King County
Explorer Search and Rescue

Course B

Map & Compass

Disclaimer

- The intent of this presentation is to provide a basic overview of maps, compasses, and location finding. It is not meant to be a replacement to actual practice route finding and navigating. Completing this course, along with the rest of ESAR training, will provide a basic level of wilderness navigation and survival. ESAR is not responsible for any actions you take navigating during trainings, missions, or your personal time.

Welcome to Course B

- Welcome to Course B! This is the first of a series of 6 skills oriented trainings to complete basic training for ESAR
- If you have any questions regarding content or the homework, please contact CourseB@kcesar.org

- ~~Course A~~
- Course B 
- Course C
- Course 1
- Course 2
- Searcher First Aid
- Course 3

General Notes

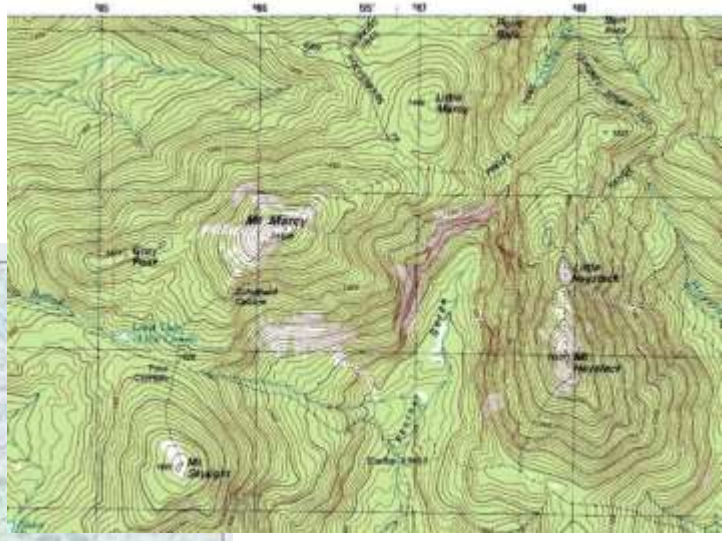
- Please review this entire lesson and complete your homework. This will need to be turned in at Course B
- The homework can take anywhere from 2 to 10 hours to complete. Please do not wait until the last minute to complete the homework
- The homework map is a subsection of the Green Trails 207S map
- For the purpose of homework (and classwork) assume your declination to be 16.5°

Maps

- The following section will cover the following:
  - Types of maps
  - Map symbols
  - Map Legend
  - Declination
  - Scales
  - Datums

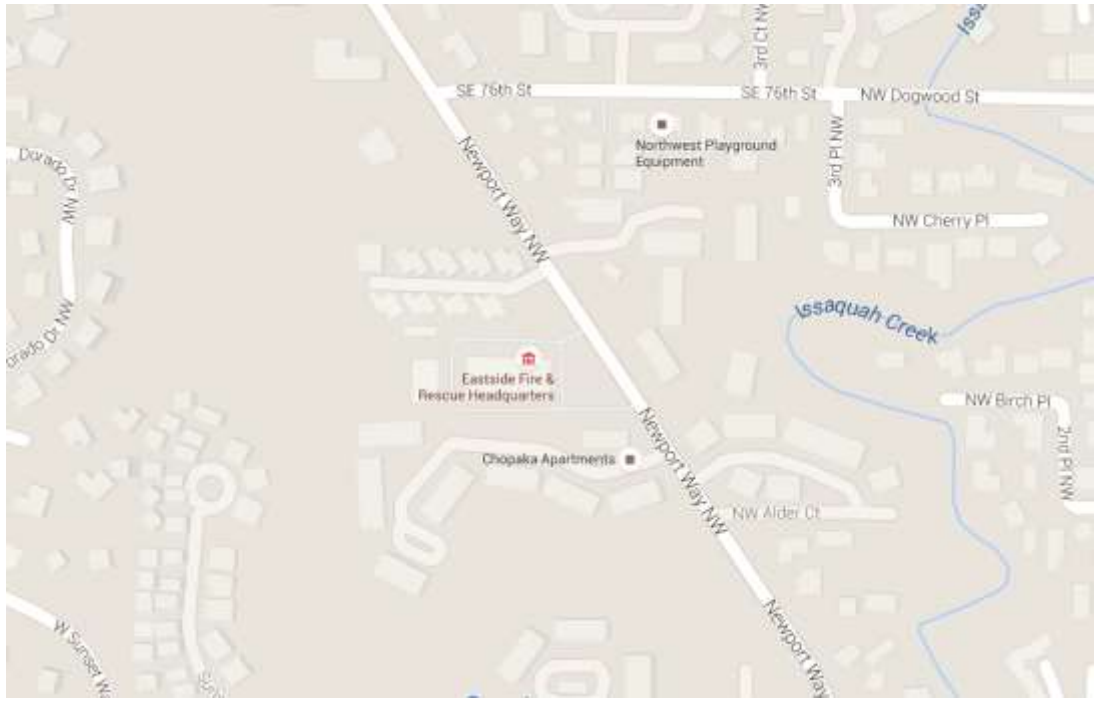
What is a map?

