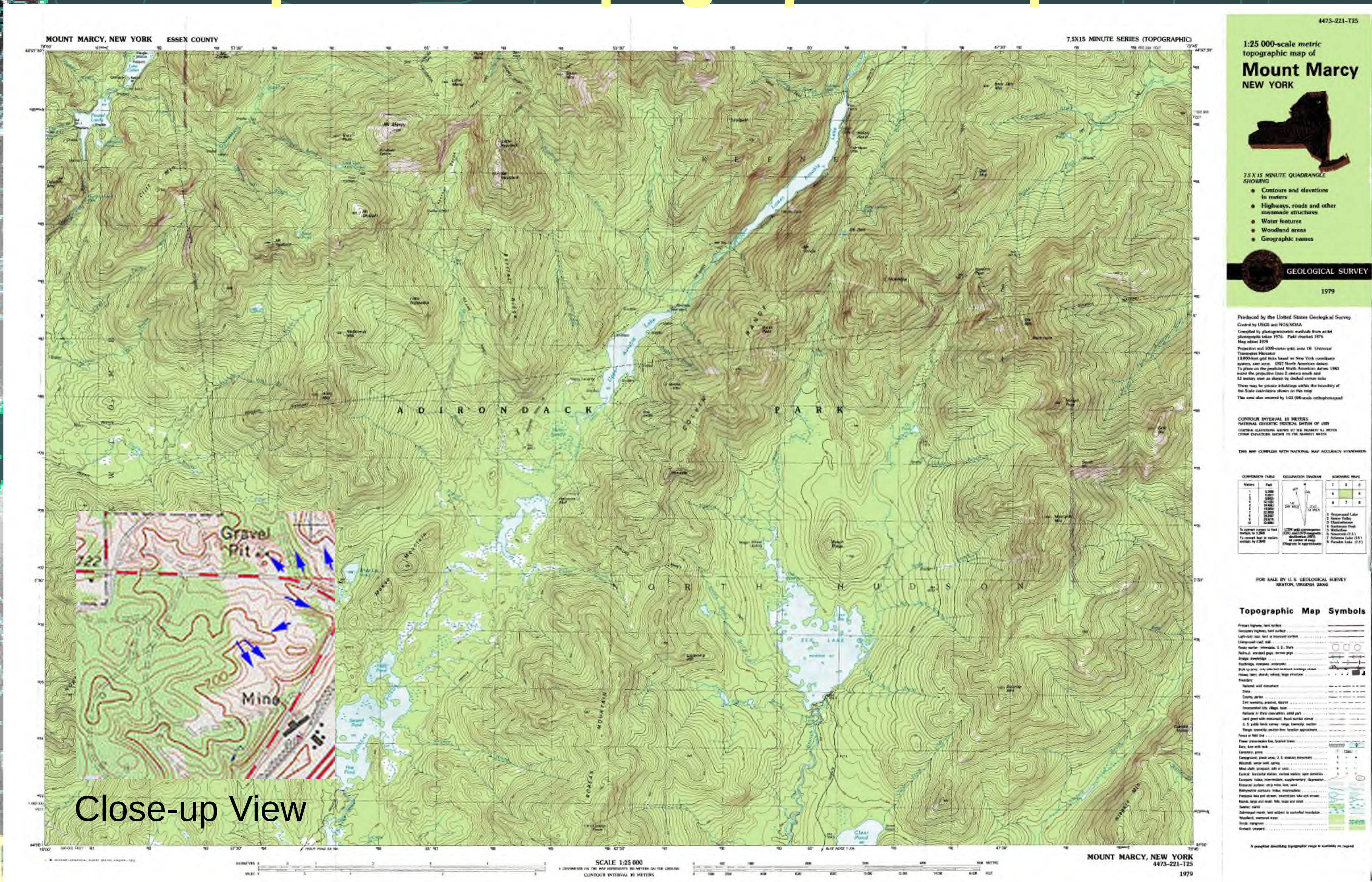
NOAA Bathymetry Maps

Coastal || Fishing || Global || Lakes || Multibeam
NOS surveys || Trackline

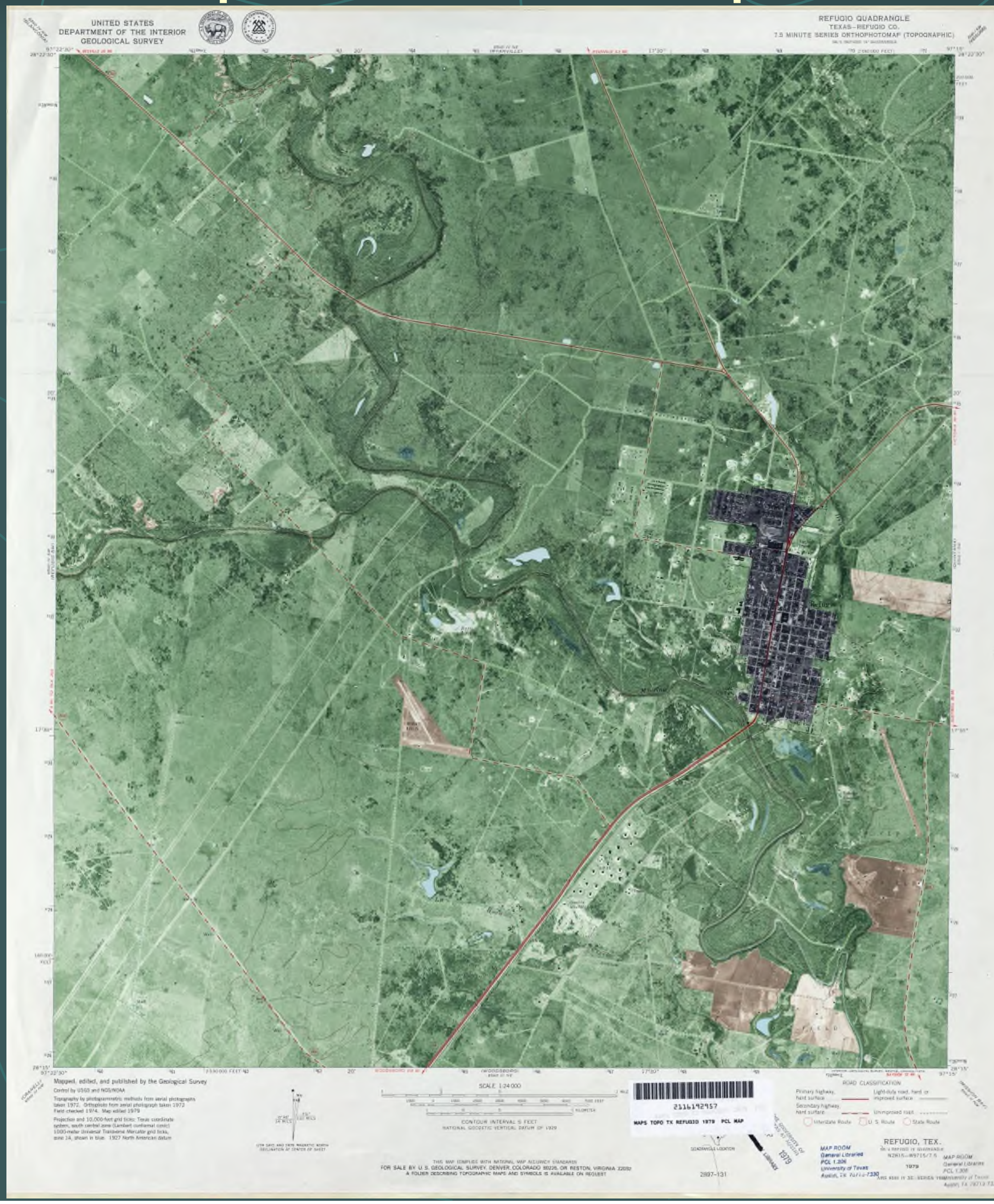
A Topographic Map Images the Ground



Example of a Topographic Map



Example of a Orthoquad Map



Importance of Topographic Maps to Geologists and Geographers

1) Navigation and Orienteering
2) Geologic Studies – Geologic Mapping and Sampling
3) Geographic Studies
4) Engineering Projects

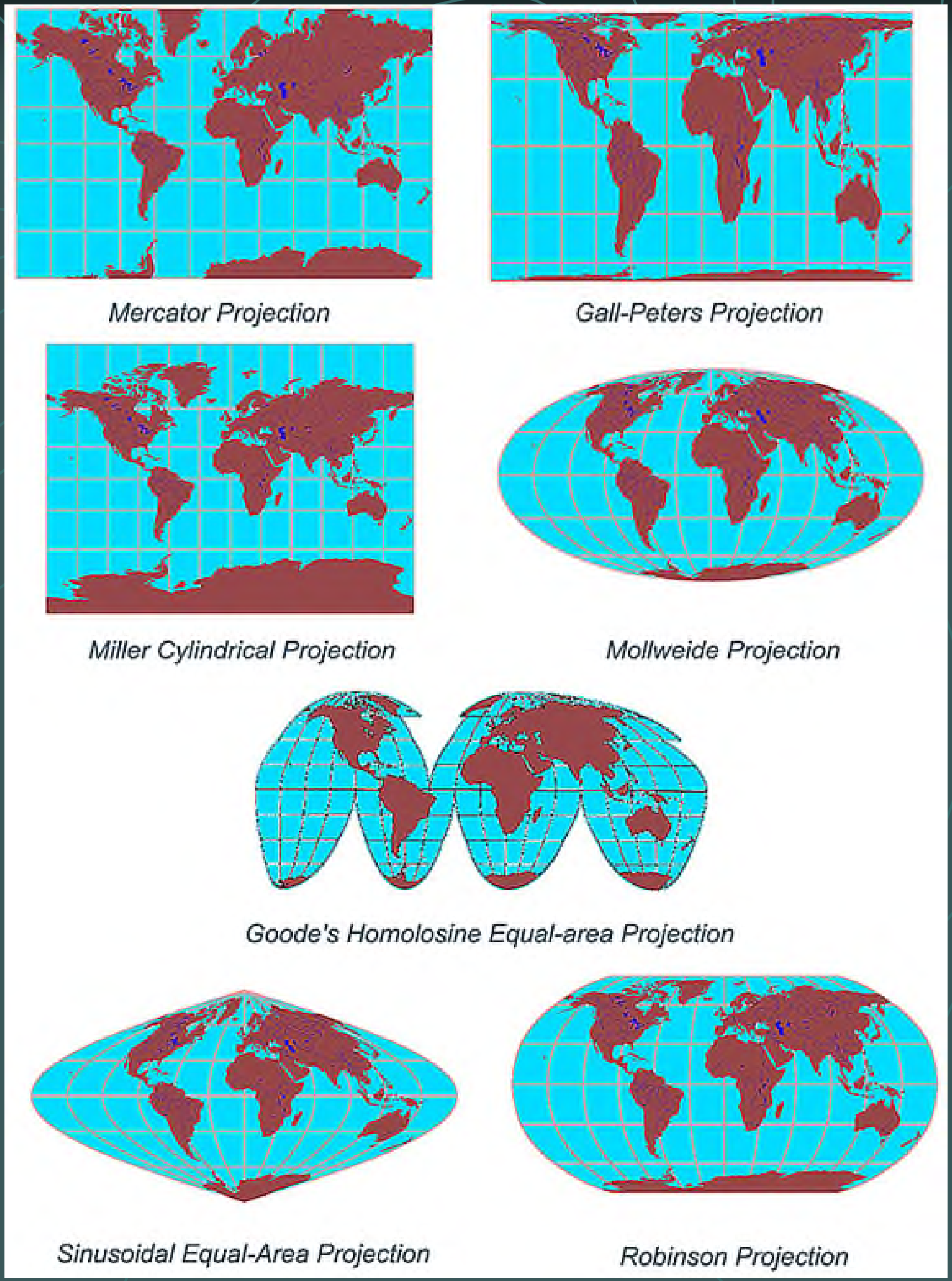
Key Concepts of Topographic Maps

1) Map Projection
2) Compass Directions – N-S, E-W
3) Location – Longitude-Latitude and UTM
4) Map Scale – Fractional, Verbal and Bar
5) Magnetic Declination
6) Map Series / Map Name
7) Map Symbols
8) Elevation Contour Lines

Map Projections

1) Transferring a Curved Surface to a Flat Surface

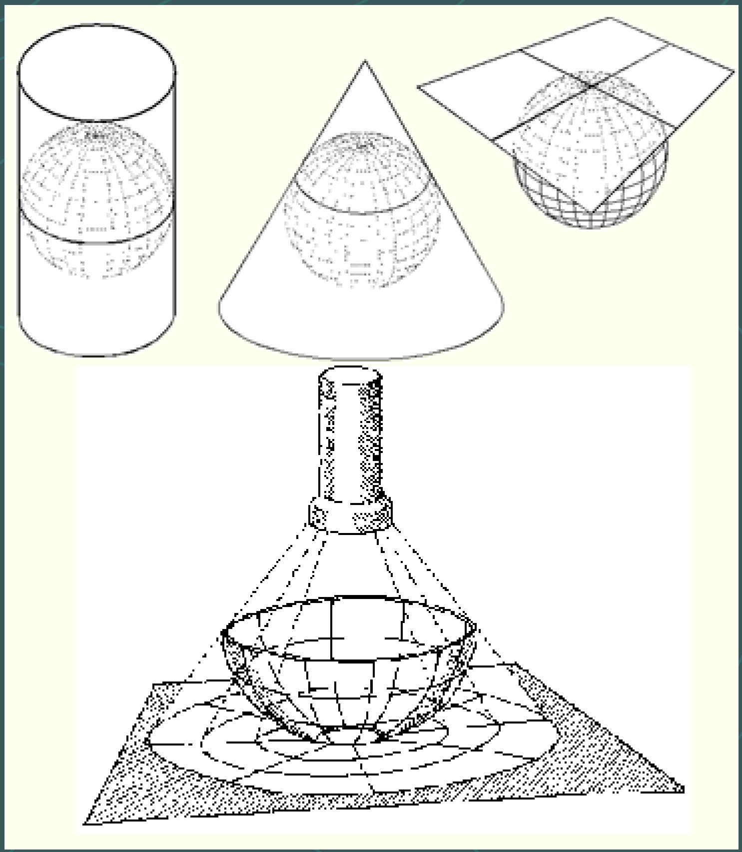
- Cannot avoid distortion
- Numerous methods
- Each method has a specific type of distortion
- Each method preserves a correct aspect of the earth's surface



Map Projections

1) Transferring a Curved Surface to a Flat Surface

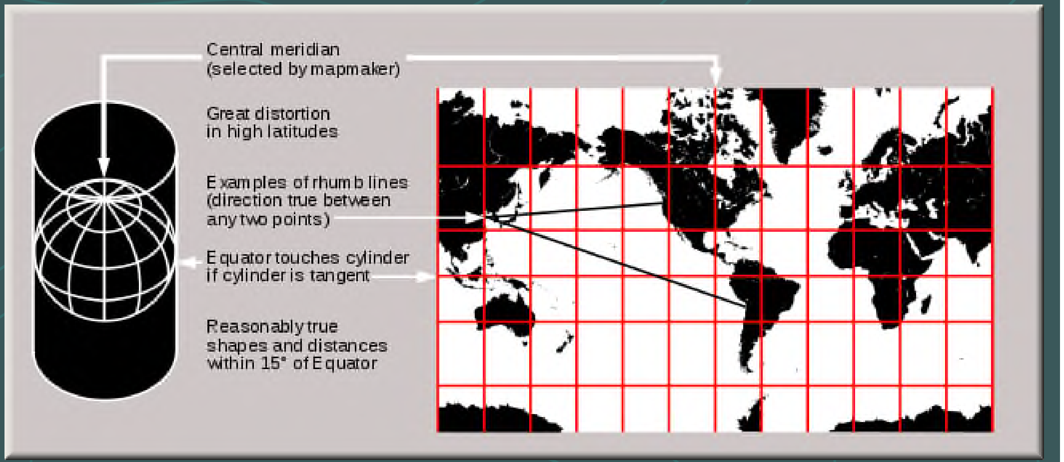
- Cannot avoid distortion
- Numerous methods
- Each method has a specific type of distortion
- Each method preserves a correct aspect of the earth's surface



Various Map Projections

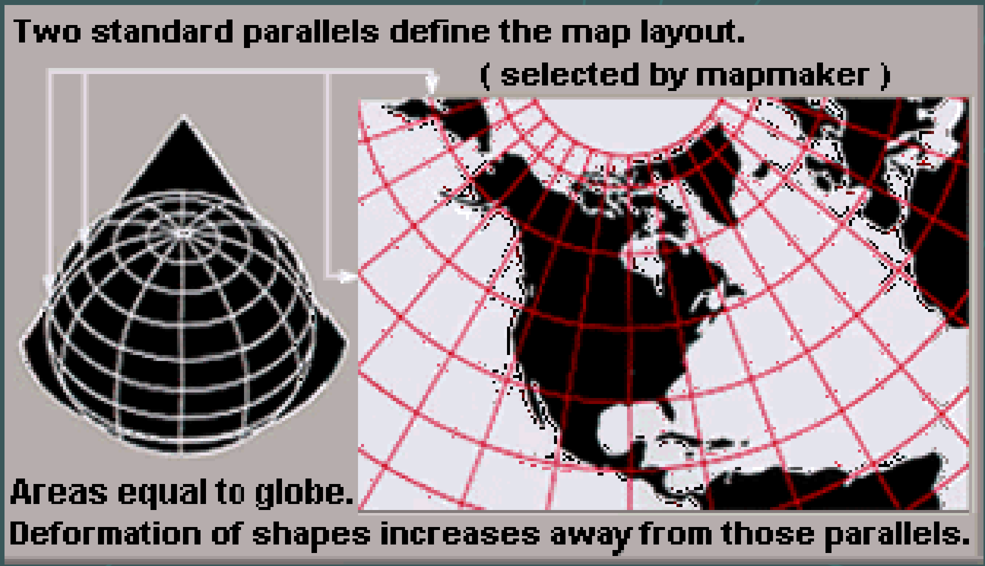
1) Preserve Direction/Angle

- Directions preserved
- Area is distorted
- Example is Mercator
- Popular projection



2) Preserve Area-Shape

- Preserves area size and shape
- Direction/angle is distorted
- Example is Albers
- Less popular projection



Map Scale

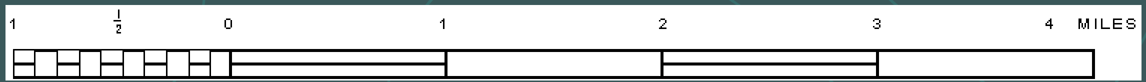
1) All maps are drawn to a specific scale

2) Distances on the map are proportional to distances on the ground

3) For example, 1 inch distance on a map with a 1:62,500 scale will represent 62,5000 inches of real ground distance, which translate to about 1 inch to 1 mile.

4) There are three ways to express map scale:

- Fractional scale: 1:62,500
- Verbal scale: 1 inch (map) equals 1 mile (ground)
- Bar scale:



5) Only bar scale stays accurate if the map shrunk or enlarged

Geographic Orientation of Maps

1) Compass direction of maps:

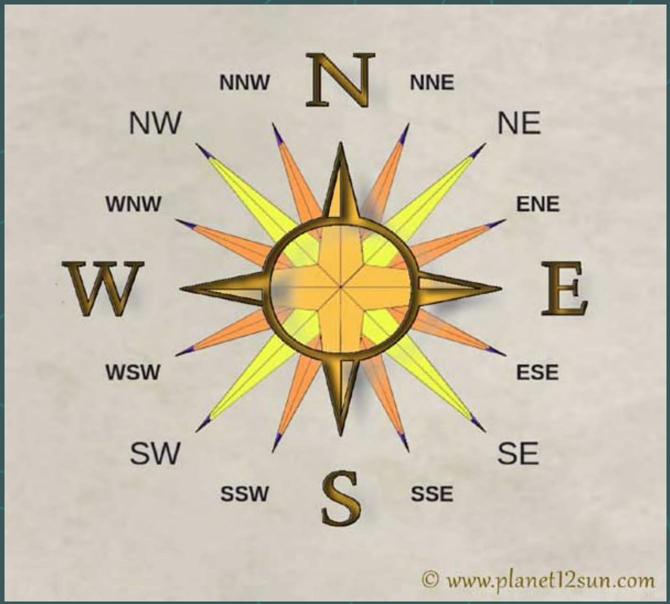
- True North points toward Top
- Due South points toward Bottom
- Due East points to the Right
- Due West points to the Left

2) Note that a compass points to Magnetic North

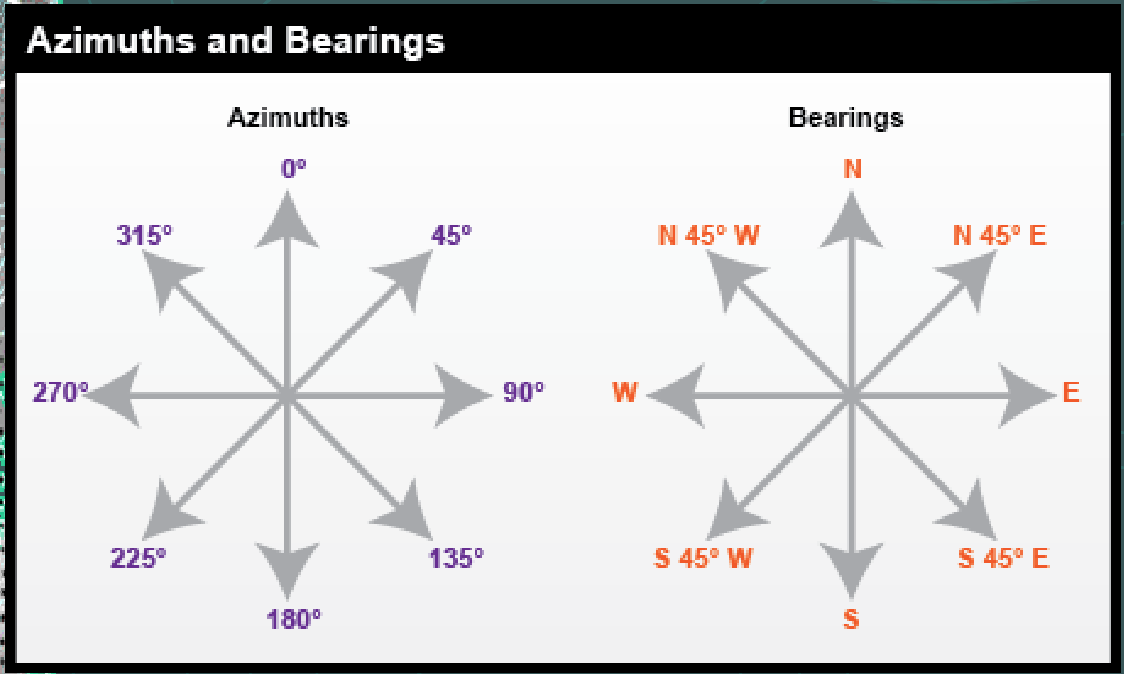
- Magnetic declination information should be found in the map legend

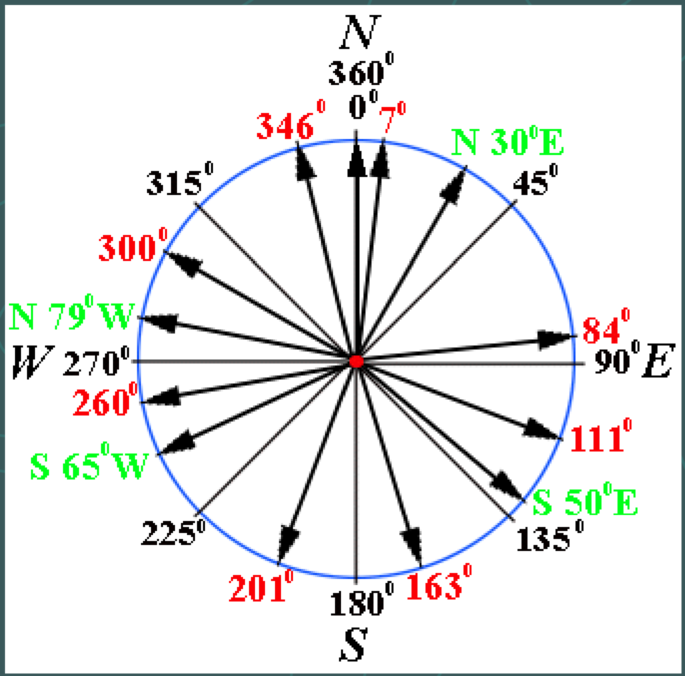
The Four Directional Quadrants

1) Compass direction of maps:
   - ➢ True North points toward Top
   - ➢ Due South points toward Bottom
   - ➢ Due East points to the Right
   - ➢ Due West points to the Left



Map Direction – Azimuth and Quadrant



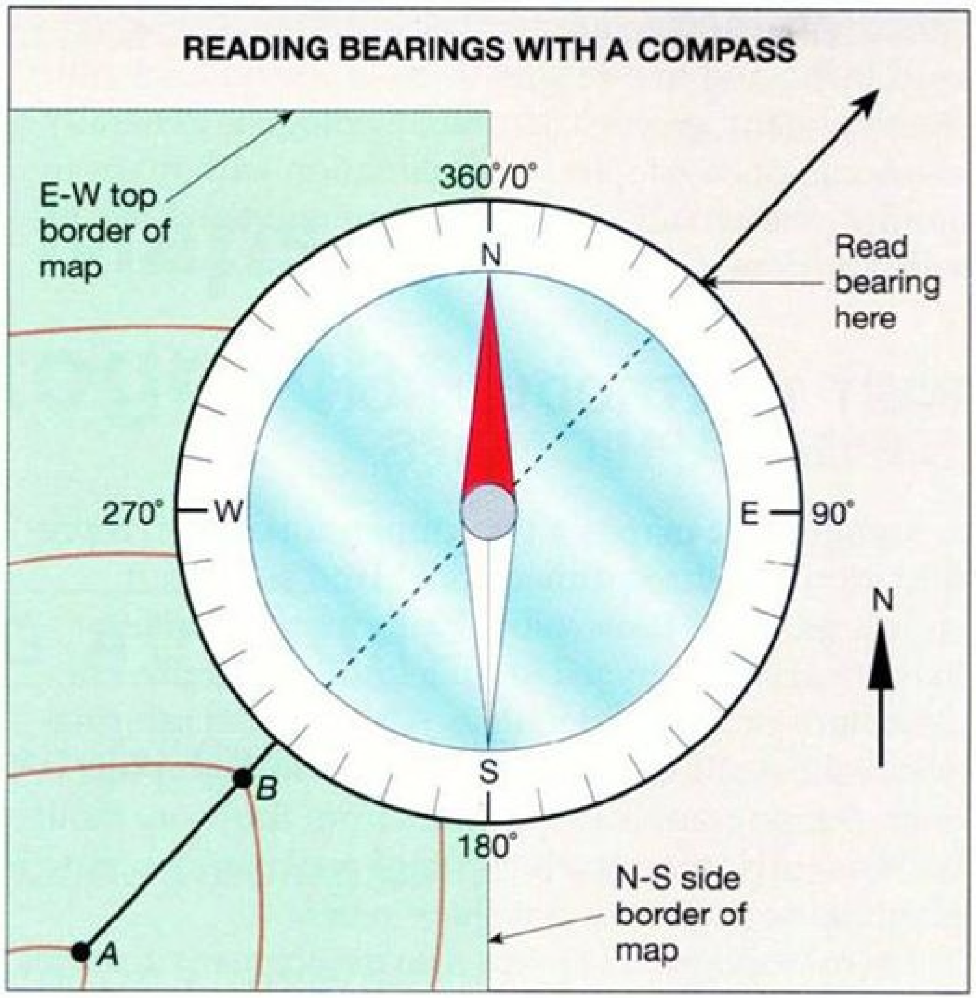


1) Azimuth measures direction from north (zero) 360 degrees clockwise around compass (E=90 – 180=S – 270=W)

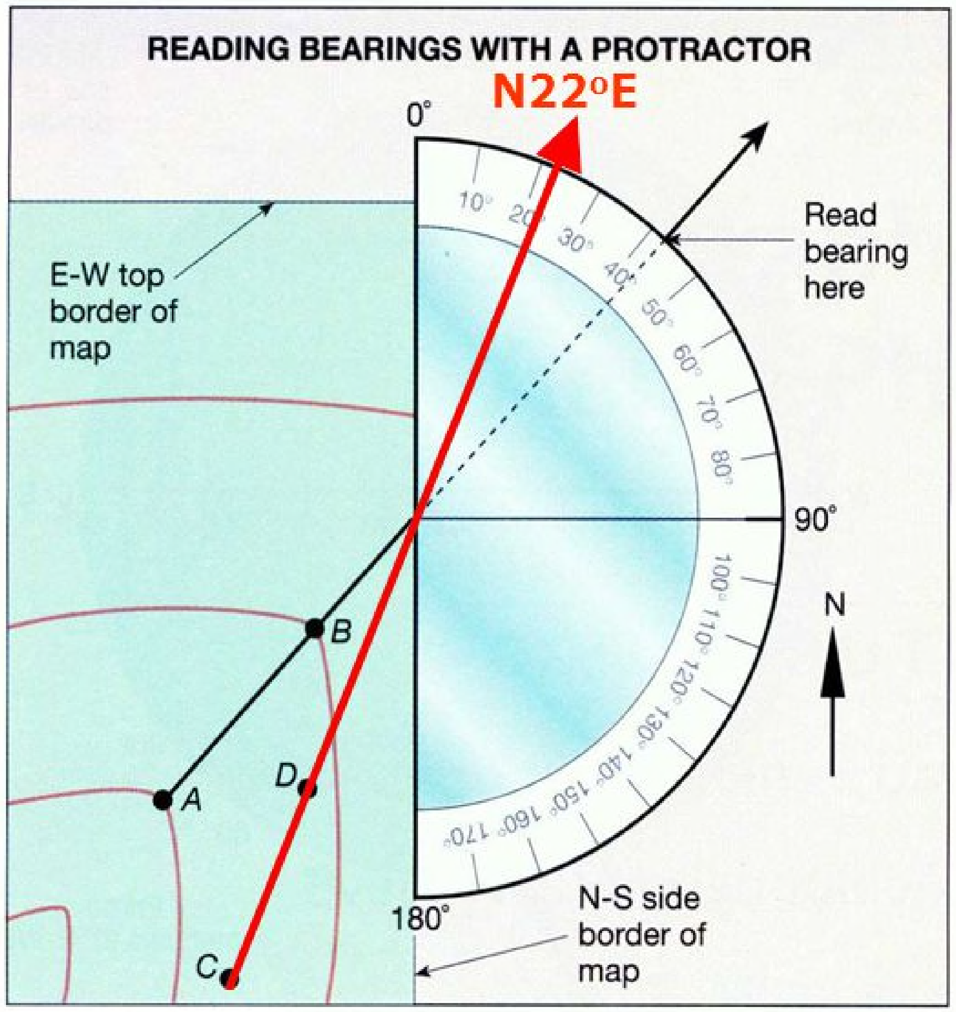
2) Quadrant measures direction: either North or South; then so many degree off of N or S; then either toward West or East

3) Difference between True Bearing *Versus* Magnetic Bearing

Azimuth Bearing

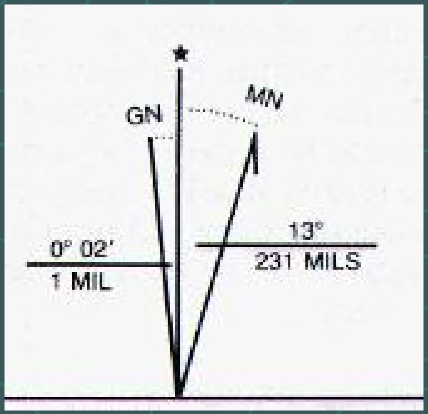


Quadrant Bearing



What is the bearing from C to D?

Magnetic Declination on Topo Map

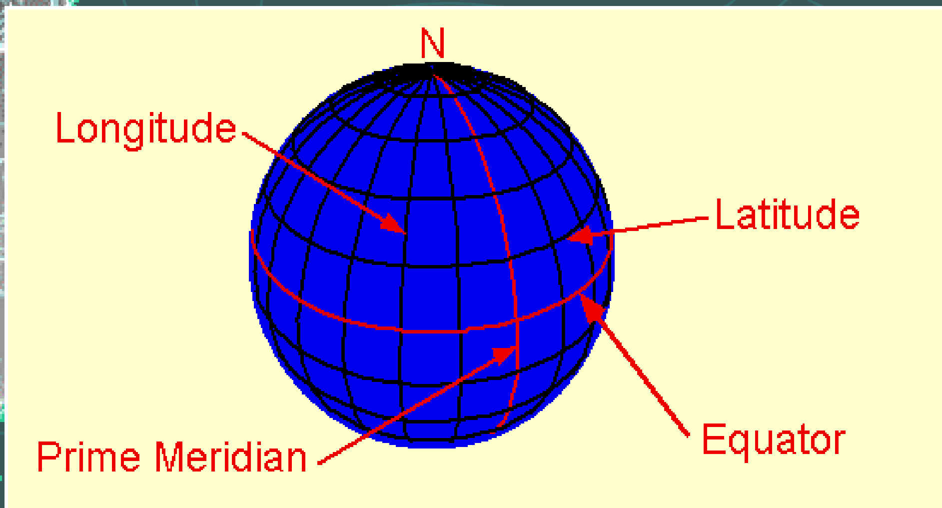


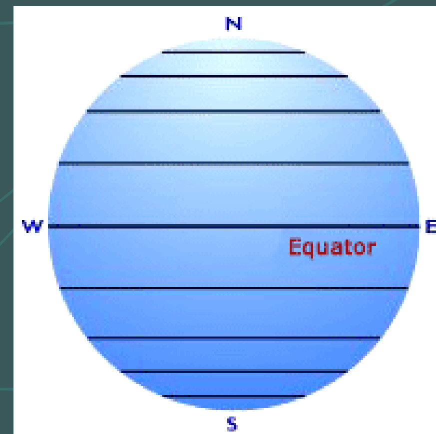
- Magnetic declination information should be found in the map legend
  - ✓ ★ = true north
  - ✓ MN = magnetic north
  - ✓ GN = grid north

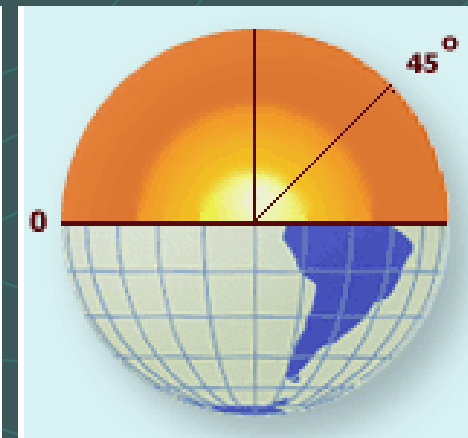
- Magnetic declination has a magnitude and direction

Finding One's Position on the Earth's Surface

Latitude and Longitude: A Global Coordinate System







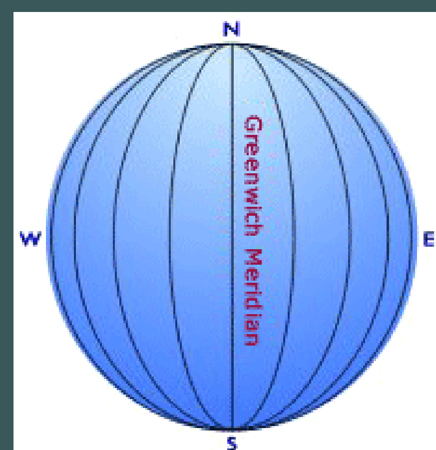
Lines of Latitude: N – S Position

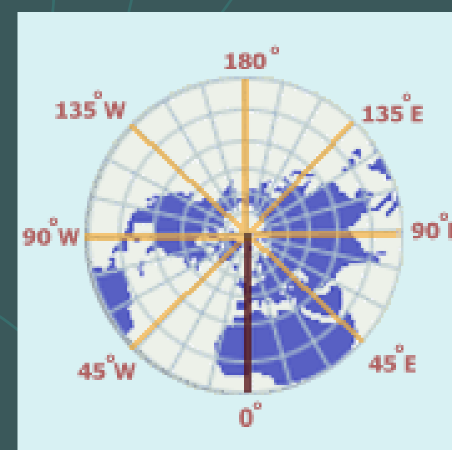
Latitude:

- ✓ Equator = 0º
- ✓ Poles = 90º N and S

Longitude:

- ✓ Prime Meridian = 0º
- ✓ IDL = 180º W and E

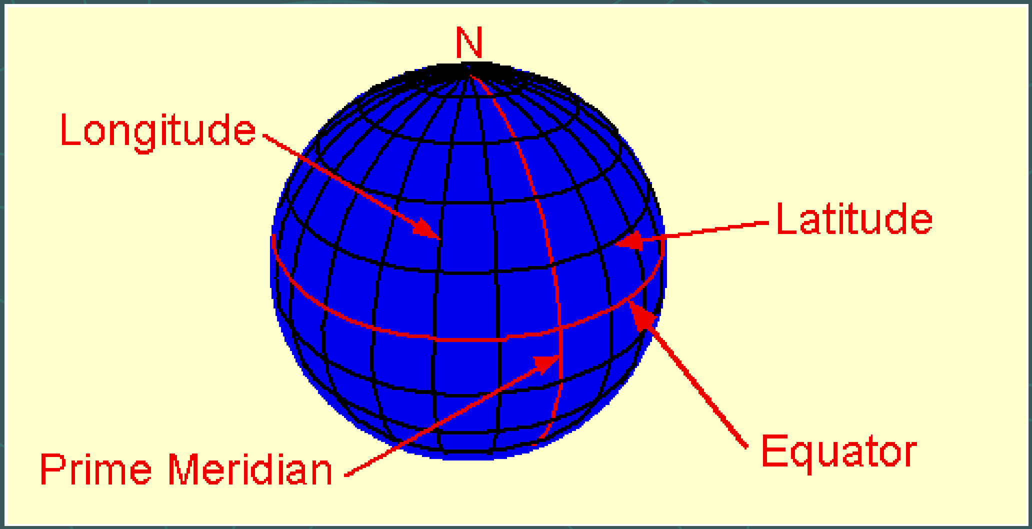


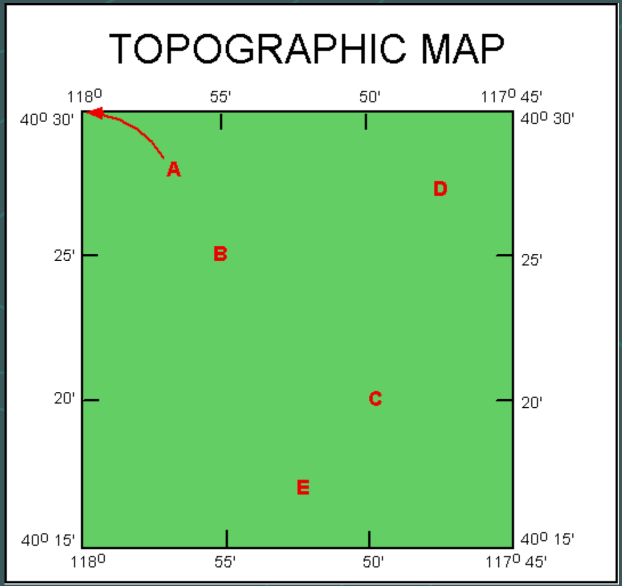


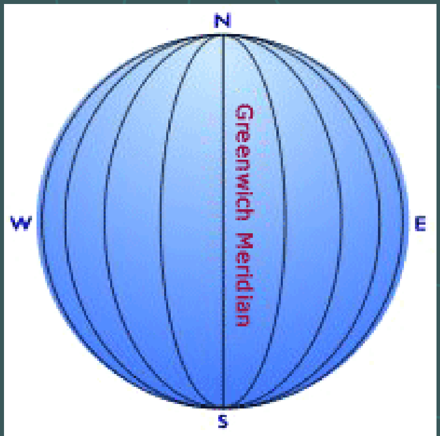
Lines of Longitude: W – E Position

Finding One's Position on the Earth's Surface

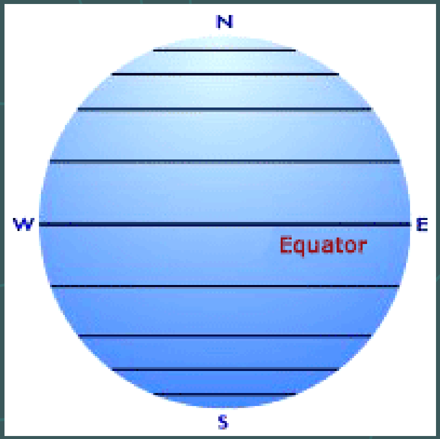
Latitude and Longitude: A Global Coordinate System