- A map is a scaled-down two-dimensional representation of the three-dimensional world around you
- Different types of maps have different uses
  - Planimetric
  - Topographic
  - Aerial Photography
  - Nautical, weather, aviation, subway, etc



Planimetric

- Planimetric maps show only horizontal positions of features on Earth's surface
- A good example of a planimetric map is a road map or Thomas Guide



Topographic

- Topographic maps shows relief, or lines that represent elevation
- These lines are called contour lines
- Different maps have different contour definitions; make sure you check your map!

Aerial

- Like it sounds, these are maps based off of aerial or satellite imagery

Other maps

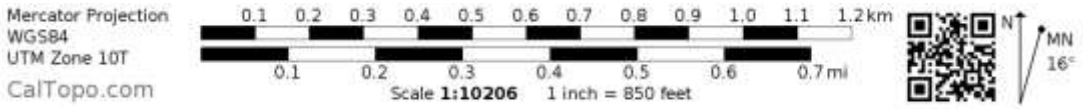
- SAR primarily uses planimetric and topographic maps
- There are many other maps that are available, but they are not as commonly used in SAR
- Nautical Maps – boat/ship navigation
- Weather maps – maps of weather systems
- Subway Maps – Map of subway systems

Map Symbols

- Every map should have a legend to reference roads, points of interests rivers, etc
- Every publisher may print features using different colors or symbols, so be sure to check the map legend when you get a new map