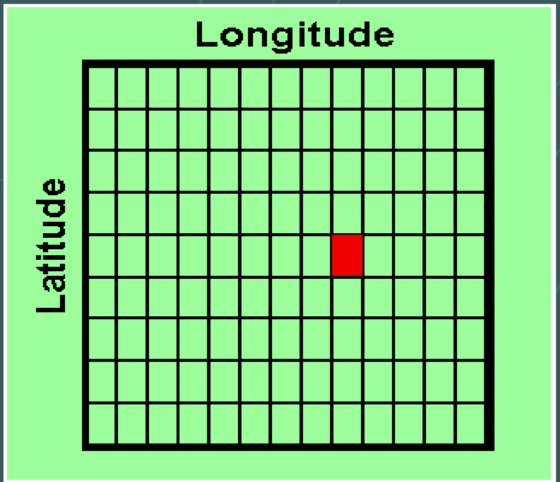




Lines of Longitude



Lines of Latitude

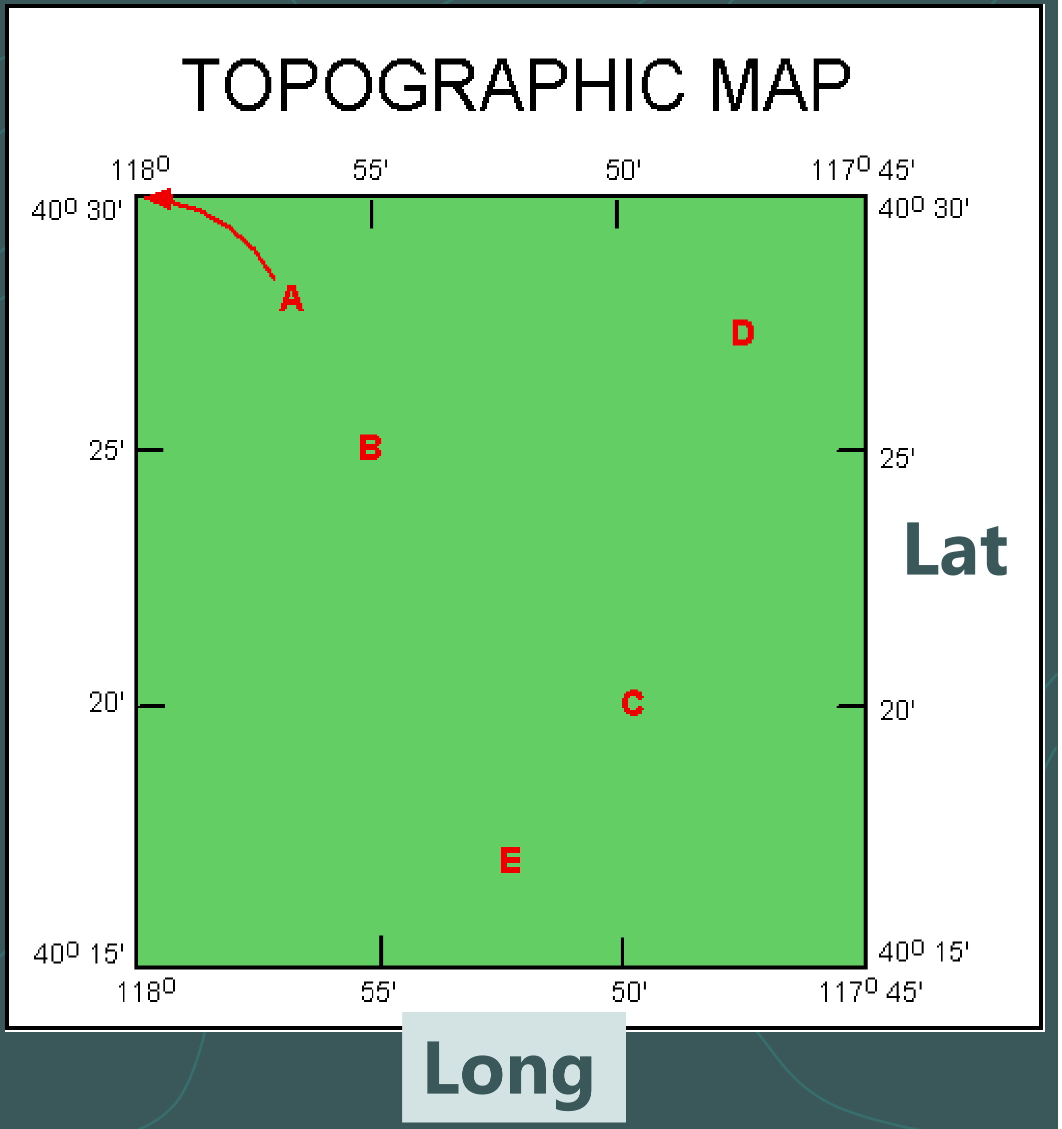


Finding Position on the Earth's Surface

Latitude and Longitude: Global Coordinate System

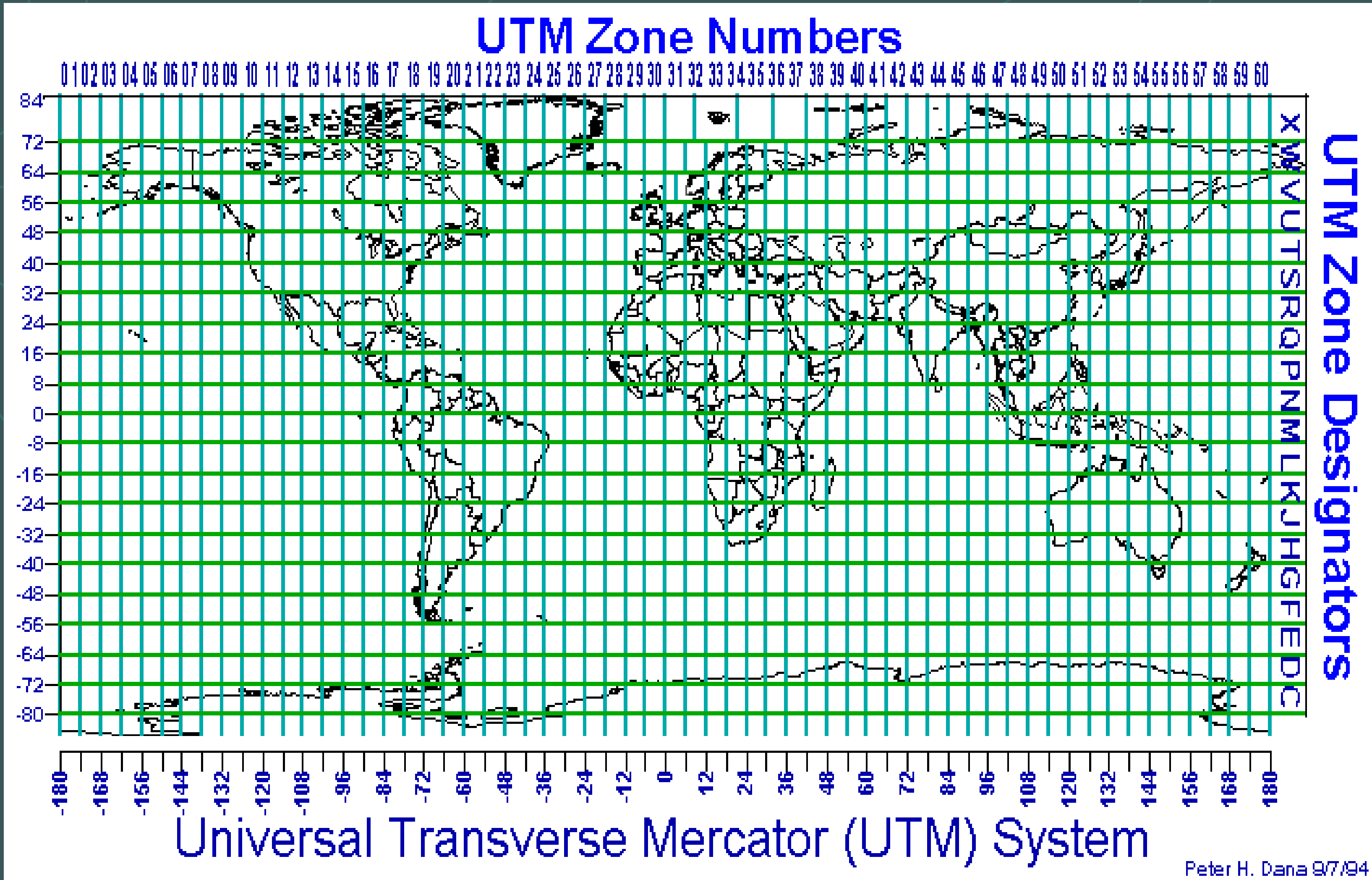
1) Given a specific location on map – Need to determine Latitude/Longitude coordinates

2) Given a specific set of Lat-Long coordinates – Need to determine the location on the map



Universal Transverse Mercator (UTM):

Another Global Coordinate System



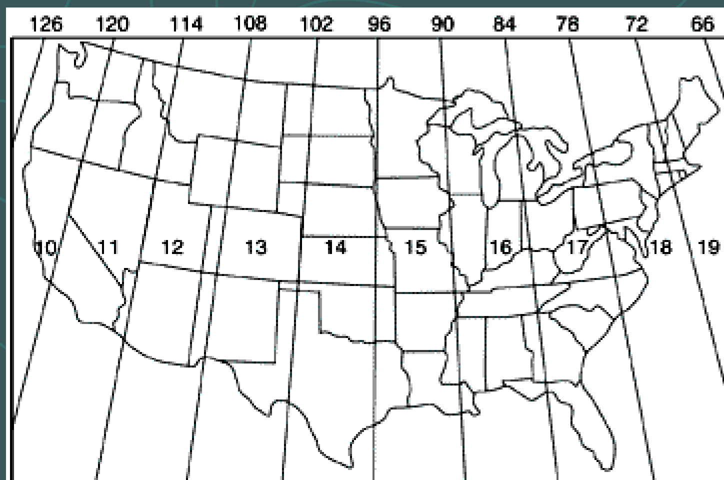
Earth Divided into 60 *6º degree* Longitudinal UTM Zones

Finding One’s Position on the Earth’s Surface

Universal Transverse Mercator (UTM):

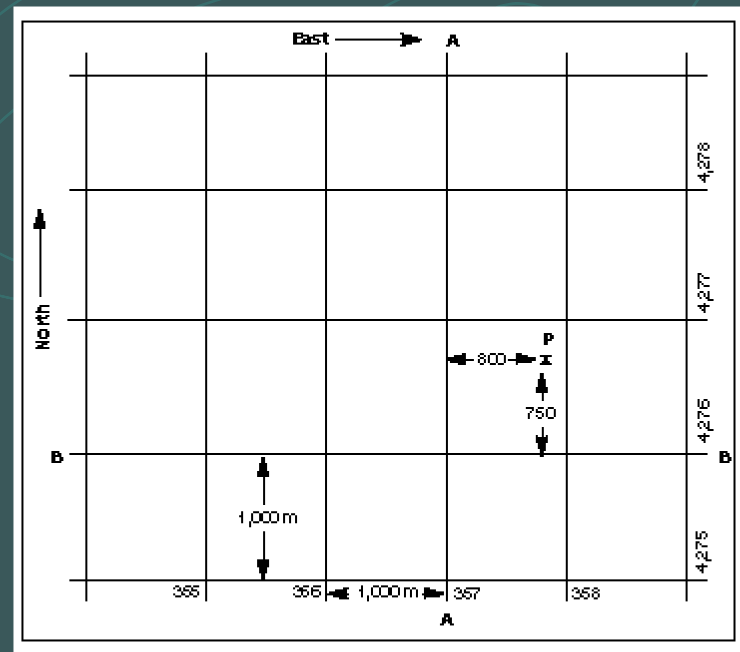
Another Global Coordinate System

UTM Zones



Easting →

Northing ↑



Northing: The number of meters north of the equator the location lies

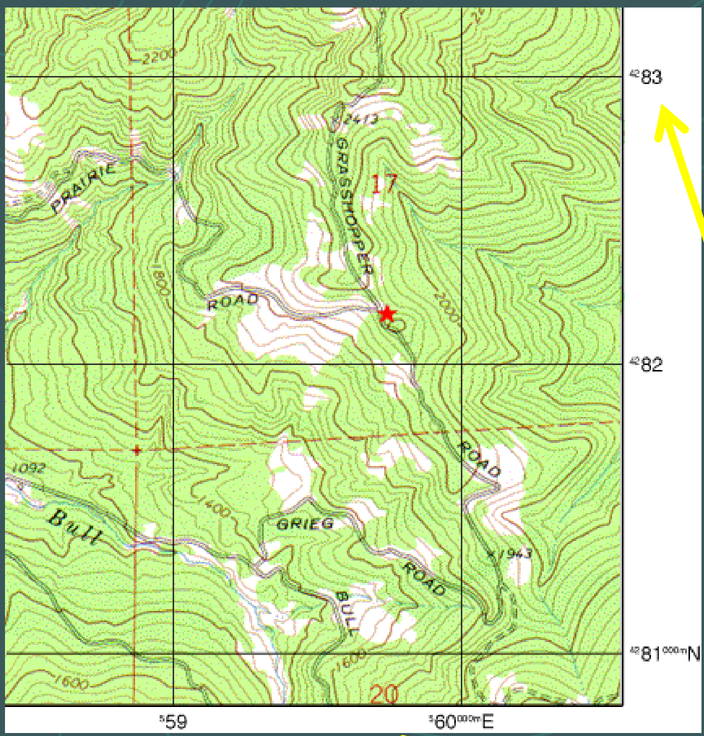
Easting: The number of meters east from the west side of the local zone the location lies

UTM map grid is divided into 1000 meter squares. This may be printed or not printed over the map

Universal Transverse Mercator (UTM):

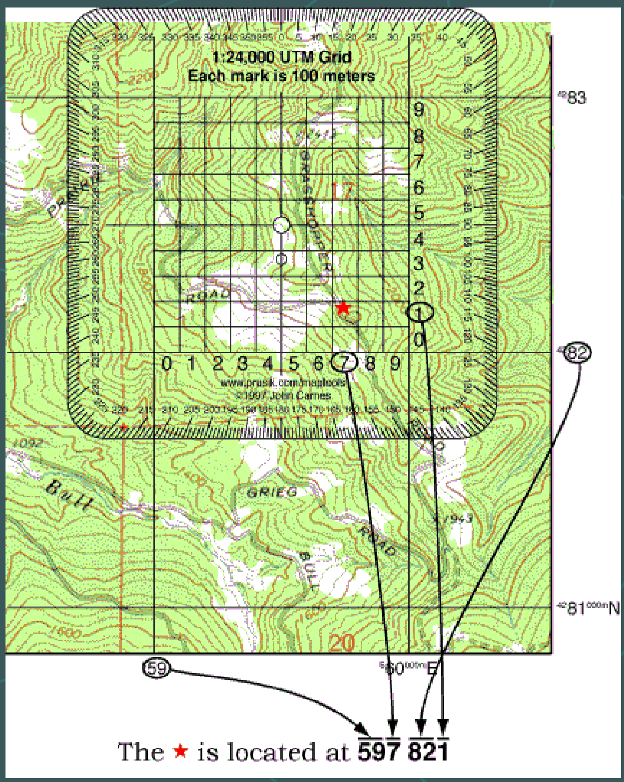
Another Global Coordinate System

UTM Zones, Northing and Easting on a Topo Map



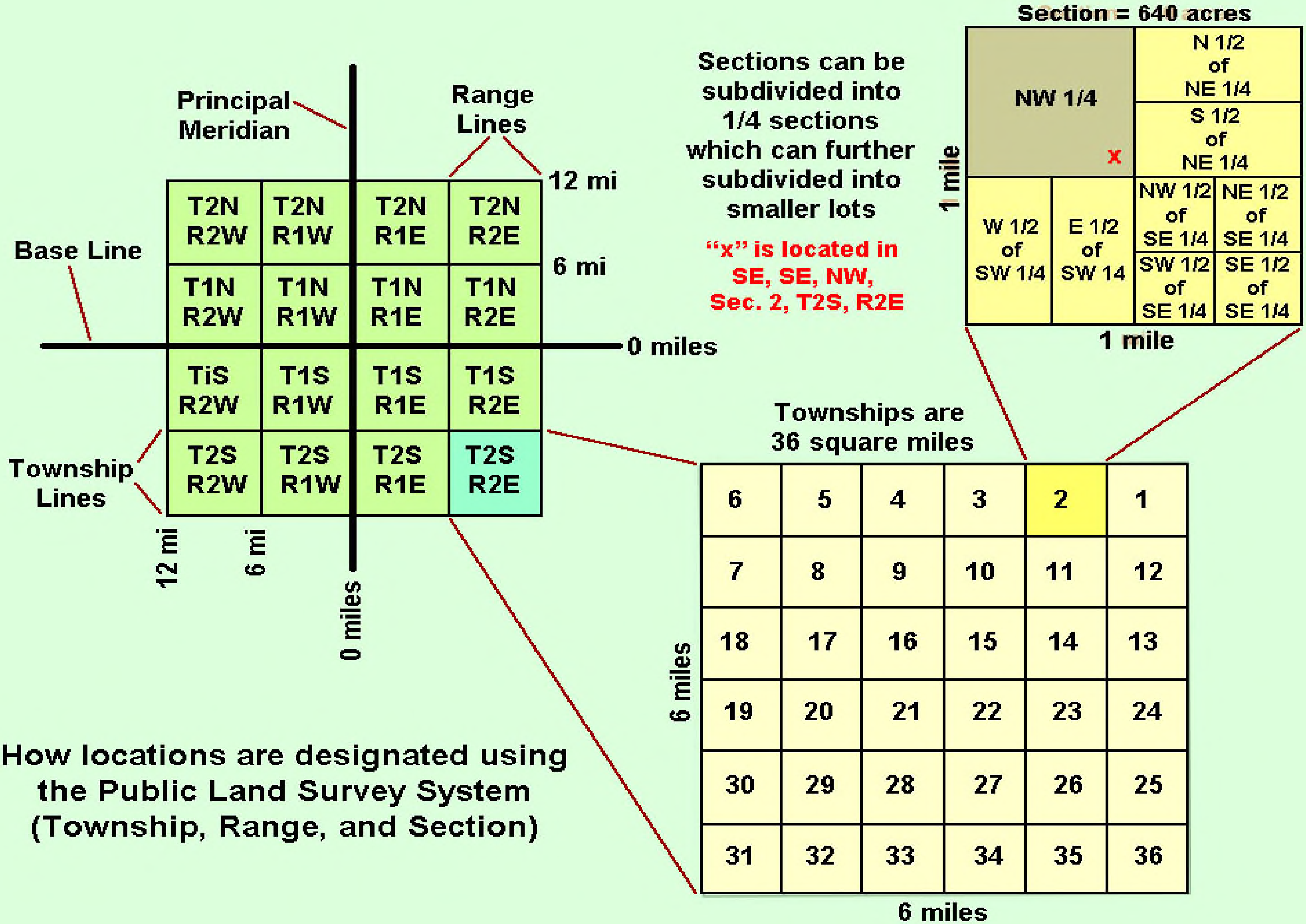
Northing values on the sides of the map

Easting values on the top and bottom of the map



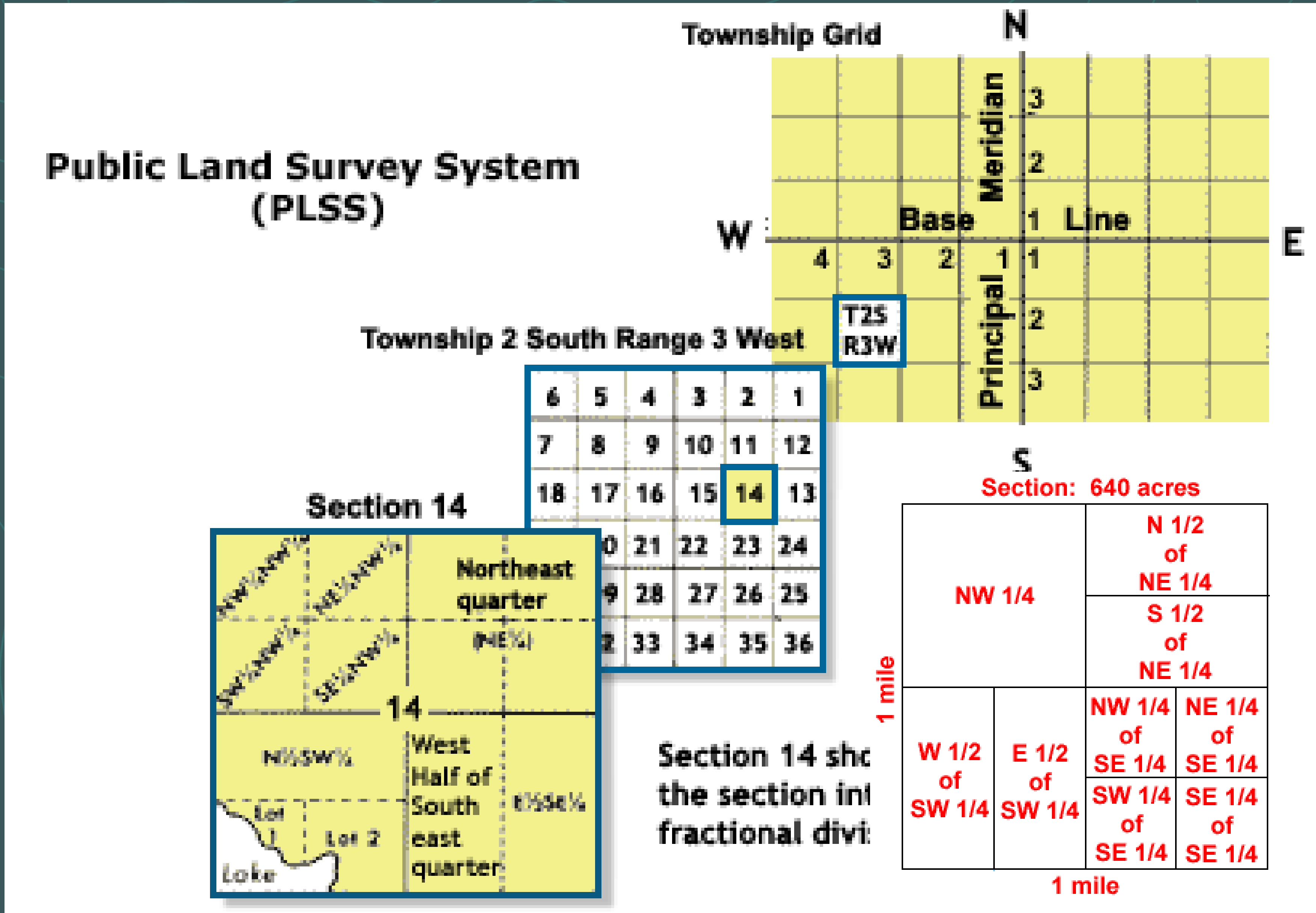
Using a UTM Grid template overlay on a Topo Map

Township Range Land Survey

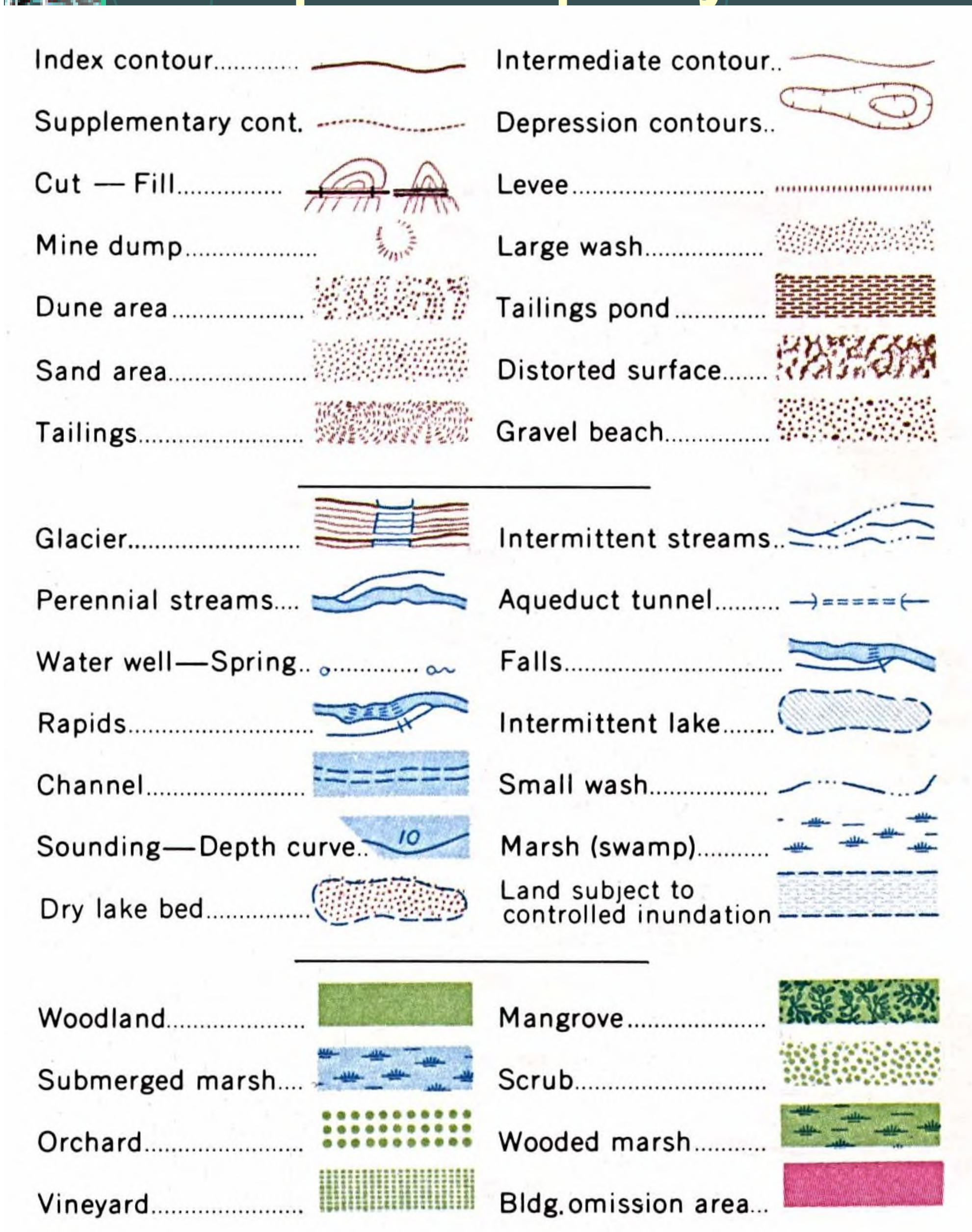


How locations are designated using the Public Land Survey System (Township, Range, and Section)

Township Range Land Survey

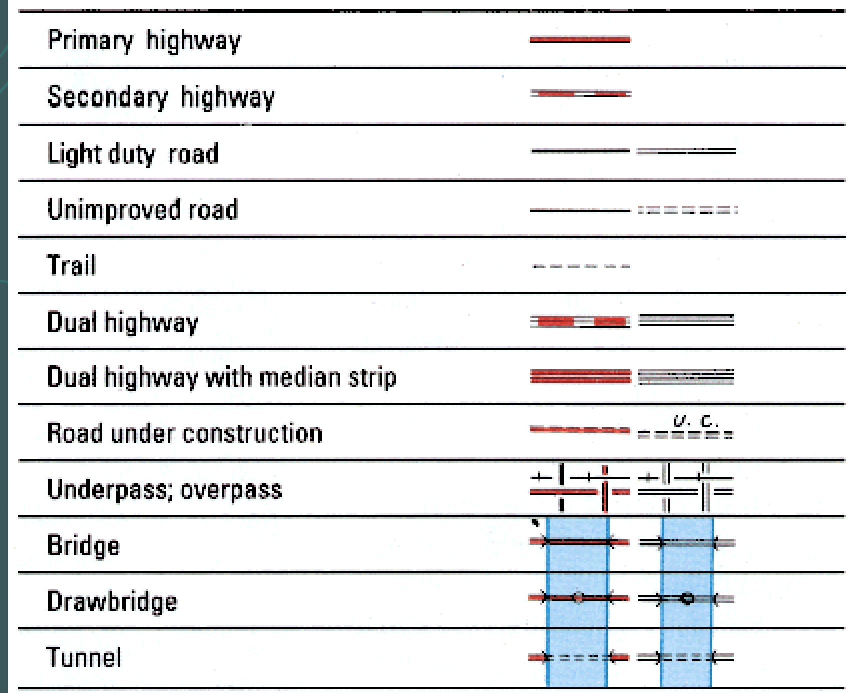


Topo Map Symbols



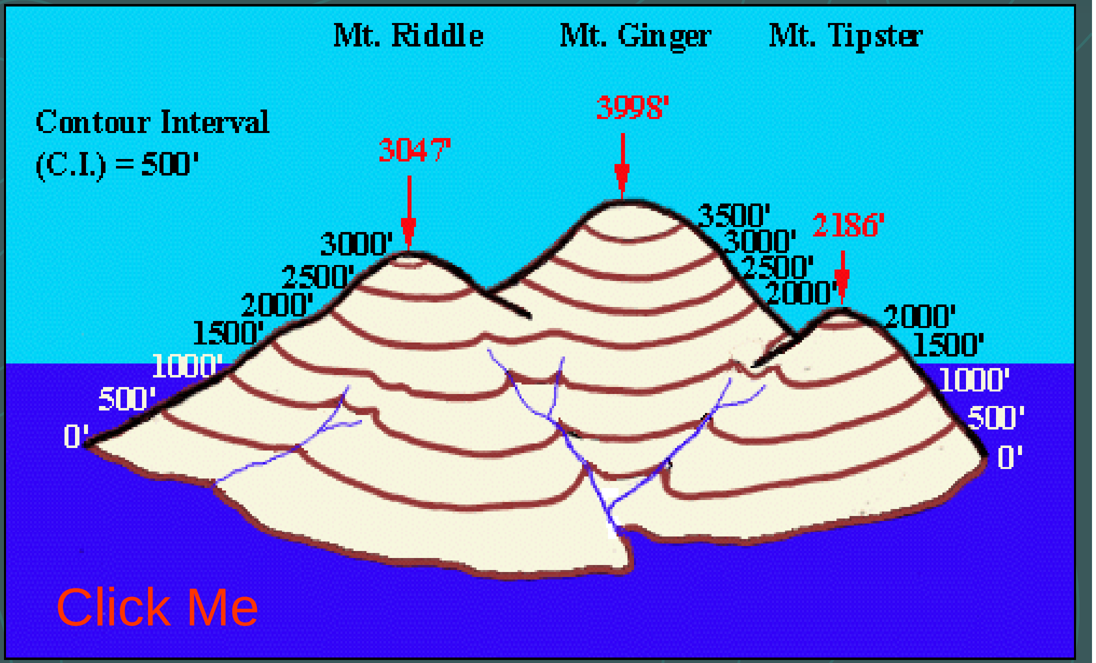
ROADS AND RELATED FEATURES

Roads on Provisional edition maps are not classified as primary, secondary, or light duty. They are all symbolized as light duty roads.



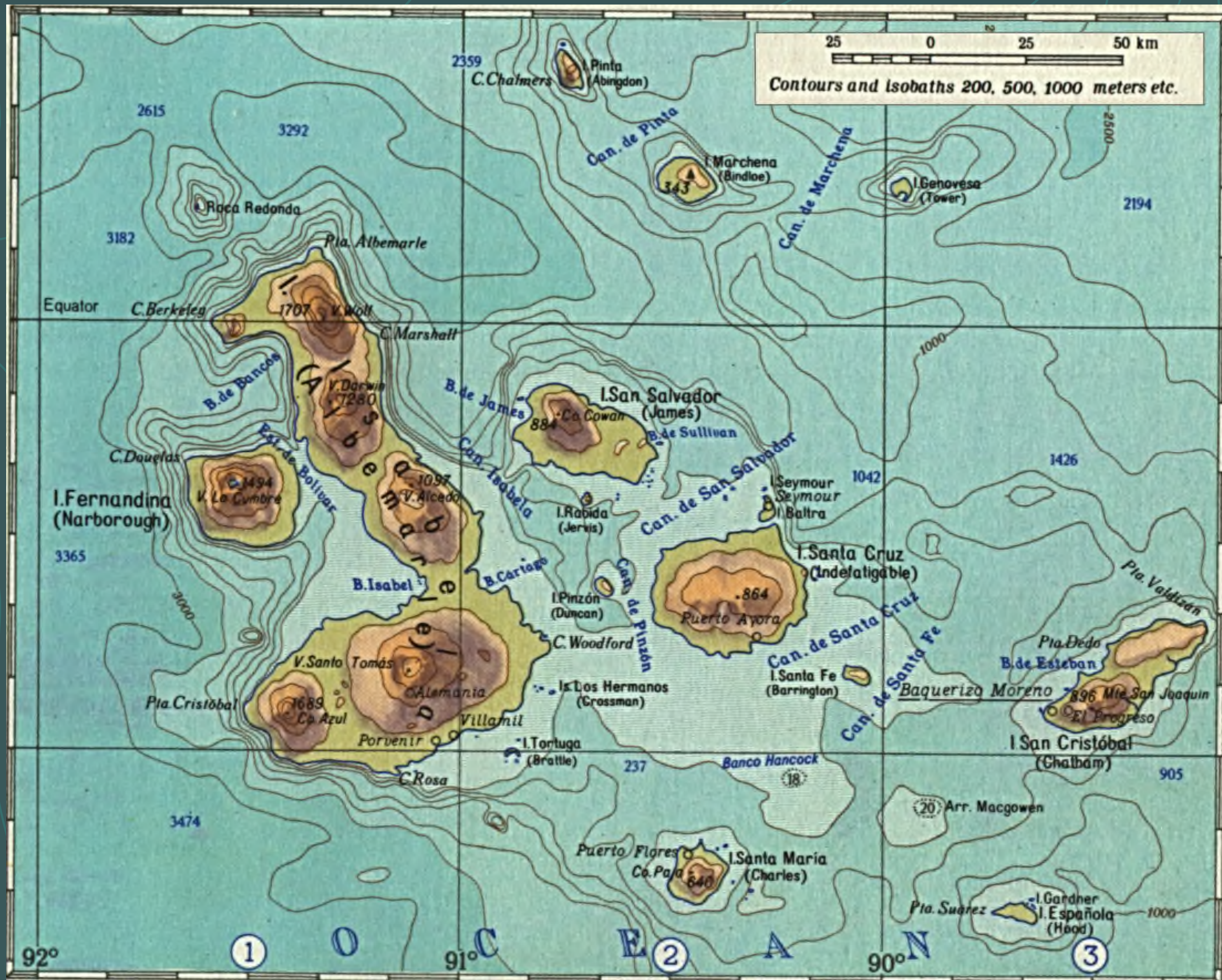
Understanding Contour Lines

1) Contours are imaginary lines that join points of equal elevation on the surface of the land above or below a reference surface, such as sea level.

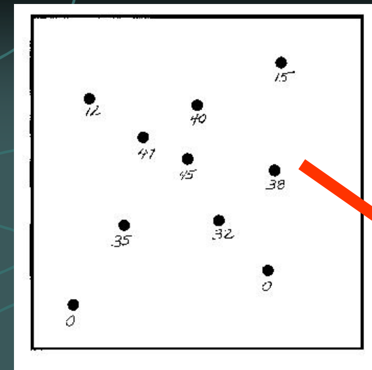


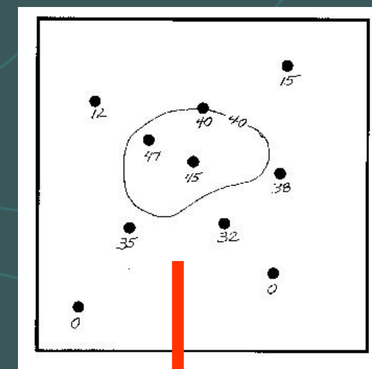
2) Contours make it possible to measure the height of mountains, depths of the ocean bottom, and steepness of slopes.

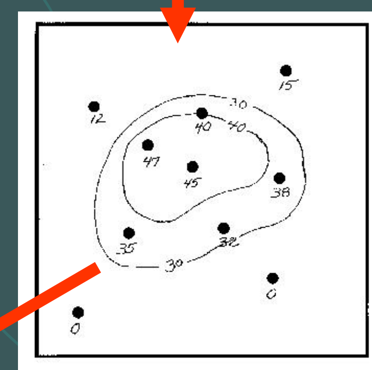
Map with Topography and Bathymetry



How to Make a Simple Contour Map







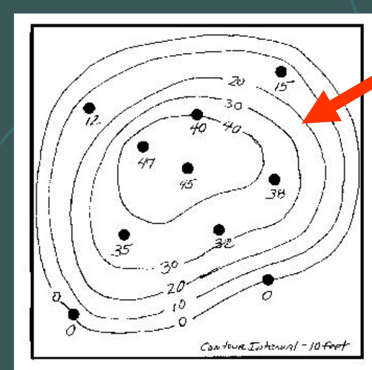
1) Start with a set of locations that have been measured for a certain surface attribute: Ex: elevation or water depth

2) Set a contour interval, based on range of values mapped

3) Draw a contour line for each interval multiple

4) Each contour must be drawn between higher and lower point values or on exact values

5) Interpolate between the high and low value where the contour line should be positioned



Click here for Internet example

Contouring Exercises

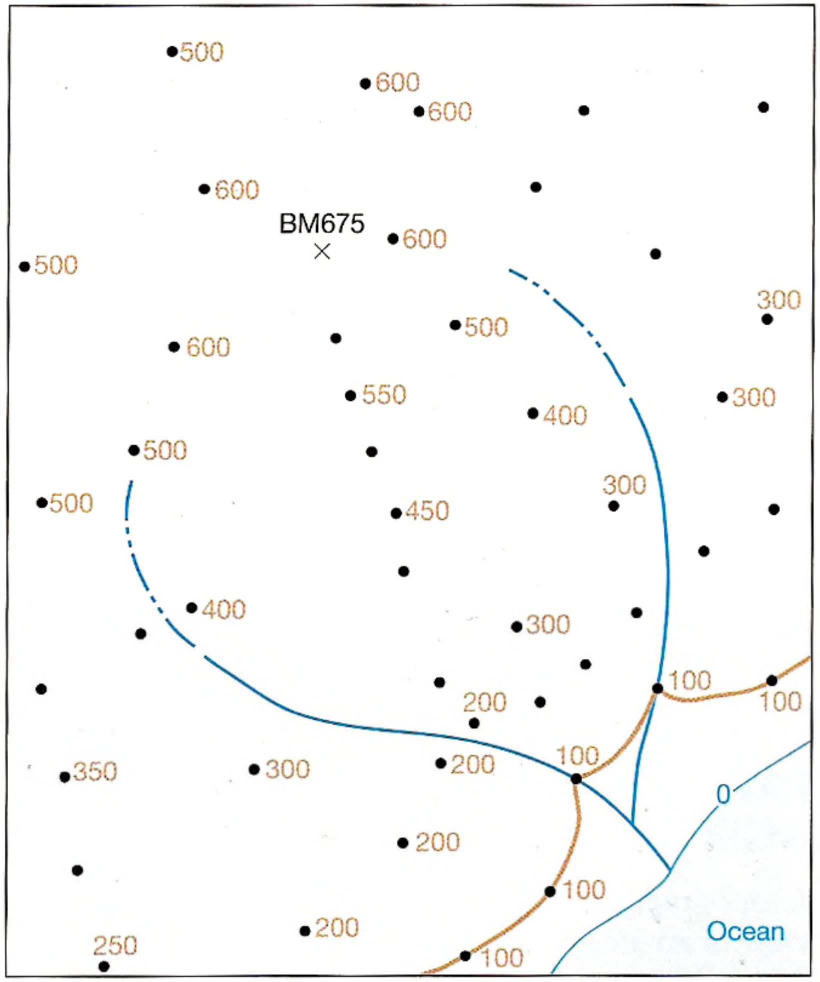


FIGURE 9.15 Use interpolation and extrapolation to estimate elevations of points that are not labeled (see Figure 9.6). Then add contour lines with a 100-foot contour interval. Note how the 0-foot and 100-foot contour lines have already been drawn.

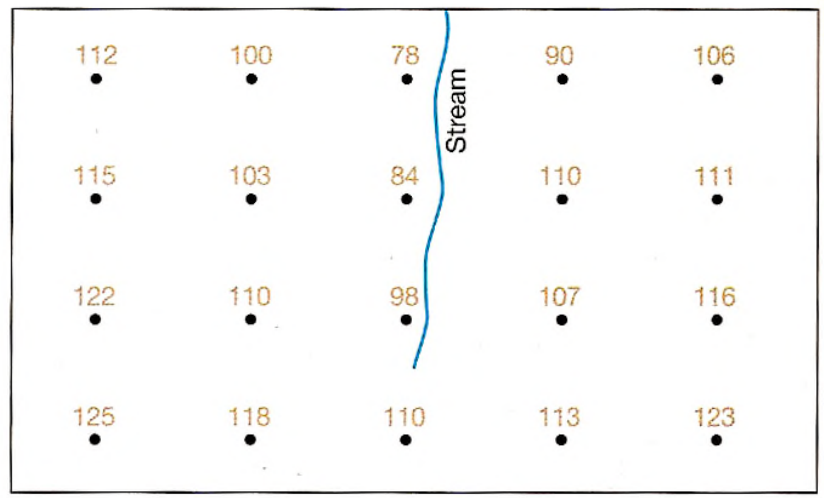


FIGURE 9.16 Construct a topographic map by contouring these elevations. Use a contour interval of 10 feet. (Refer to Figure 9.5 as needed.)

Contouring Exercises

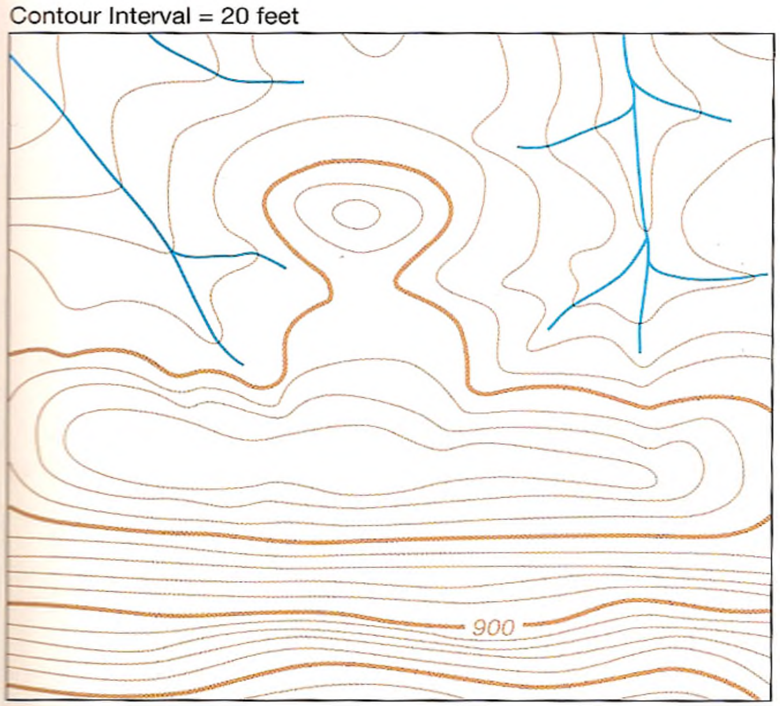


FIGURE 9.17 Topographic map interpretation. Use your pencil to lightly shade in the portion of this map that represents the highest elevation of land. Label a hill, "H." Label a ridge, "R." Label a saddle, "S." Use an arrow to label the lowest contour line in the map and label the arrow with the elevation of the contour. (Refer to Figures 9.5–9.8 as needed.)

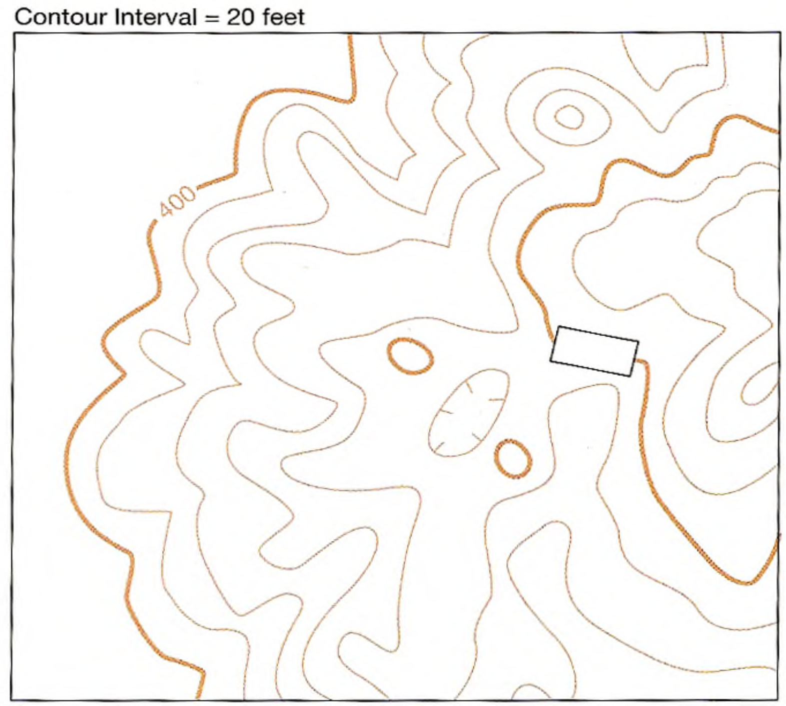


FIGURE 9.18 Topographic map interpretation. Use your pencil to lightly shade in the portion of this map that represents the lowest elevation. Label a closed depression, "CD." In the small box, write the elevation of the index contour on which it lies. (Refer to Figures 9.5–9.8 as needed.)

Contouring Exercises

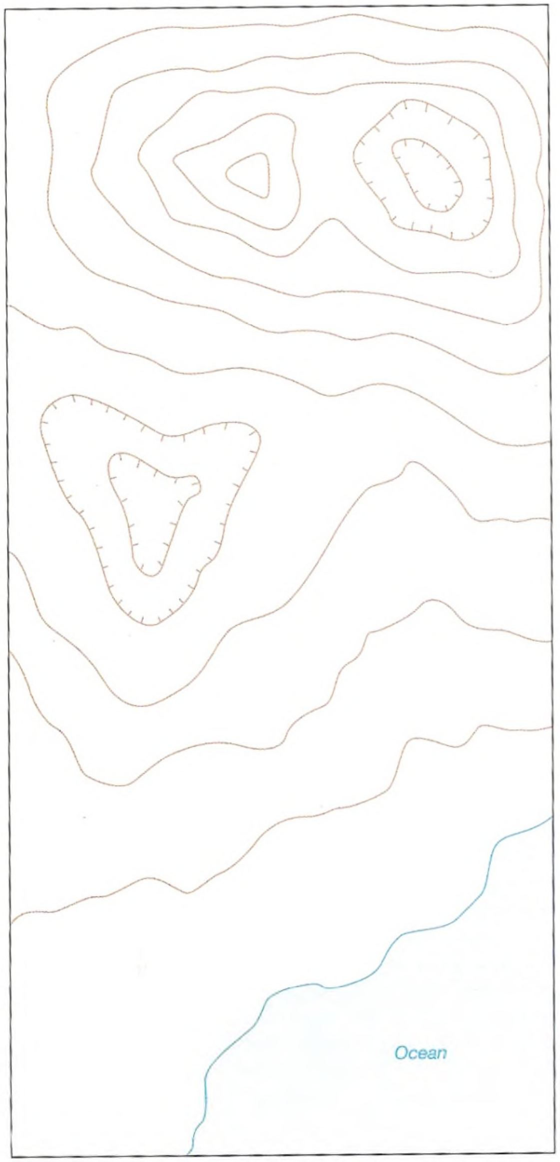
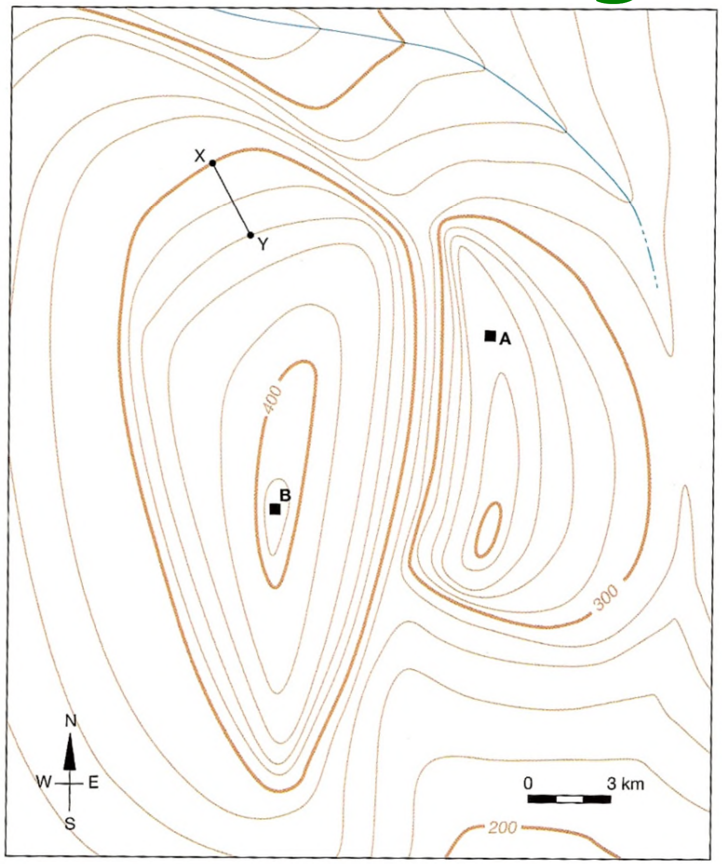


FIGURE 9.19 Complete this topographic map. Use a contour interval of 10 ft and label the elevation of every contour on the map. (*Hint*: Start at sea level and refer to Figures 9.8 and 9.9.)