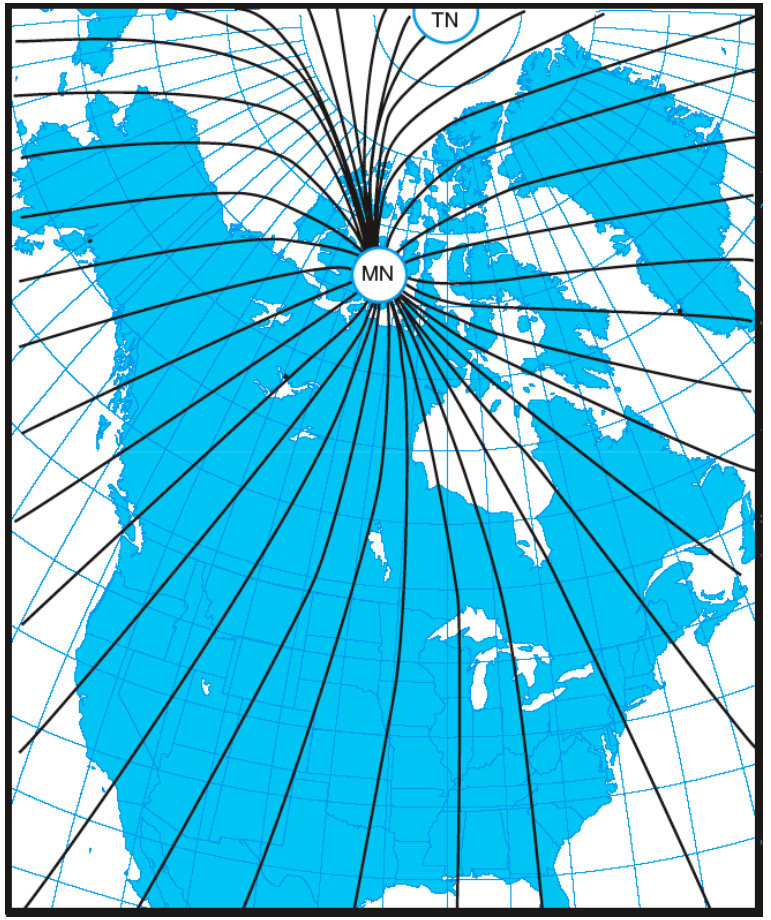
Map Legend

- In addition to symbols, there's a few more important features
  - North Line – indicates which way is true north
  - Declination – shows the declination for the year the map was published
  - Scale – Map scale for that map (relates inches measured on map to inches in real life)
  - Datum – Marks the "starting point" (more on this later)
  - Contour Interval – distance between contour lines



Declination

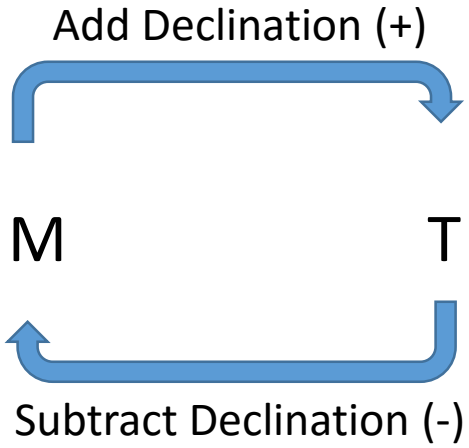
- True North – Where the north pole is
- Magnetic North – where your compass will point, location of earths magnetic pole
- Declination – angle between True and Magnetic North
- This means if you don’t take declination into account, you could be 16.5° off when navigating



Declination conversion

- For the purpose of SAR (and because we live on the West Coast) you can convert between magnetic and true north with the following equation (Note: this is a simplification of the actual calculation)

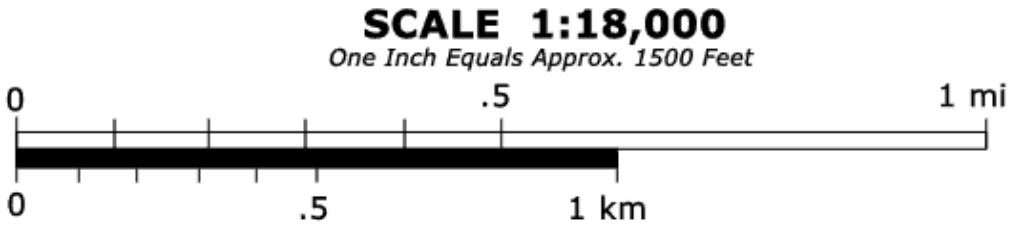
Magnetic + Declination = True



- NOTE!!! Declination changes from year to year!