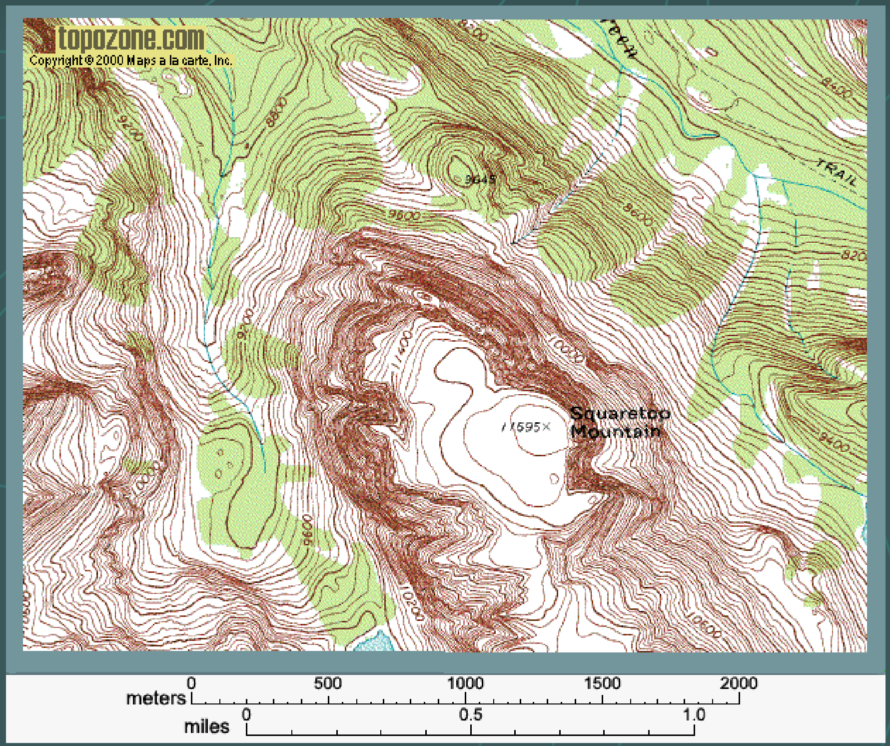


Elevations are in meters.

FIGURE 9.20 *Gradient* is a measure of the steepness of a slope, expressed in feet per mile or meters per kilometer. To determine the gradient of a slope, divide the *relief* (difference in elevation between two points on a map) by the distance measured between the two points. This is sometimes called *rise over run*. For example, this topographic map is contoured in meters. Can you determine the contour interval? Can you determine the gradient from point **X** to point **Y**? Can you plot a path from point **A** to point **B** that does not cross any slopes with a gradient above 20 meters per kilometer? Explain your reasoning.

Rules of Contour Line

1) Contour lines never cross
2) Widely spaced contours indicate a gradual slope
3) Tightly-spaced lines indicate a steep slope
4) “V”-shaped contour pattern indicate either a valley or ridge line



✓ The “V” points toward higher area = valley

✓ The “V” points toward lower area = ridge

5) “Bull’s Eye” contour pattern indicate a peak or basin

✓ Center of “bull’s eye” is highest point = peak

✓ Center of “bull’s eye” is lowest point = basin

RULES FOR CONTOUR LINES

Every point on a contour line is of the exact same elevation; that is, contour lines connect points of equal elevation.

Contour lines always separate points of higher elevation (uphill) from points of lower elevation (downhill). You must determine which direction on the map is higher and which is lower, relative to the contour line in question, by checking adjacent elevations.

Contour lines always close to form an irregular circle. But sometimes part of a contour line extends beyond the mapped area so that you cannot see the entire circle formed.

The elevation between any two adjacent contour lines of different elevation on a topographic map is the *contour interval*. Often every fifth contour line is heavier so that you can count by five times the contour interval. These heavier contour lines are known as *index contours*, because they generally have elevations printed on them.

Contour lines never cross one another except for one rare case: where an overhanging cliff is present. In such a case, the hidden contours are dashed.

Contour lines can merge to form a single contour line only where there is a vertical cliff.

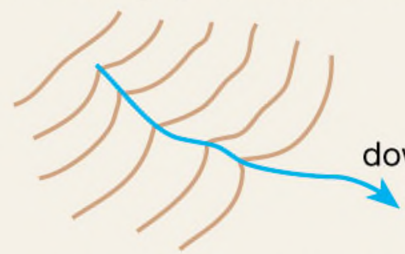
Evenly spaced contour lines of different elevation represent a uniform slope.

8. The closer the contour lines are to one another the steep the slope. In other words, the steeper the slope the close the contour lines.

9. A concentric series of closed contours represents a hill:

10. *Depression contours* have hachure marks on the downhi side and represent a closed depression:

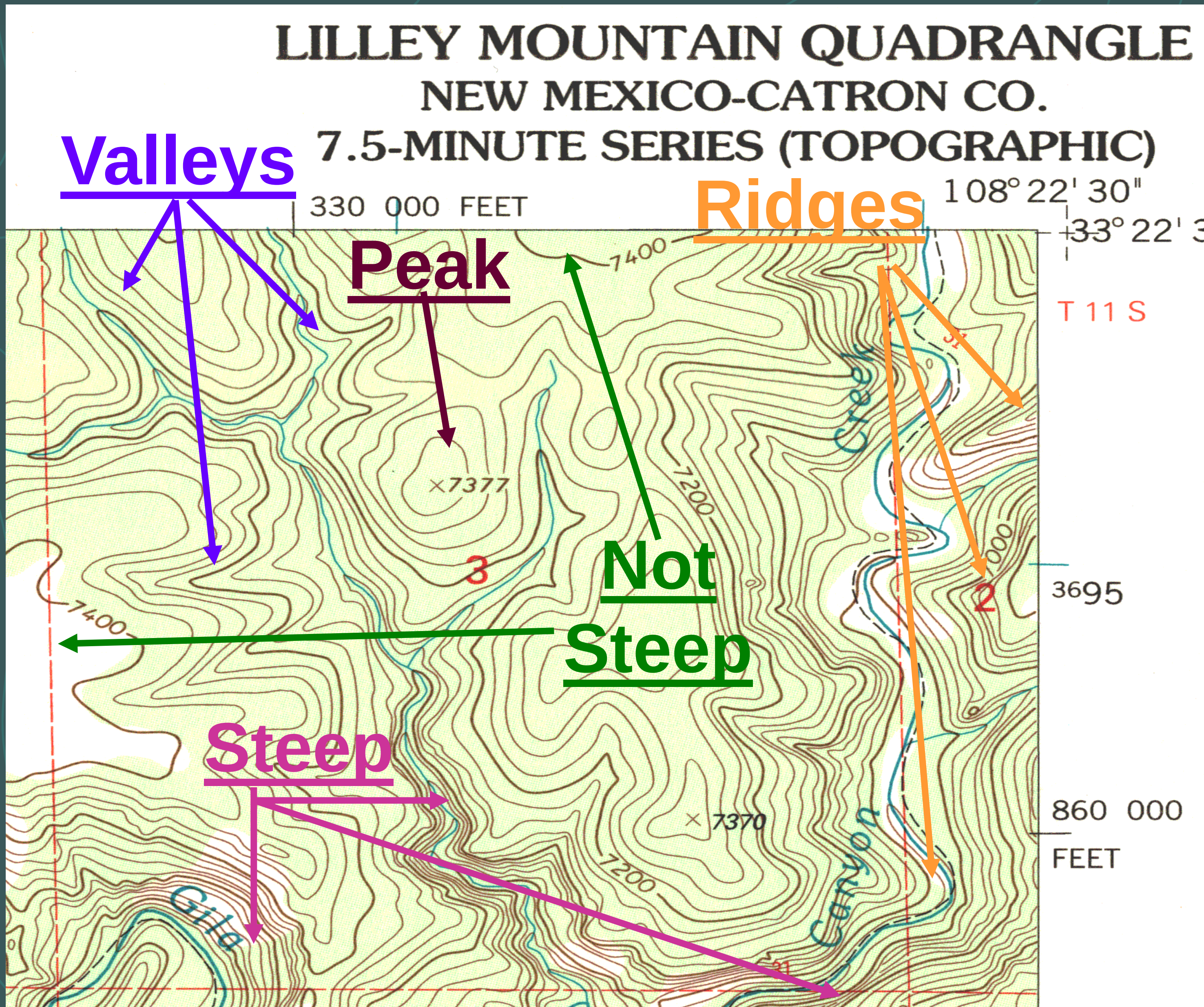
11. Contour lines form a V pattern when crossing streams. The apex of the V always points upstream (uphill):



12. Contour lines that occur on opposite sides of a valley always occur in pairs.

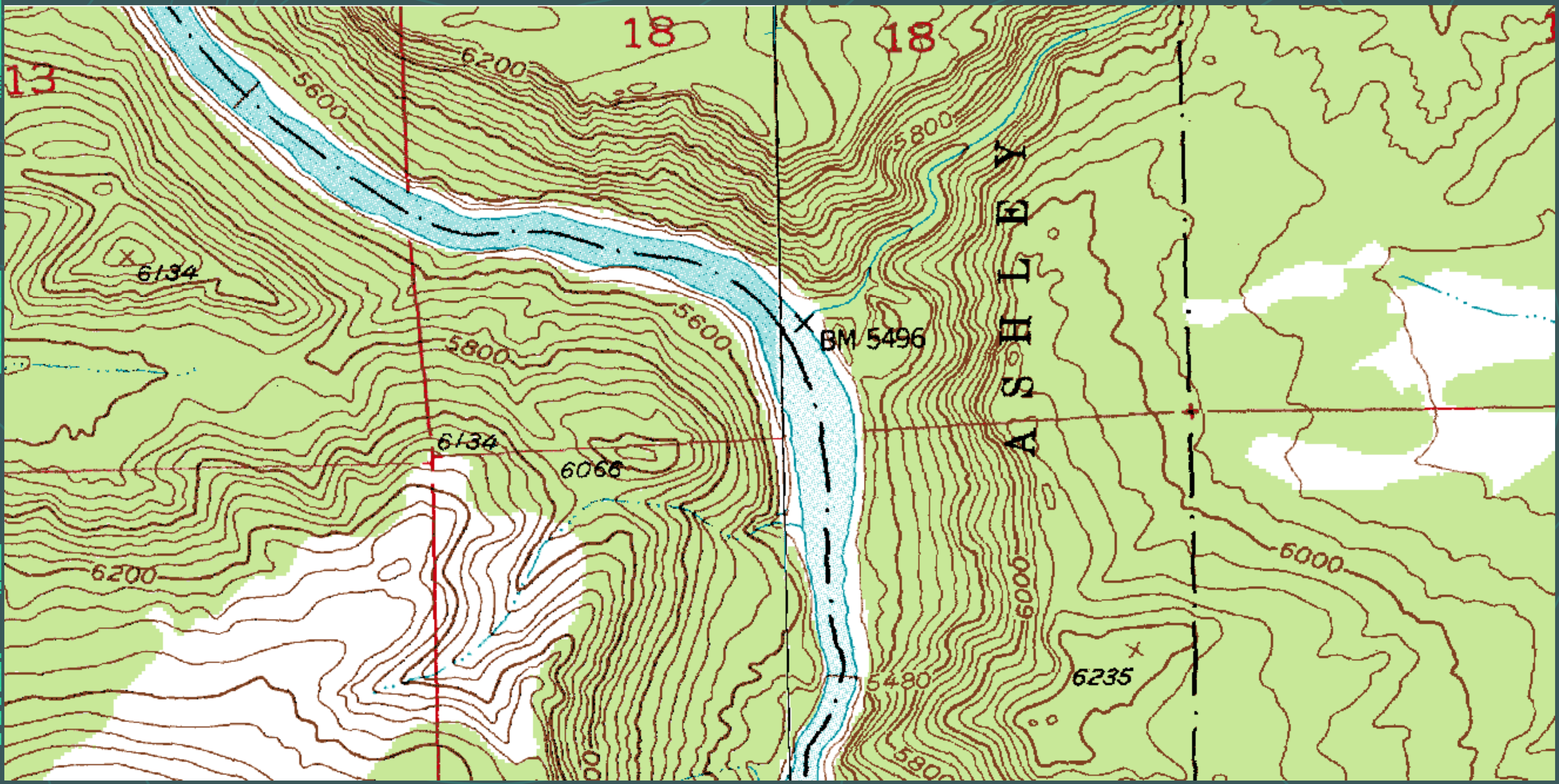
13. Topographic maps published by the U.S. Geological Survey are contoured in feet or meters referenced to sea level.

Example for Understanding Contour Rules

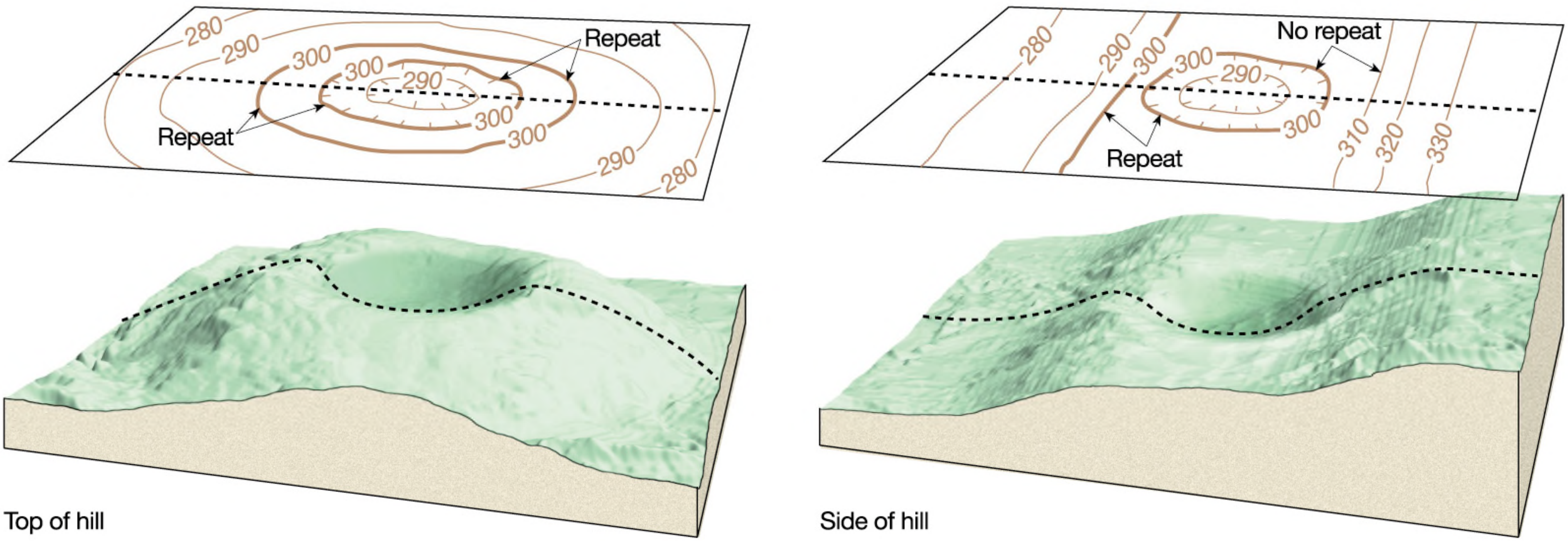


Can You Point Out These Features?

1) Valleys
2) Ridges
3) Steep terrain
4) Not Steep terrain
5) Peak tops
6) Total relief of map



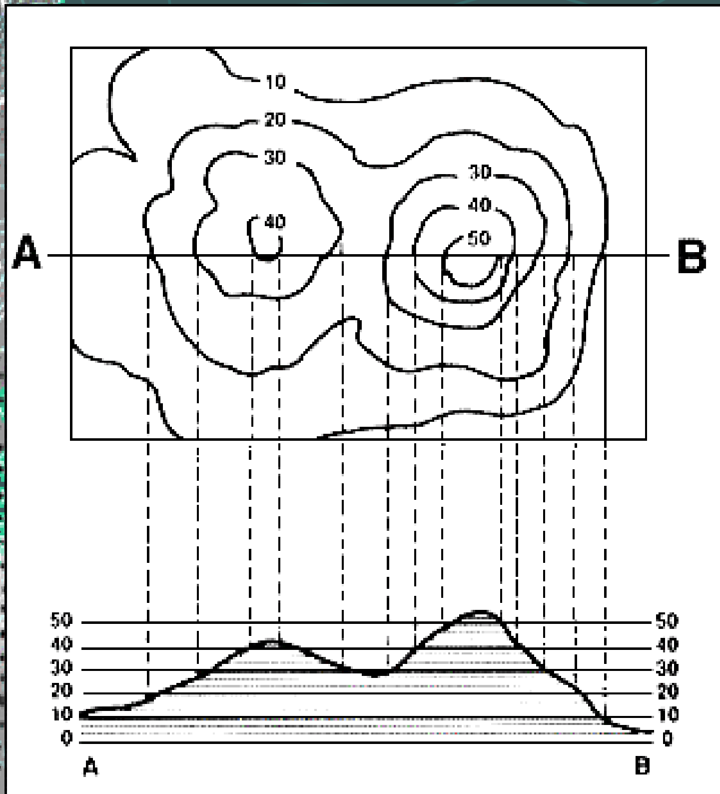
Question: Which way does the river flow? North or South?