Scale

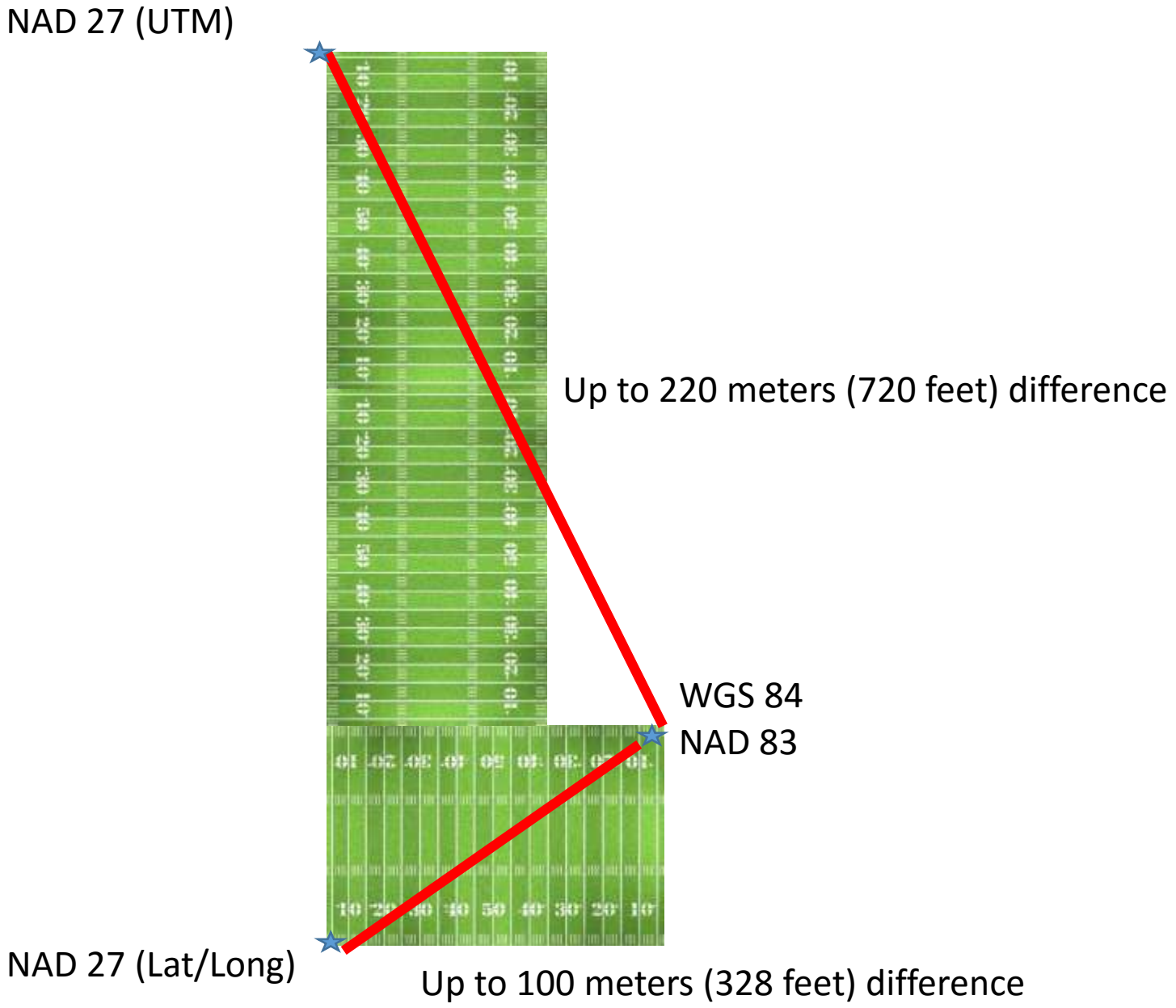
- Scales are used to represent distances on maps vs real life
- If a map scale is 1:18000, this means for every inch you measure on your map, you would actually measure 18,000 inches in real life (or 1500 ft)



Datum

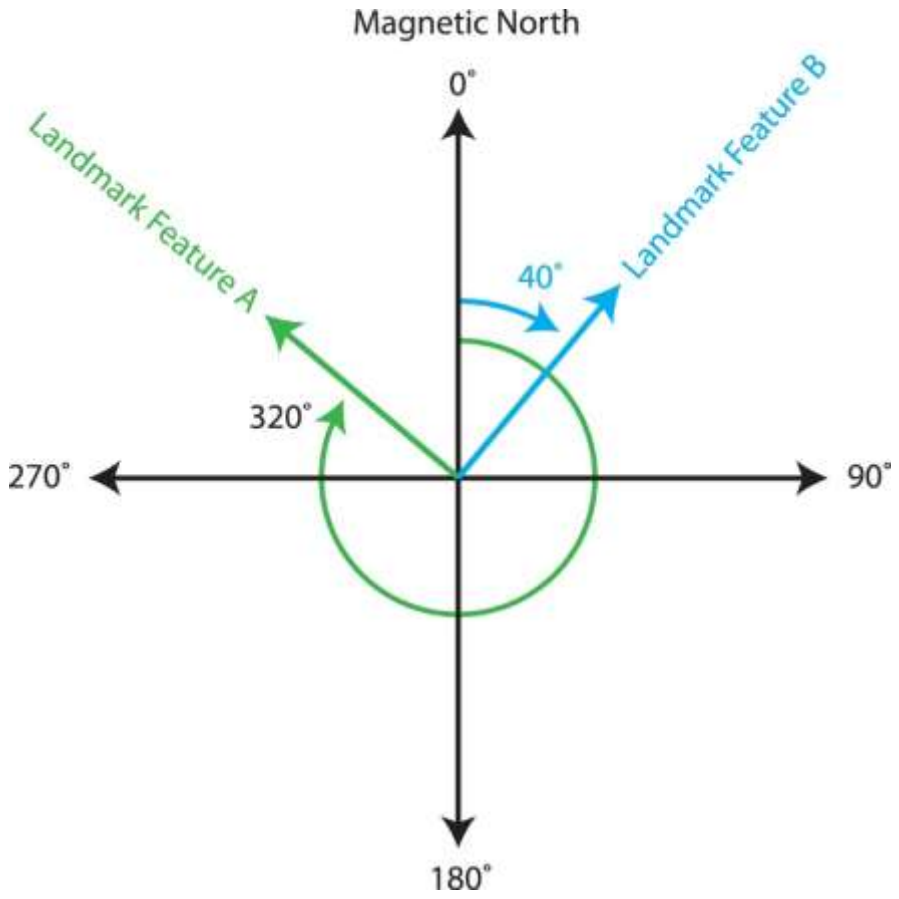
- A datum is a reference point, where all measurements begin
- We operate with a number of datums
  - WGS84 – most common (used on cell phones, new maps)
  - NAD27 – pretty common (used on some Green Trails, many older maps)
  - NAD83 – less common
- Why do datums matter? If you are operating in the wrong datum, you can be off in position up to 220 meters!

- What this figure shows are the datums relative to each other.
- If you are given a coordinate in latitude and longitude in WGS 84, but you plot it on a map using NAD 27, you could be off by 100 meters
- The same is true for UTM: if you are given a coordinate in NAD27, but you plot it into your GPS device using WGS84, you could be 220 meters off
- Always check and report your datums!