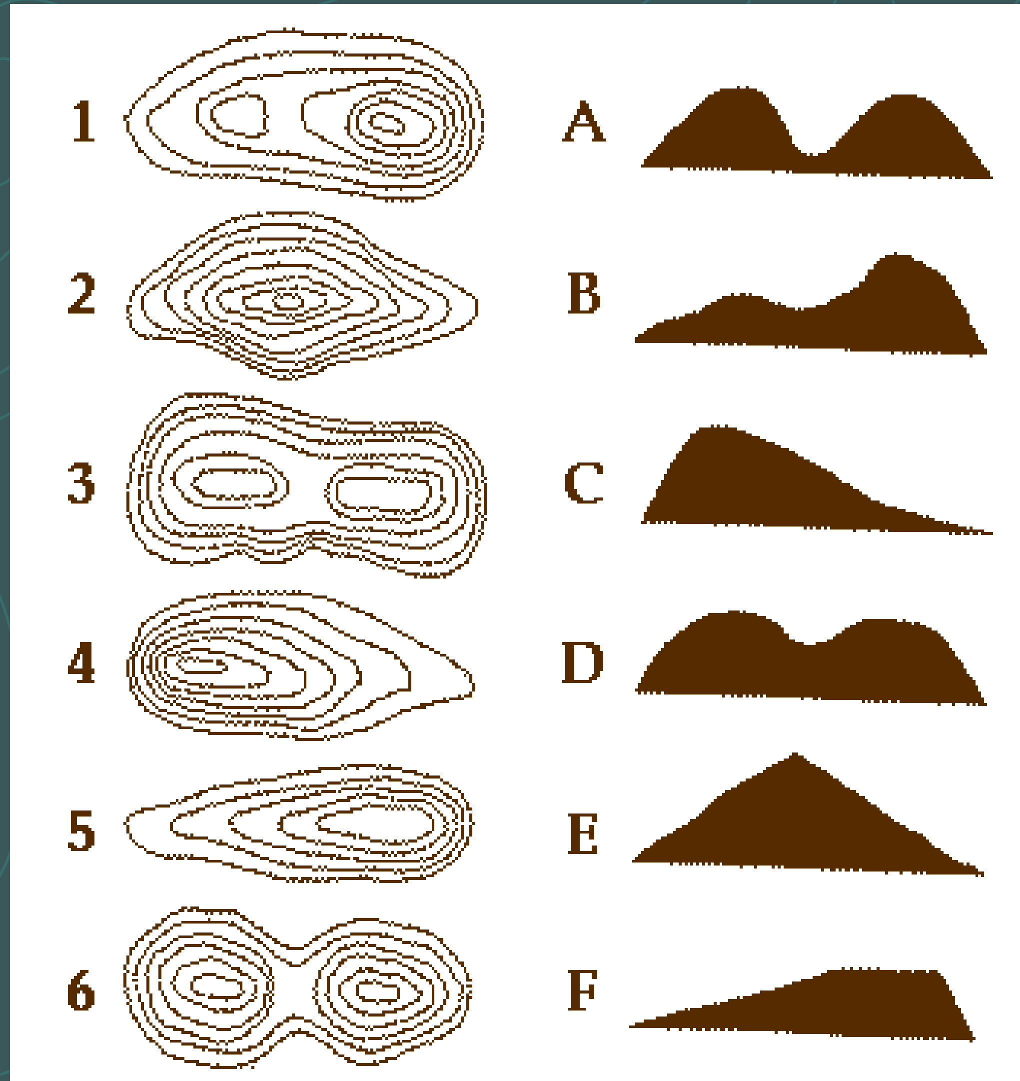


Top of hill

Side of hill

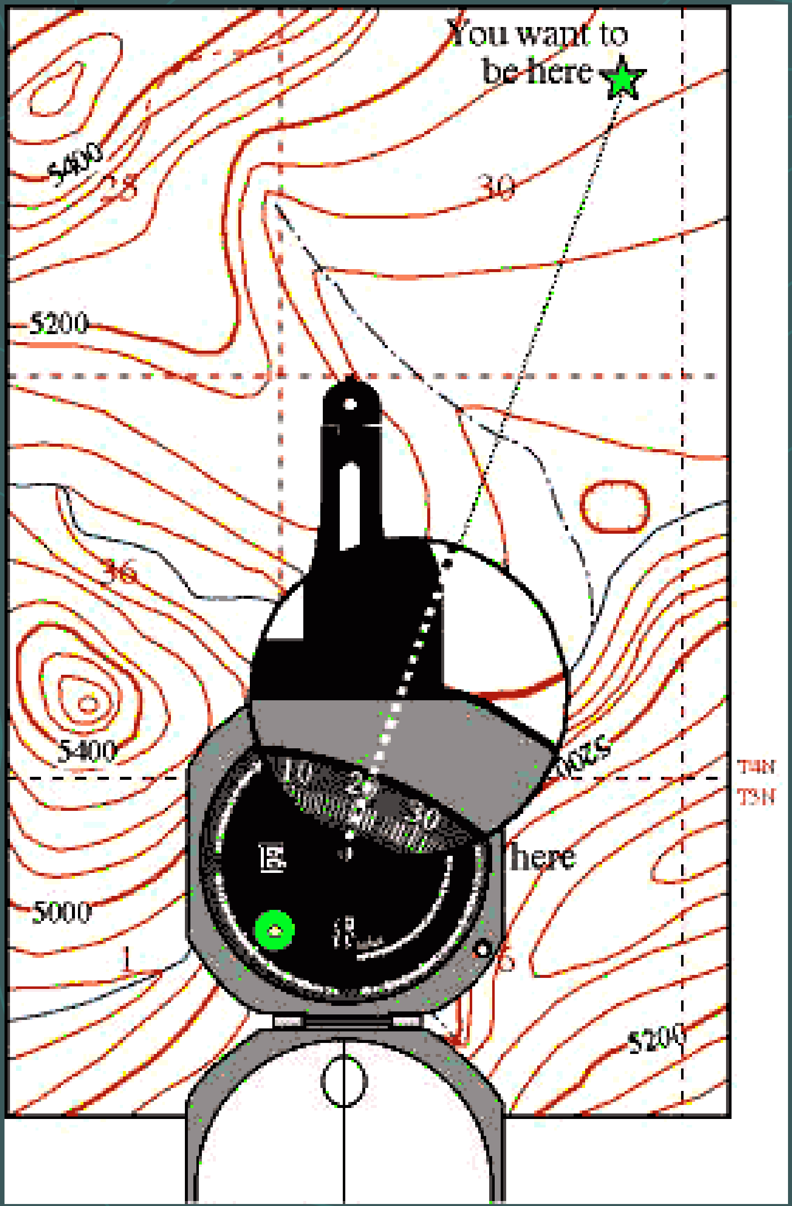
Contours Line Patterns and Landforms

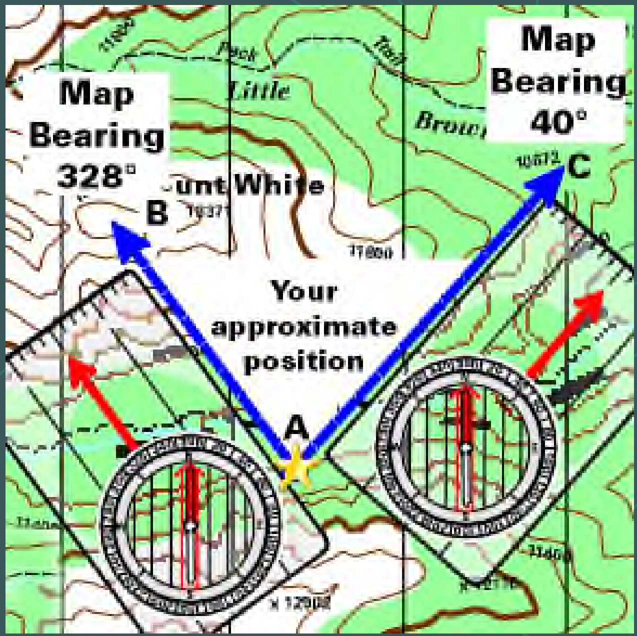




Match the Contours Line Patterns with the Hill Shape

Determining Compass Bearing on a Map





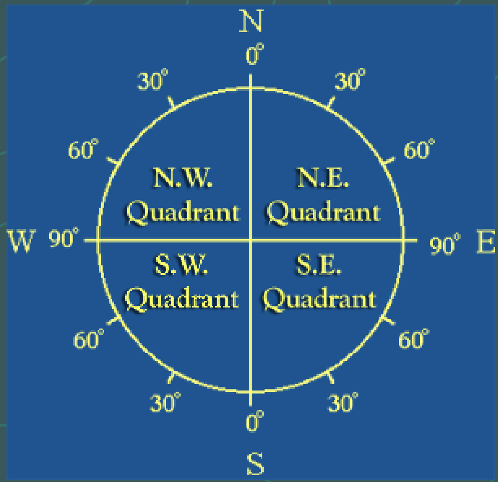
Determining Map Bearing and Distance

Understand Map Direction

1) Cardinal Directions

2) Azimuth versus Quadrant Notation

3) Difference between True Bearing *Versus* Magnetic Bearing

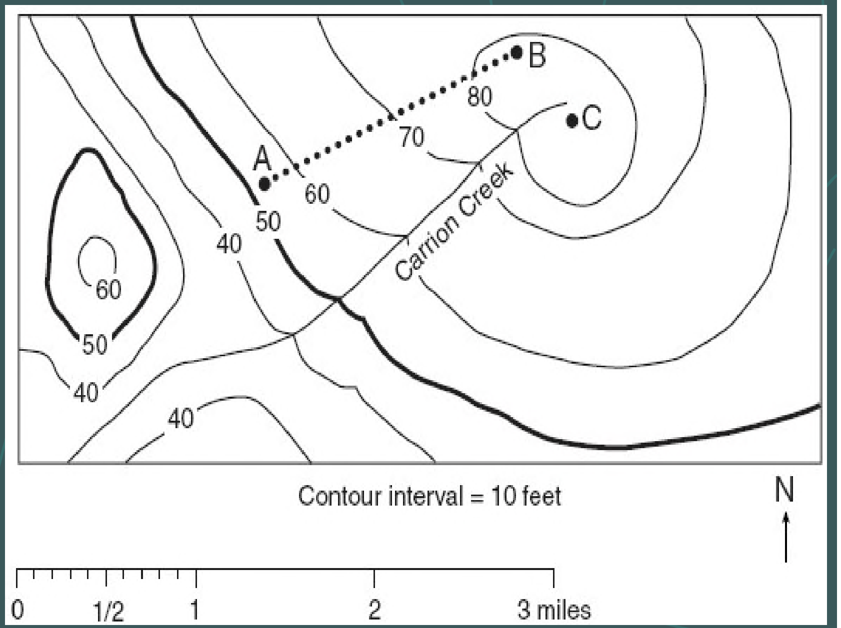


Understand Map Distance

1) Distance from One Point to Another along a Straight Line

2) Converting from Map Distance to Real Ground Distance

Going From Point "A" to "B"

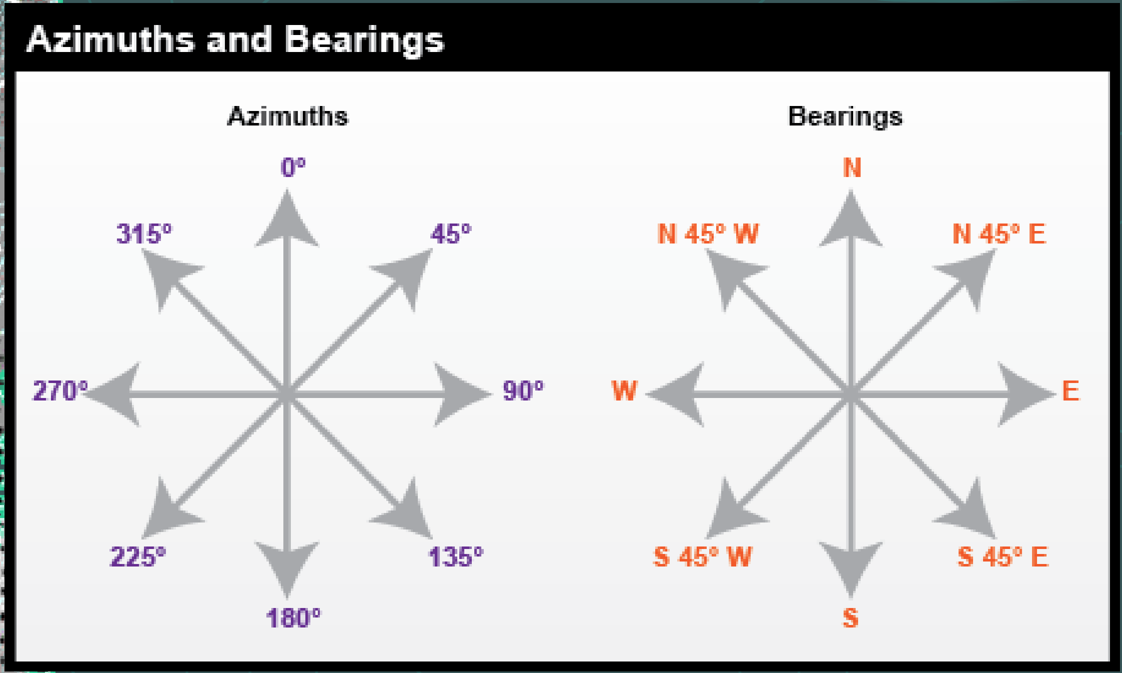


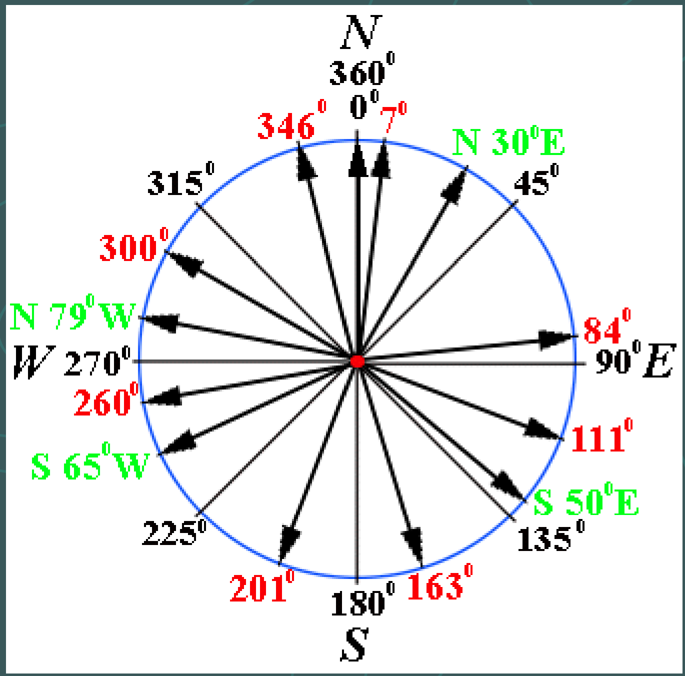
Map Direction as a Compass Bearing

Compass Bearing

- A bearing is the ***direction*** from one point to another
- If direction is expressed in degrees east or west of north, it is called a "***quadrant bearing***."
- If direction is expressed in degrees between 0 and 360, it is called "***azimuth bearing***."

Map Direction – Azimuth and Quadrant



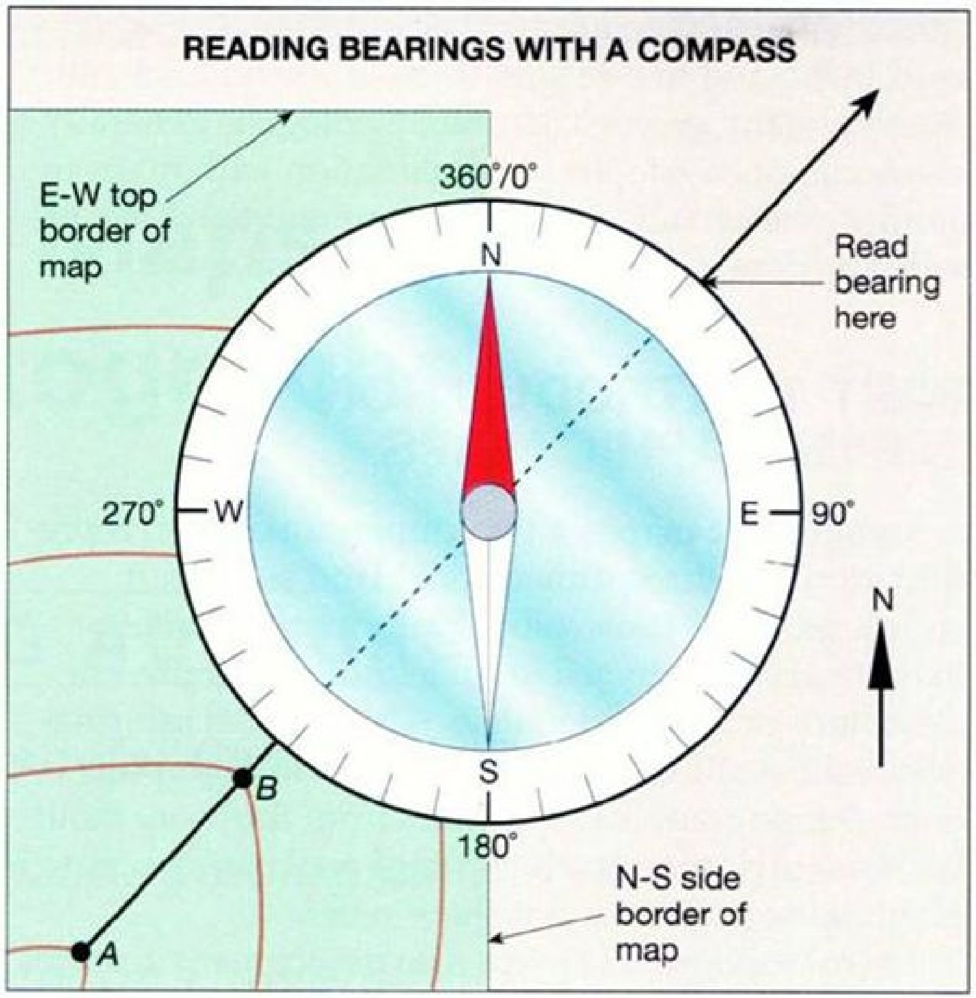


1) Azimuth measures direction from north (zero) 360 degrees clockwise around compass (E=90 – 180=S – 270=W)

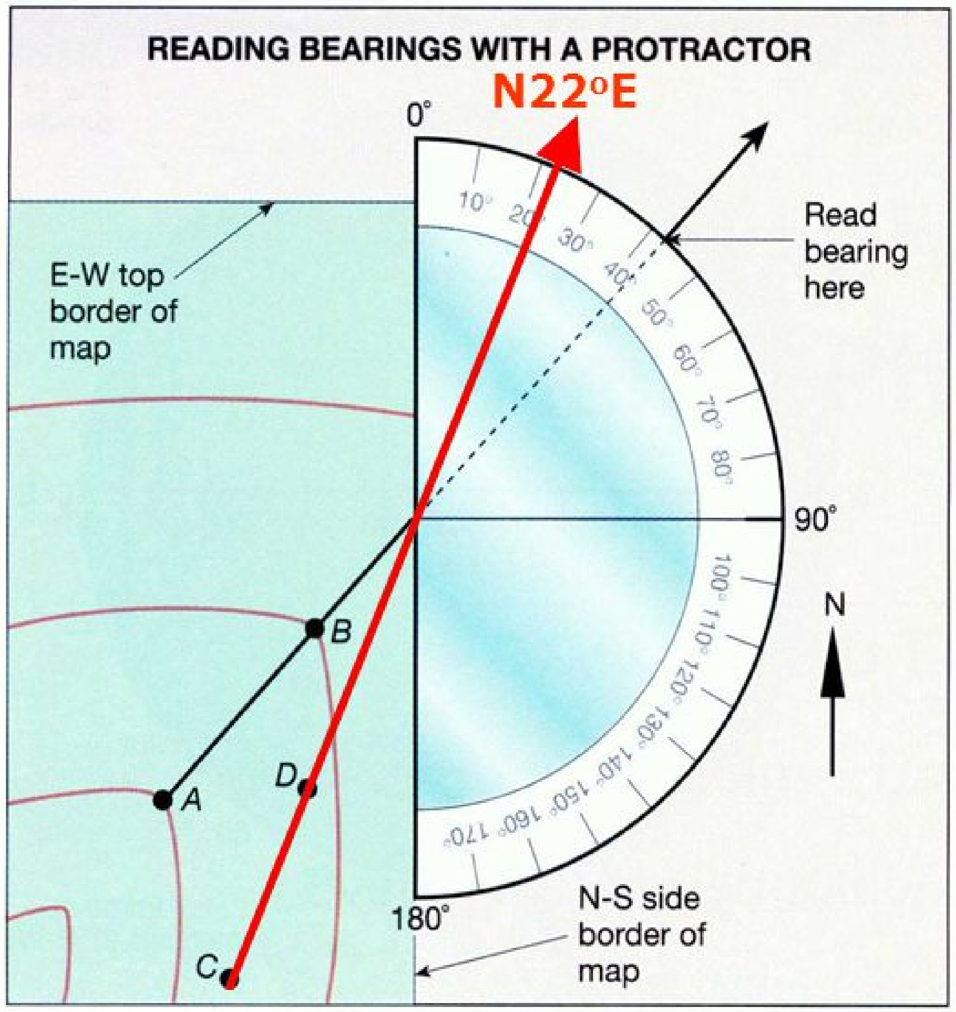
2) Quadrant measures direction: either North or South; then so many degree off of N or S; then either toward West or East

3) Difference between True Bearing *Versus* Magnetic Bearing

Azimuth Bearing



Quadrant Bearing



What is the bearing from C to D?

Determining Map Bearing with Protractor

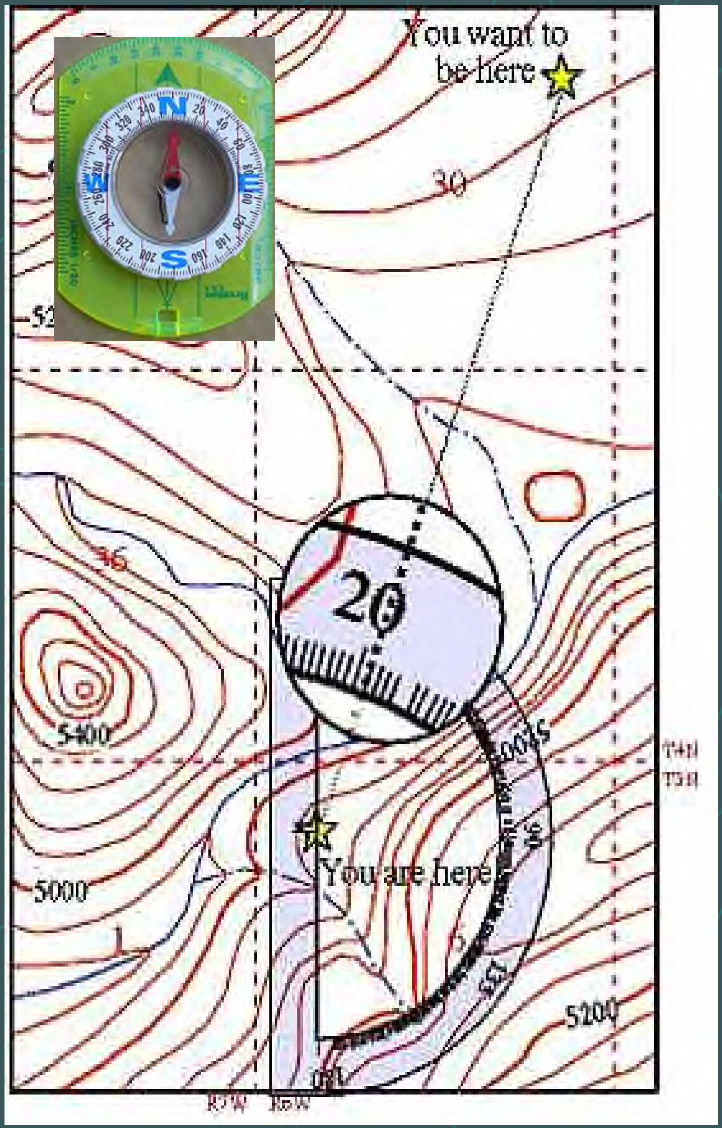
<u>Three Basic Steps</u>

1) Locate your present position

2) Locate the position you want to establish a bearing to

3) Use a properly positioned protractor to determine the true bearing from your location to the other position

4) Measure the bearing as either an azimuth or a quadrant bearing



Determining Map Bearing with Compass

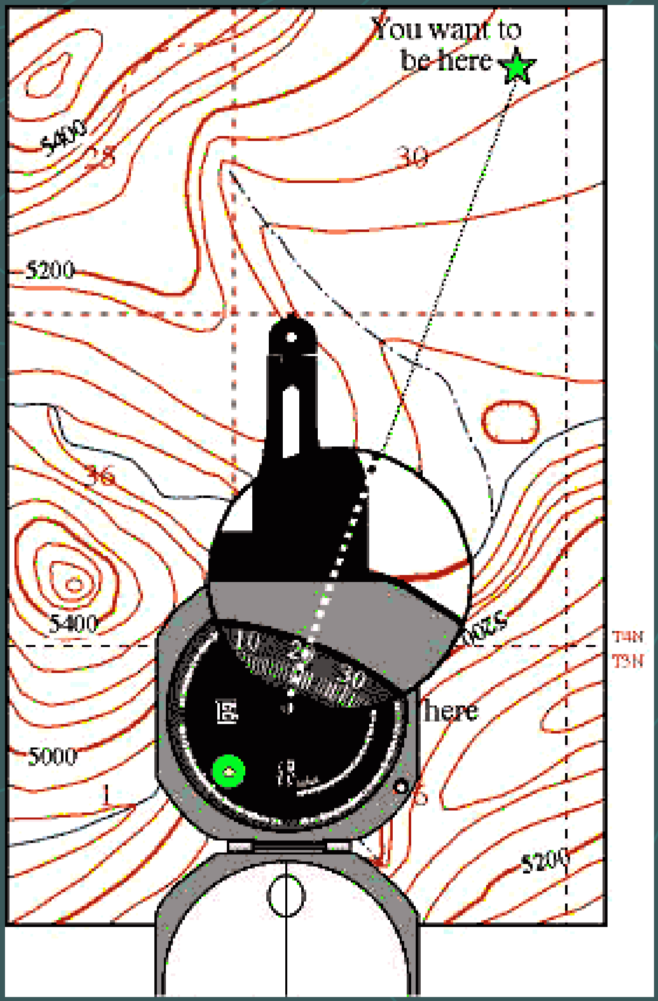
Four Basic Steps

1) Locate your present position

2) Locate the position you want to establish a bearing to

3) Use a properly positioned compass to determine the magnetic compass bearing from your location to the other position

4) Measure the bearing as either an azimuth or a quadrant bearing



Determining Your Location Using Triangulation

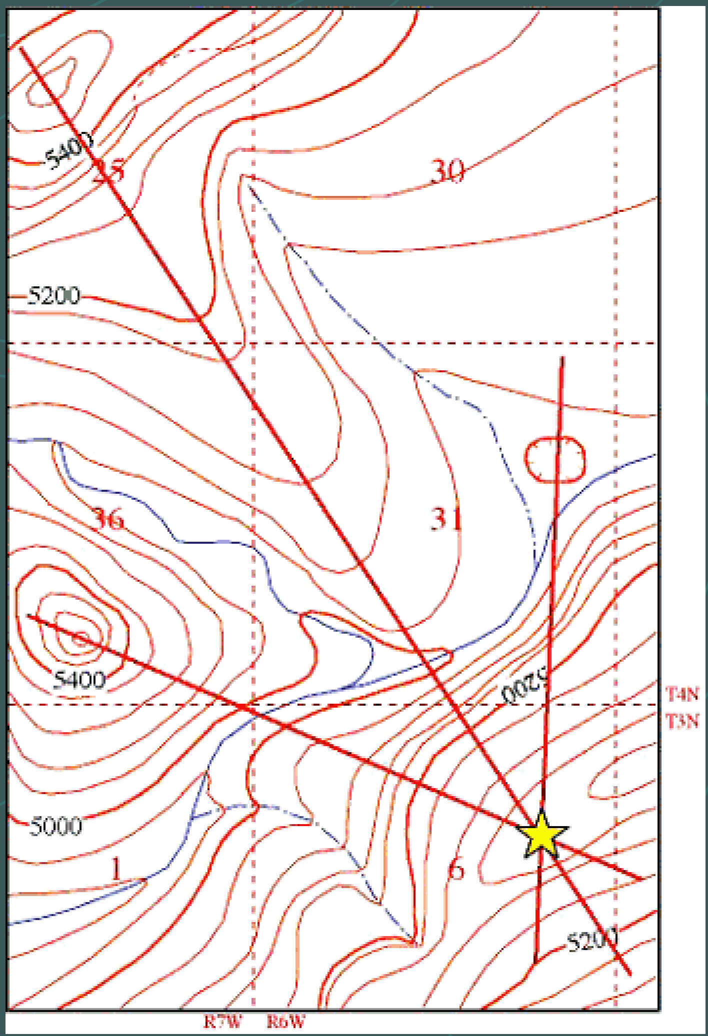
Four Basic Steps

1) Locate several local prominent landforms by sight, such as a peak top or

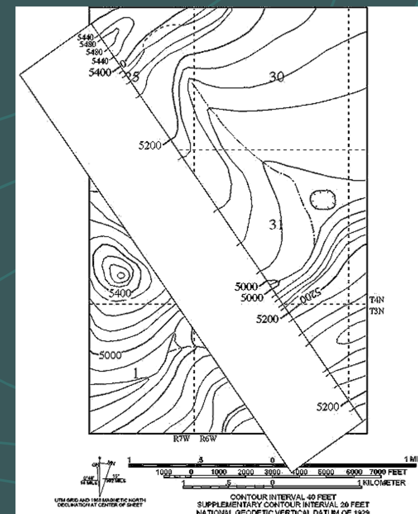
2) Take (shoot) a compass bearing to each landform and note value