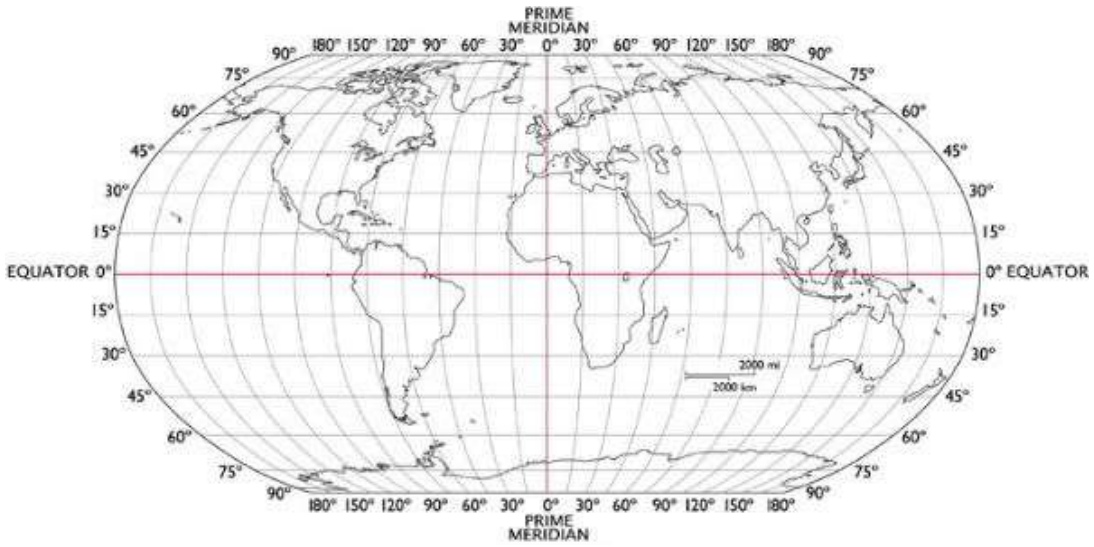
Bearing

- For navigation, we define a bearing, or azimuth, as the degrees away from True North
- To find a back bearing, or back azimuth, you add or subtract 180°
- In the image to the right, feature B has a bearing of 40° and a back bearing of 220°
- Feature A has an azimuth of 320° and a back azimuth of 140°