3) Plot the bearing lines on your map with the bearing lines crossing through the sighted landforms

4) Where the bearing lines intersect is your triangulated location

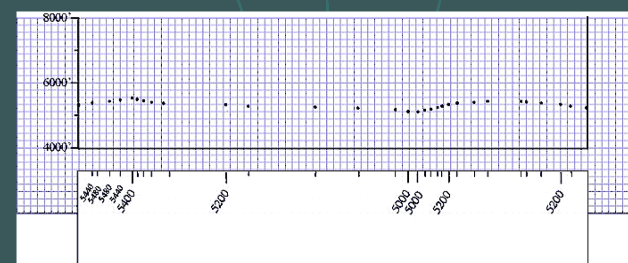


Creating Topographic Profiles

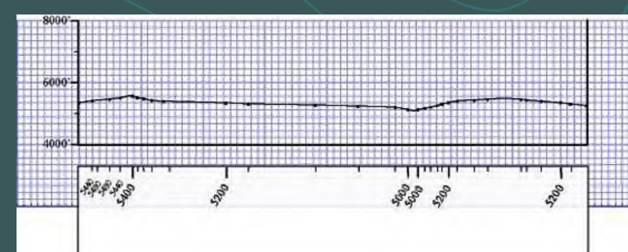


Three Basic Steps

1) Copying contour map data onto paper strip



2) Transferring paper strip contour data onto labeled profile graph as a set of dots



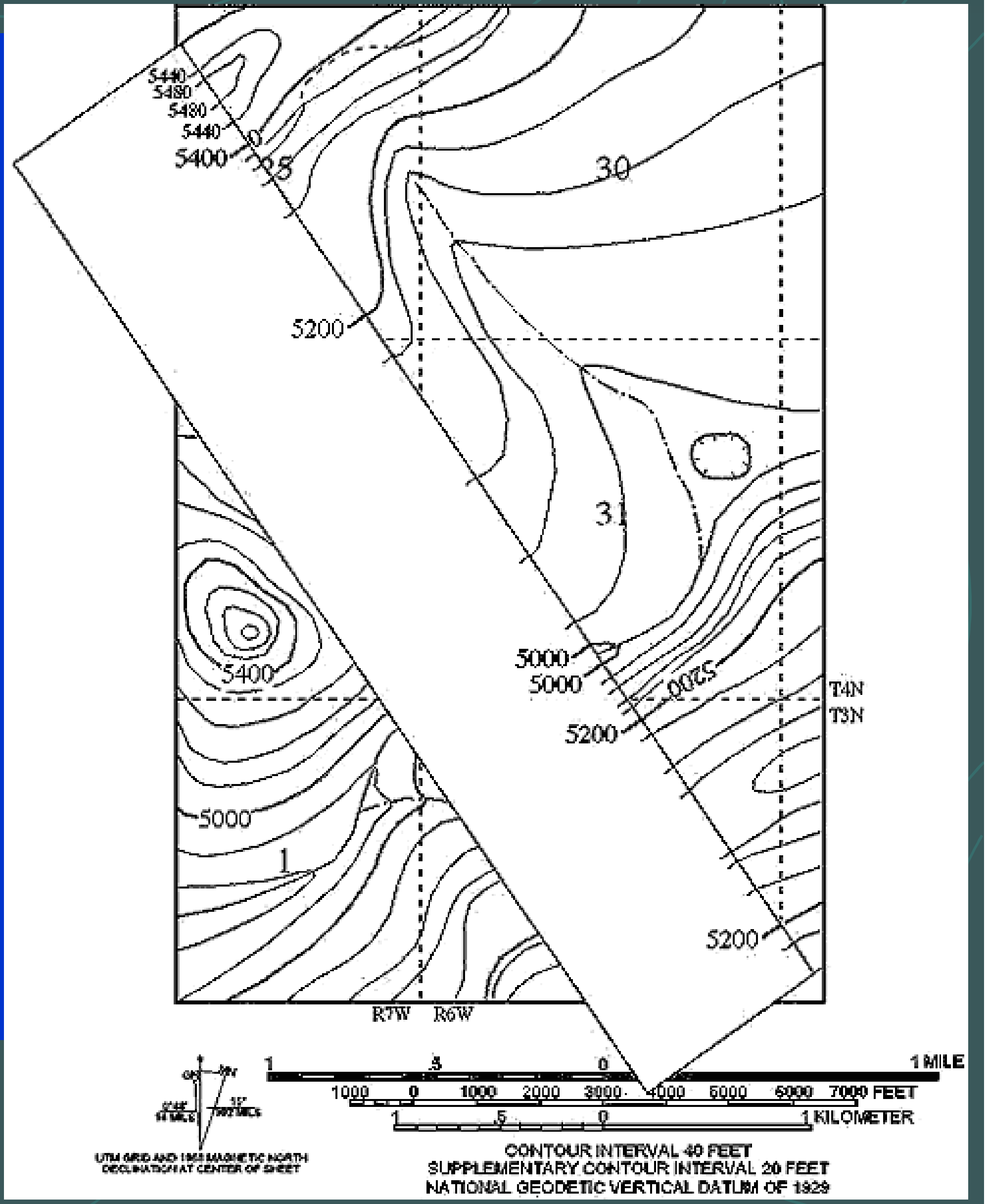
3) Connecting the dots together as a smooth line

Creating a Topographic Profile

Step 1 –

Mark and label a continuous set of elevation/depth contour points along a predetermined transverse across the map onto a strip of paper

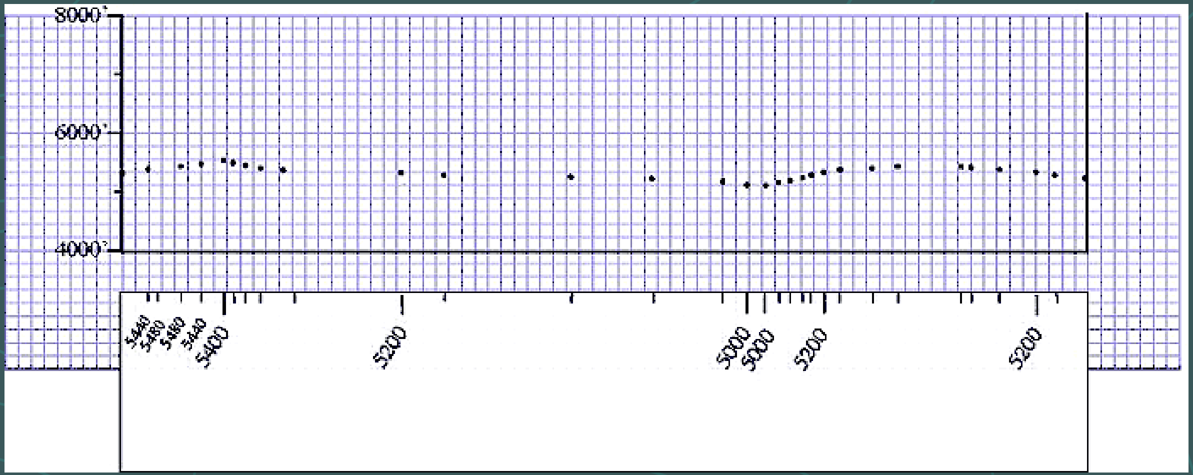
You will then use the strip of paper with the contour information to create a cross-section profile of the map transverse on a piece of graph paper



Creating a Topographic Profile

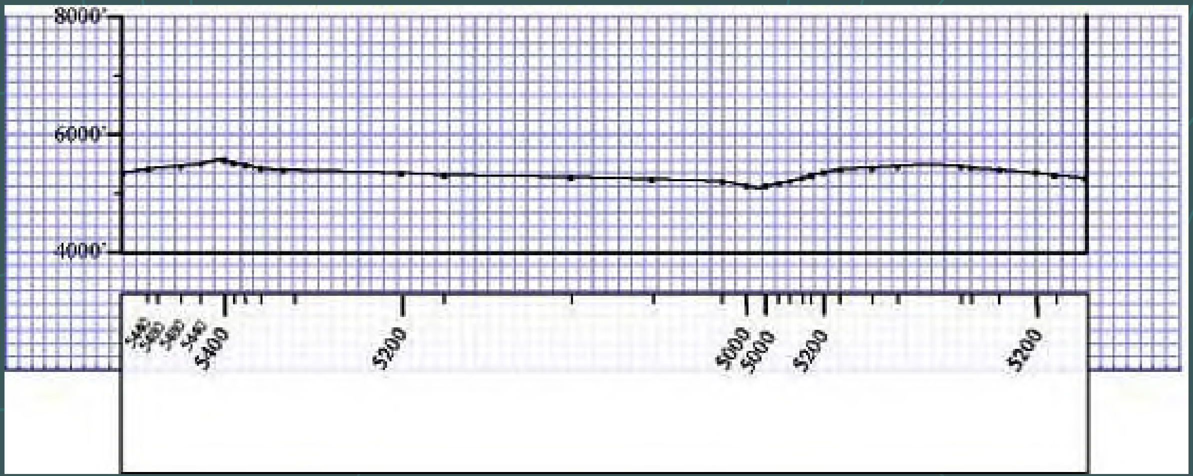
Step 2 -

Transfer contour info from strip of paper onto properly labeled graph paper as a set of dots that mark elevation or depth

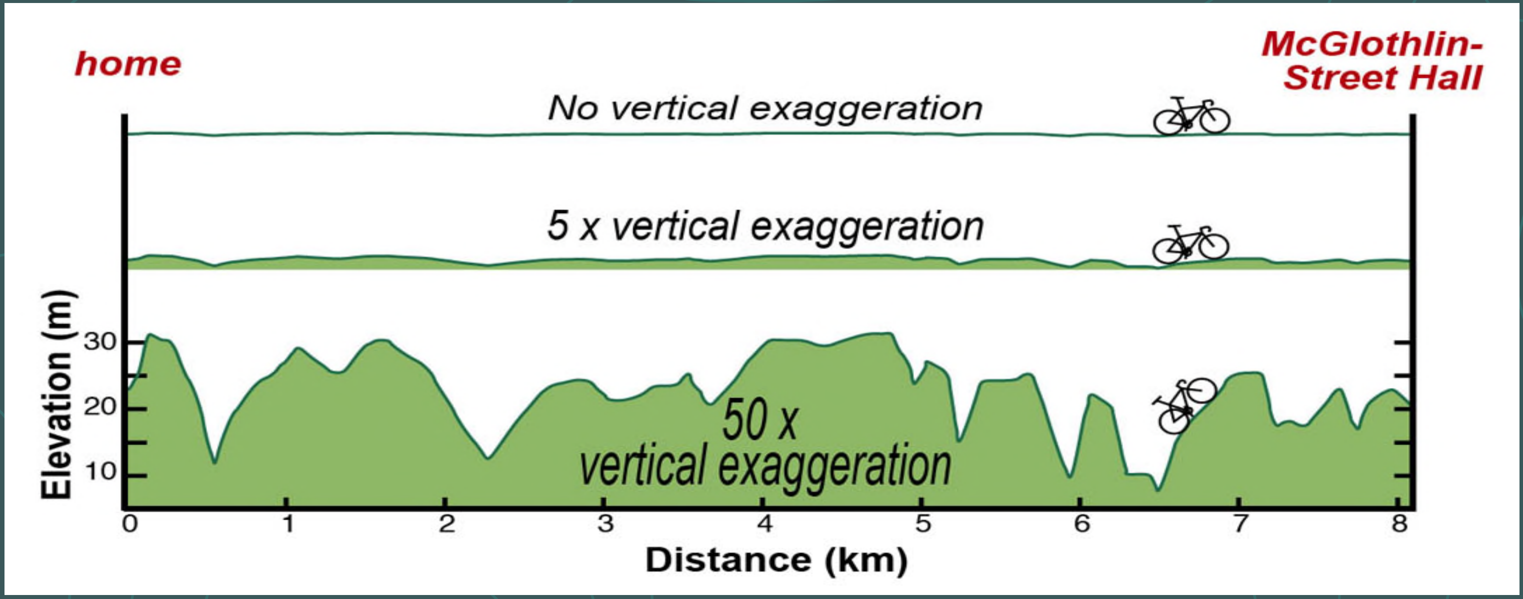


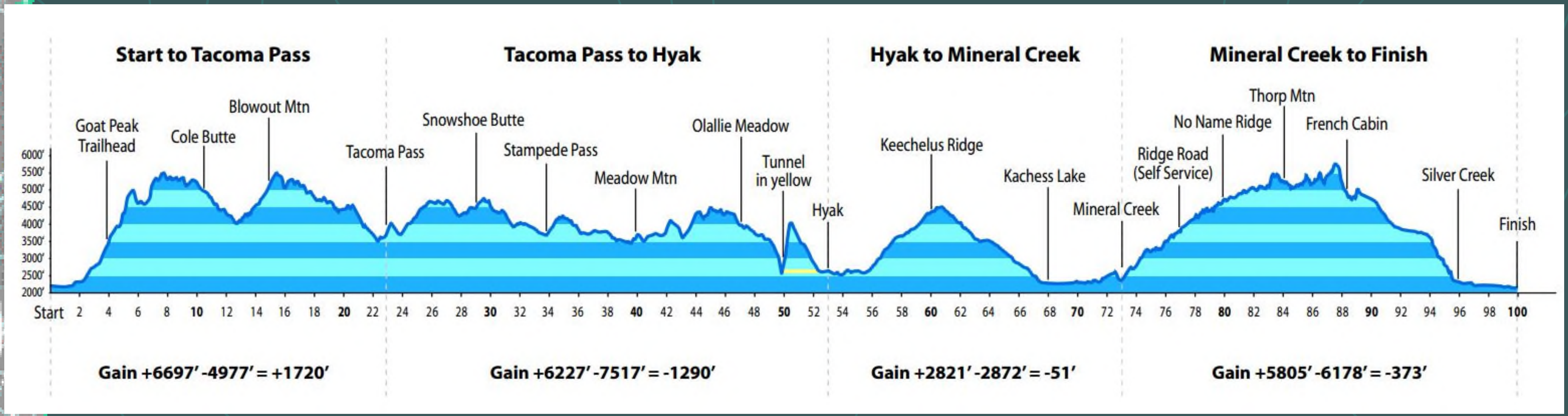
Step 3 –

Connect profile elevation or depth dots with a smooth line – this is your profile

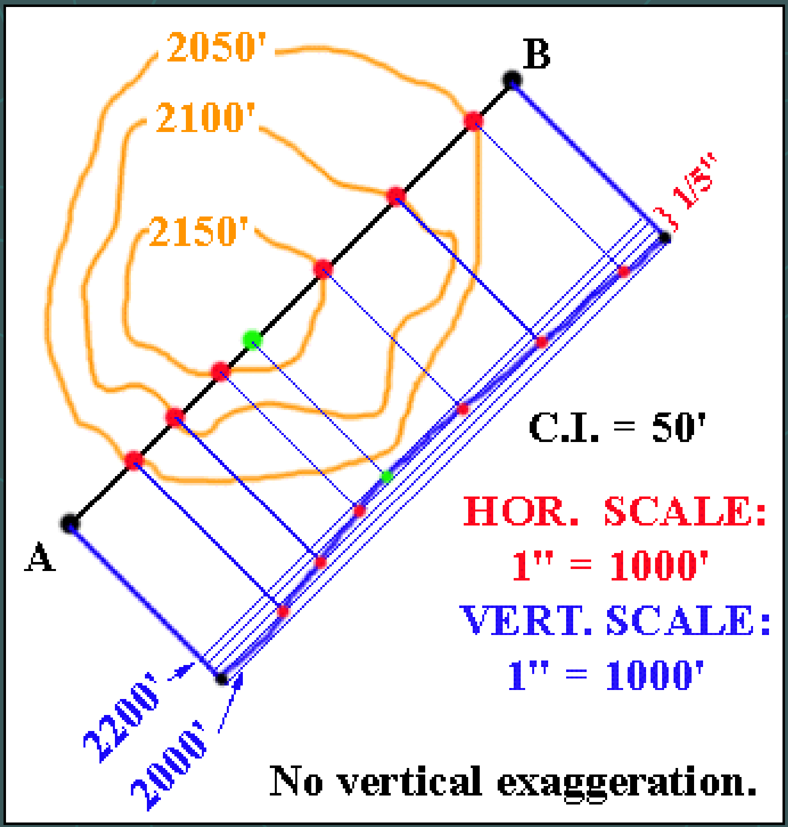


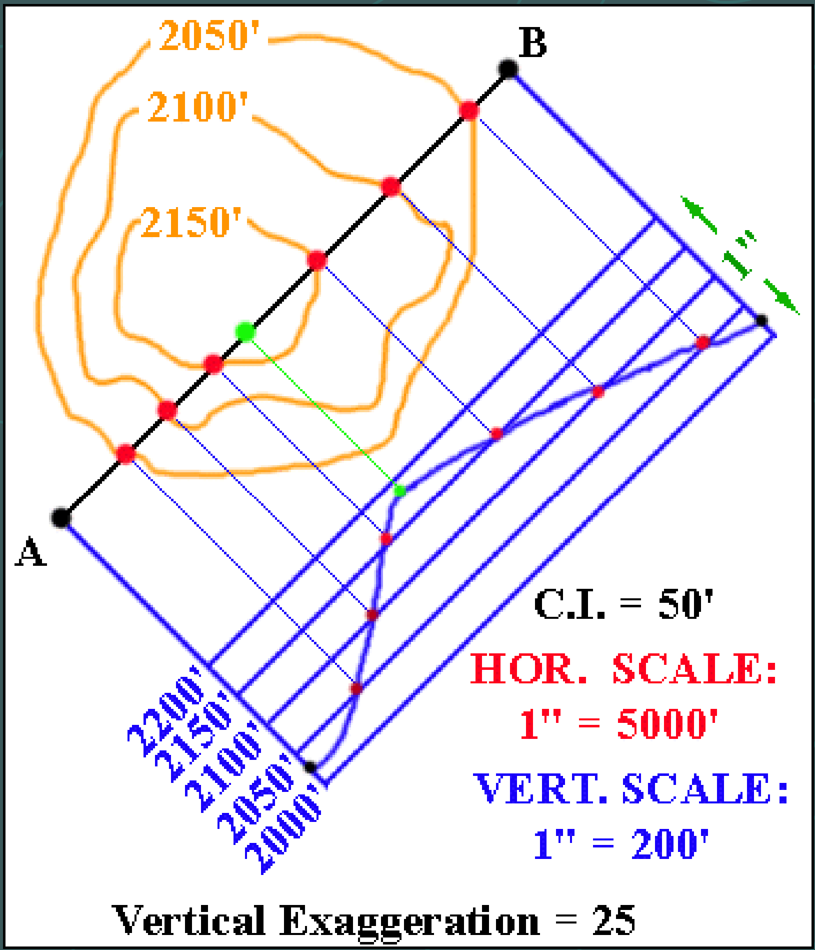
Topographic Profile – Vertical Exaggeration



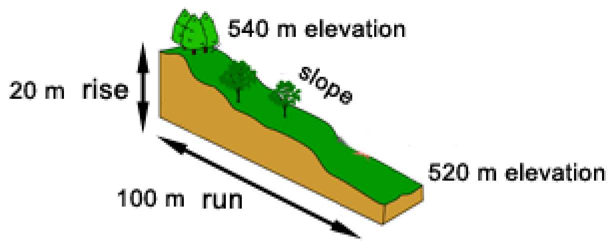


Topographic Profile – Vertical Exaggeration



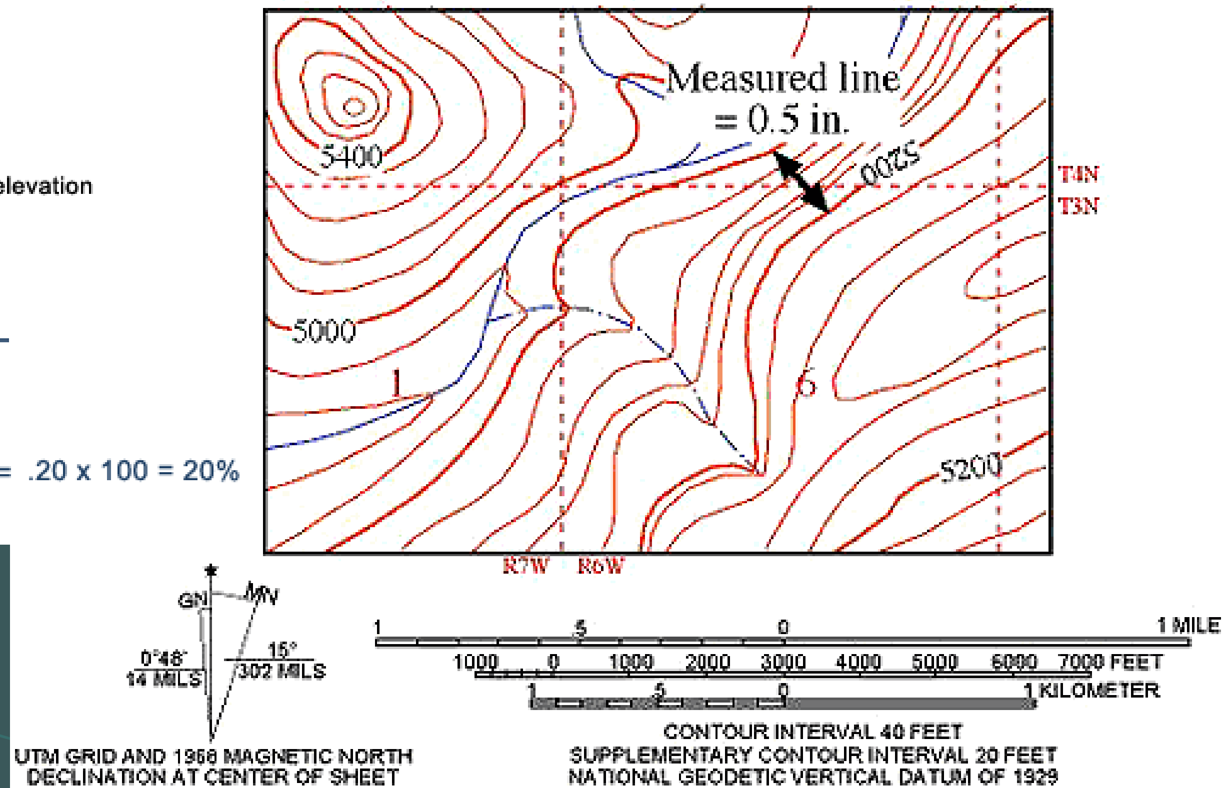


Topographic Slope Gradient / Slope Angle



$$\text{Slope} = \frac{\text{height difference (m)}}{\text{horizontal difference (m)}}$$

$$\text{Slope} = \frac{540\text{ m} - 520\text{ m}}{100\text{ m}} = \frac{20\text{ m}}{100\text{ m}} = .20 \times 100 = 20\%$$