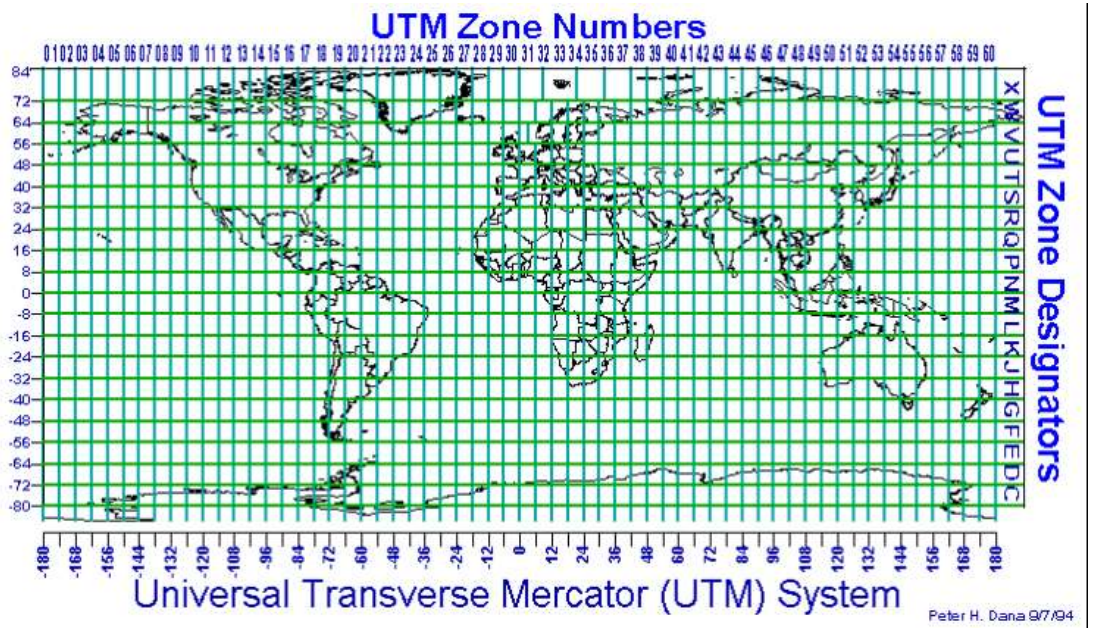


Coordinate Systems

Latitude/Longitude

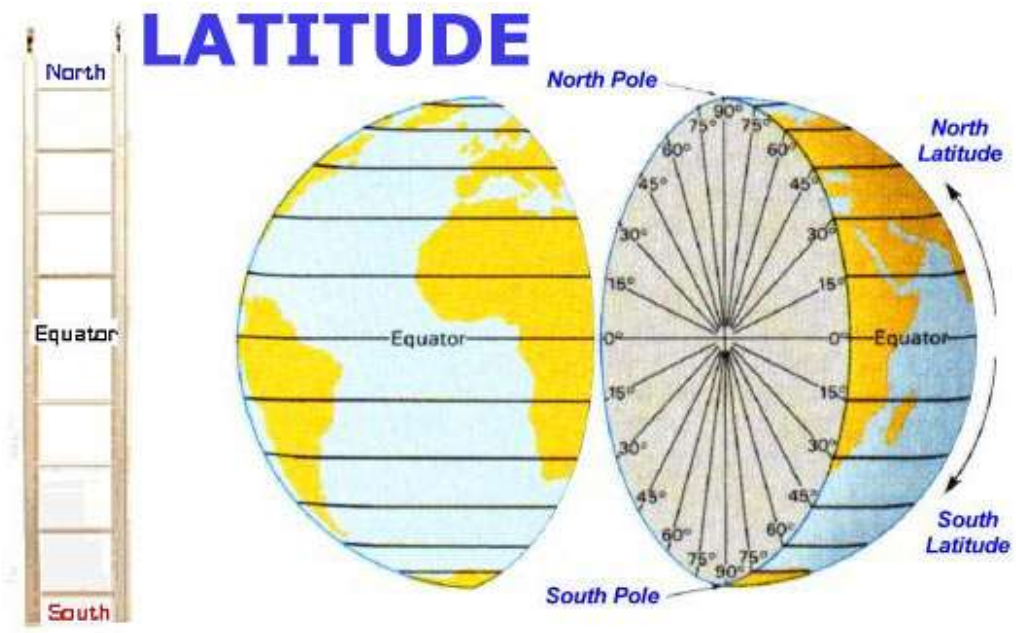


Universal Transverse Mercator



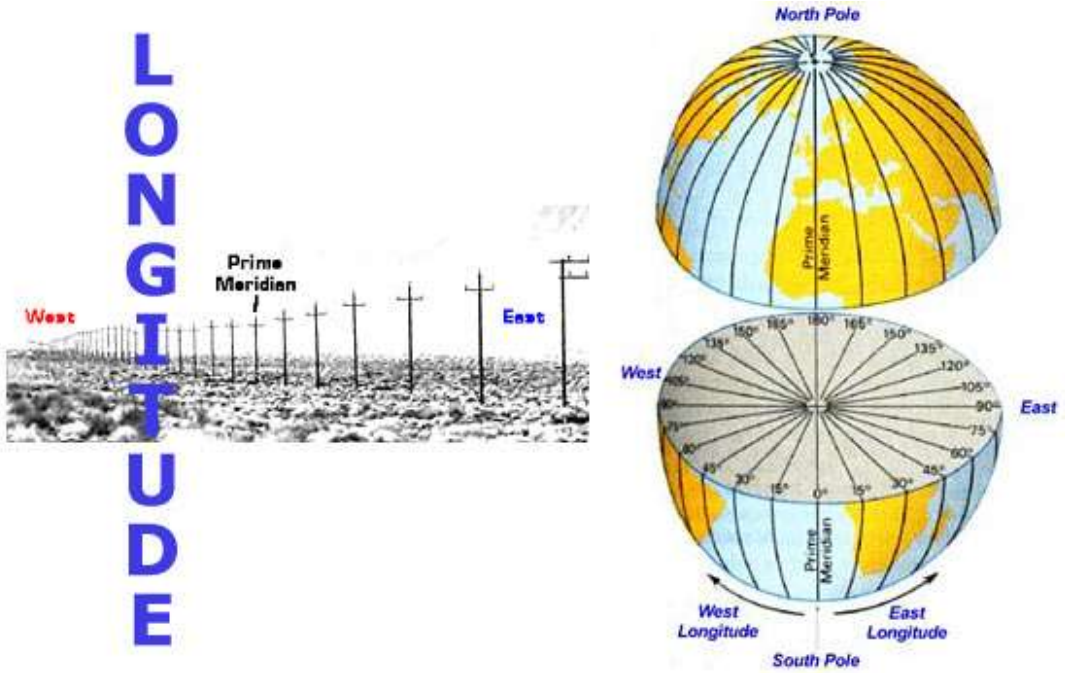
Latitude

- Latitude indicates your position North or South of the equator.
- Latitude lines run East/West, but they indicate your position North and South
- Latitude begins at the equator at 0° and can increase or decrease up to +/- 90°