Determining hillslope from a topographic map

Length of measured line = $0.5\,\cancel{\text{in}}$, $0.5\text{ in} \times \dfrac{2000\text{ ft}}{1\,\cancel{\text{in}}} = 1000\text{ ft}$ (.19 mi)= horizontal distance

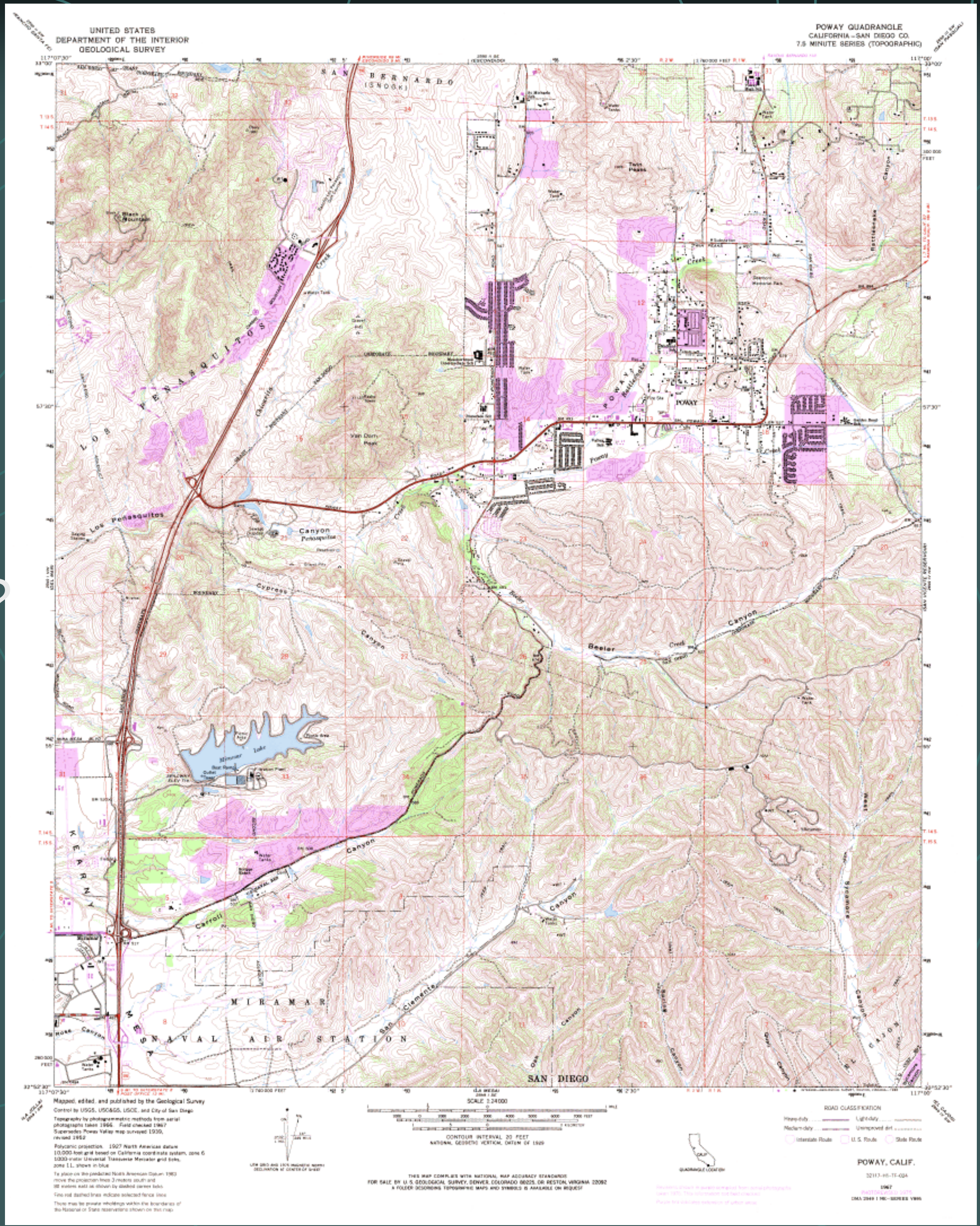
Elevation change = 200 ft. (read off of contour lines)

Percent slope = $\dfrac{200\,\cancel{\text{ft.}}}{1000\,\cancel{\text{ft.}}} \times 100 = 20\%$ slope

Slope angle = $\arctan\left(\dfrac{200\,\cancel{\text{ft.}}}{1000\,\cancel{\text{ft.}}}\right) = 11.3°$ slope

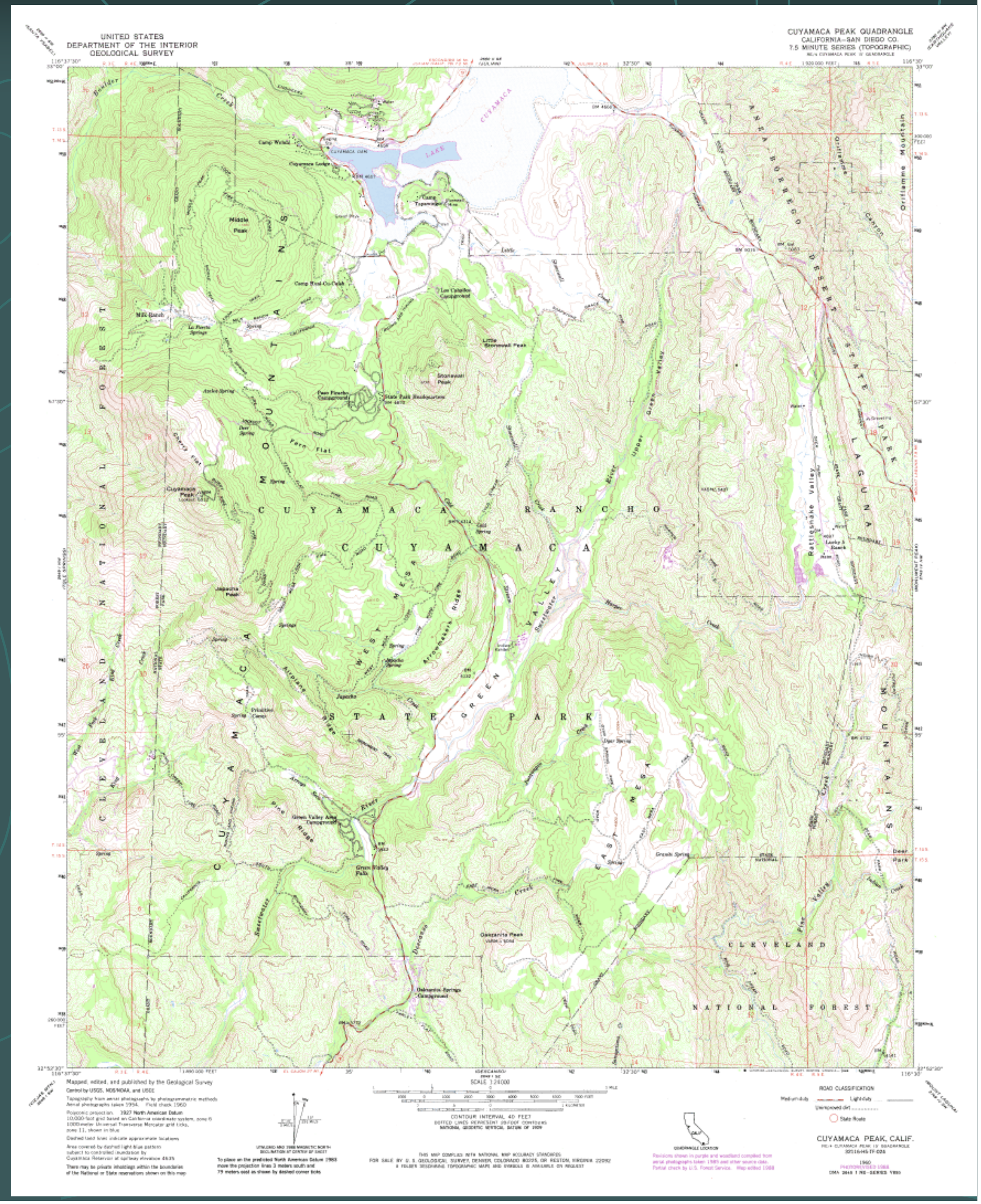
Poway 7 ½ Minute Topo Map

1) Location?
2) Map projection?
3) Map scale?
4) Verbal scale?
5) Map area?
6) Magnetic declination?
7) Contour interval?
8) Map relief? Total?
9) Latitude/Longitude?
10) UTM?
11) Drainage direction?



Cuyamaca Peak
7 ½ MinuteTopo Map

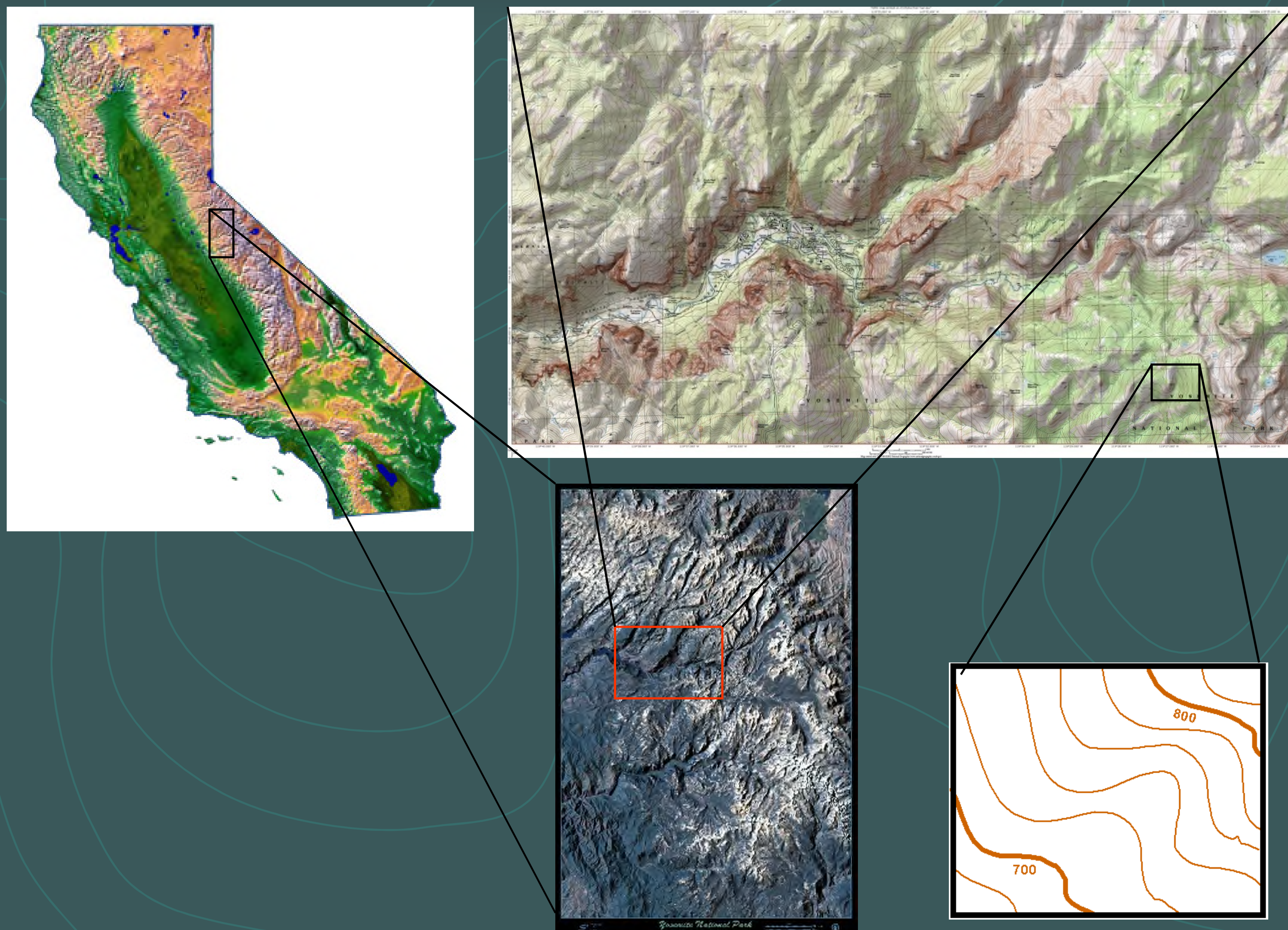
1) Location?
2) Map projection?
3) Map scale?
4) Verbal scale?
5) Map area?
6) Magnetic declination?
7) Contour interval?
8) Map relief? Total?
9) Latitude/Longitude?
10) UTM?
11) Drainage direction?



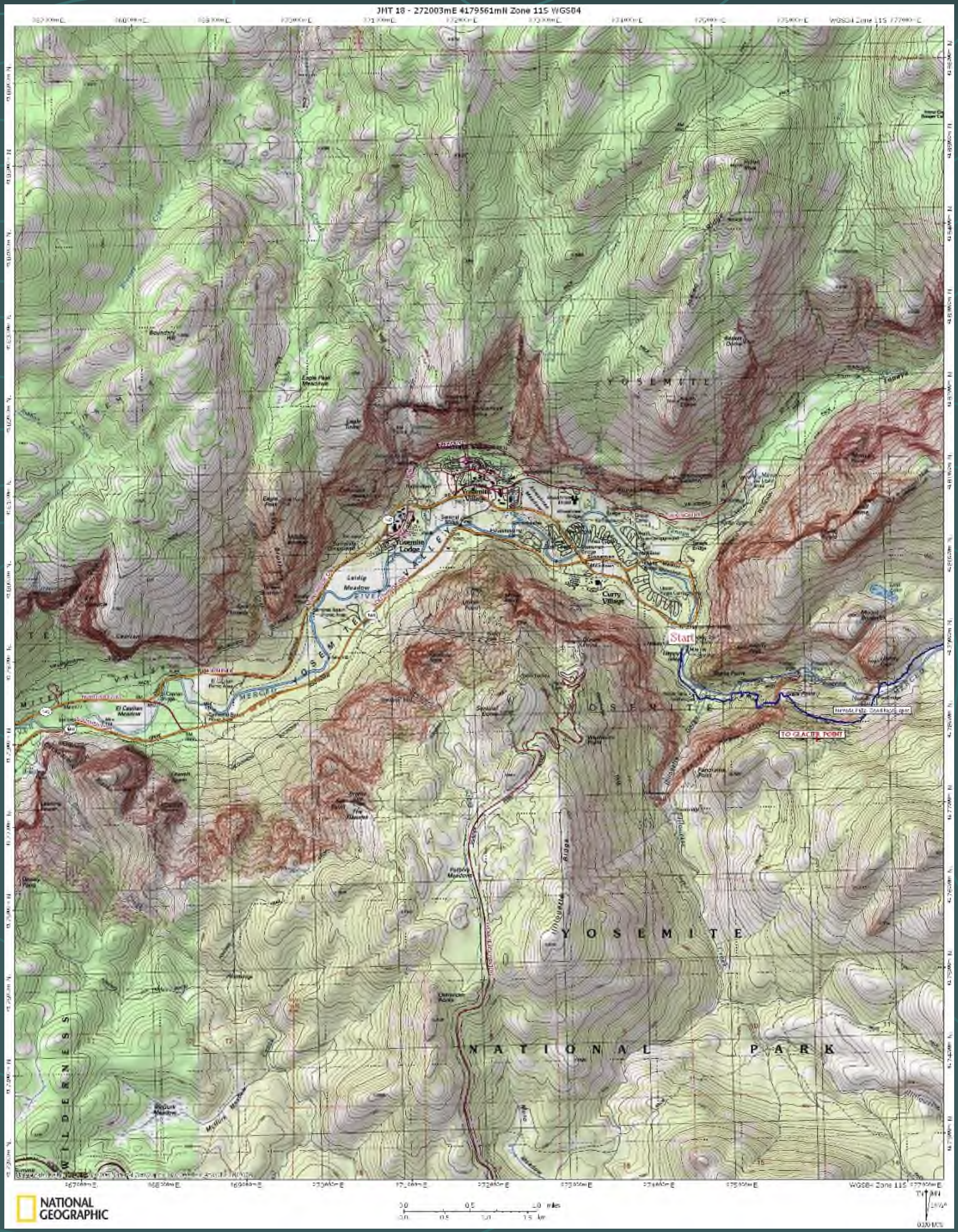
Mt Laguna
71/2 Minute Topo Map

1) Location?
2) Map projection?
3) Map scale?
4) Verbal scale?
5) Map area?
6) Magnetic declination?
7) Contour interval?
8) Map relief? Total?
9) Latitude/Longitude?
10) UTM?
11) Drainage direction?

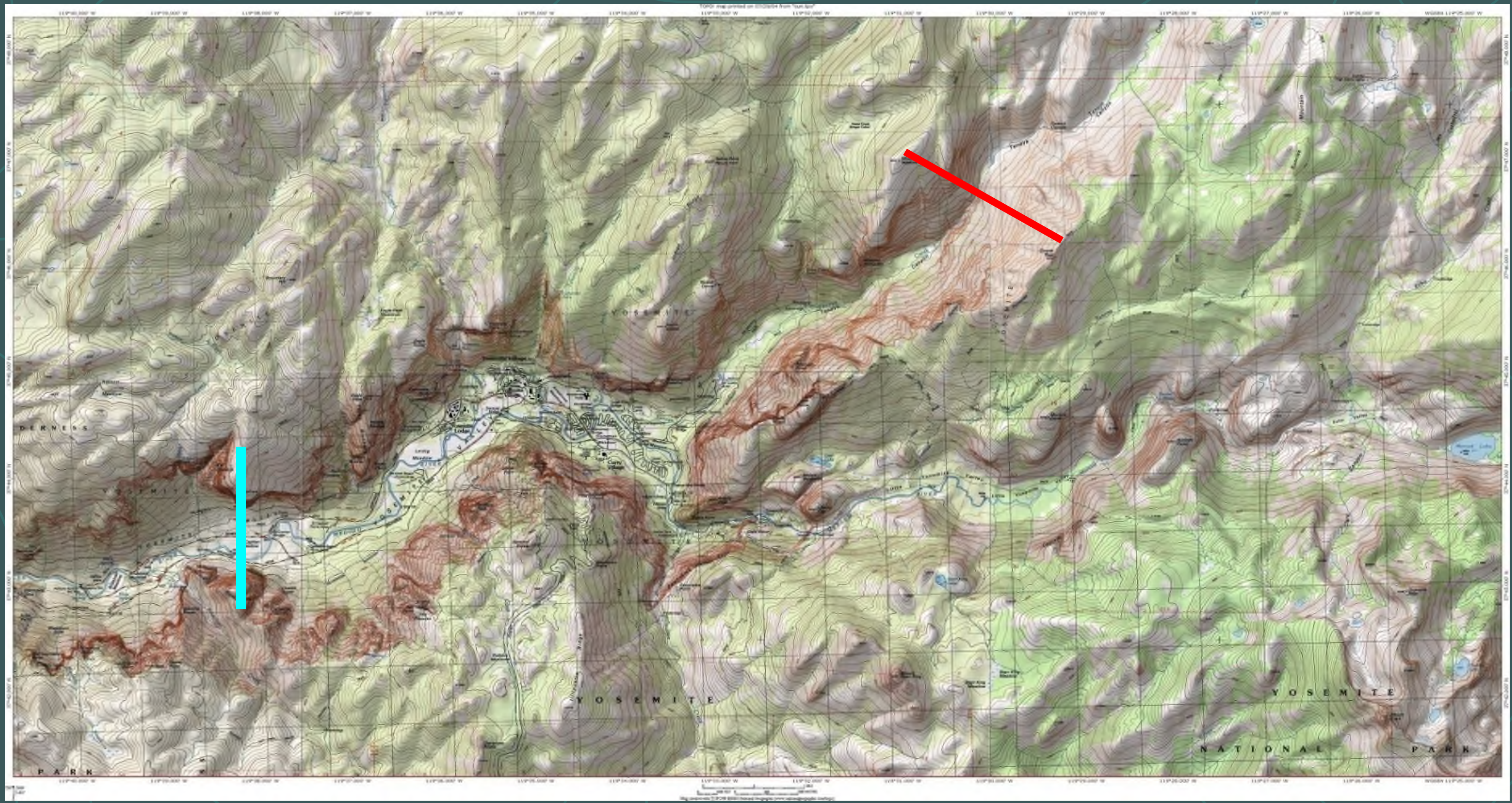
Yosemite Valley Topography



Yosemite Valley Topo Map



Yosemite Valley Topographic Map



Cross-Section Profiles

1) Mount Watkins to Clouds Rest
2) El Capitan to Cathedral Rocks

Views of Yosemite Valley

Views of Yosemite Valley

Views of Yosemite Valley

Views of Yosemite Valley

Views of Yosemite Valley

Head’s-Up for Next Week’s Lab

Earthquakes

Next Week’s Lab Activities

1) Measure Epicenter and Magnitude
2) Ground Motion Experiment
3) Measure Fault Displacement

Preparation

Recommended Pre-Lab Web Activities (Click on Link)

1) Learn About Earthquakes - USGS Site
2) Virtual Earthqauke!
3) World ocean bottom features and Tectonic plate boundaries

Earthquake Topics

What are Earthquakes?

Where and How do Earthquake Form?

How are Earthquakes Measured?

What are the Effects of Earthquakes?

Can we Predict Earthquakes?

How can we Prepare for an Earthquake?