Longitude

- Longitude indicates your position East or South of the Prime Meridian
- Longitude lines run North/South, but they indicate your position East and West
- Longitude begins at the Prime Meridian at 0° and can increase or decrease up to +/- 180°



Latitude/Longitude Position

- Your position in latitude and longitude are expressed in Degrees, Minutes, and Seconds
- For example, Eastside Fire and Rescue Headquarters (where course B is usually held) is located at

47 degrees, 31 minutes, 56 seconds North

122 degrees, 2 minutes, 38 seconds West

OR

47° 31’ 56” N, 122° 2’ 38” W

OR

47° 31’ 56” N, -122° 2’ 38” E

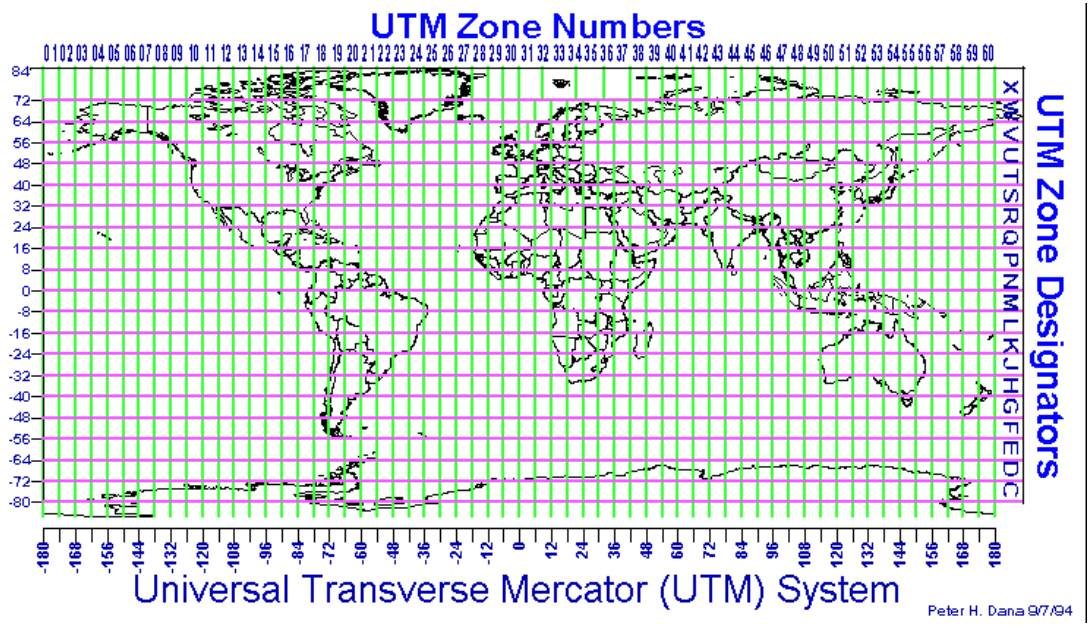
- Longitude increase as you move East, decreases as you move West.
- There are 60 seconds in a minute, 60 minutes in a degree
- There are other formats (Decimal Degrees, Decimal Minute) which we will cover in class

Latitude/Longitude

- Advantages of Lat/Long
  - Universal – It will work exactly the same anywhere in the world
  - Wide Spread – this is the most common system used; Cell phones, ships, Airplanes all use Lat/Long
- Disadvantages of Lat/Long
  - Correlation – how many miles are there in a degree? How about a second? If you don't know the conversion already, it may be difficult to do the math in the field
  - Difficult to relate distance between two points
  - Longitude scale changes the farther north you travel

Universal Transverse Mercator (UTM)

- UTM projects a 2 axis “grid” onto the map
- UTM uses meters for positions



UTM Positions

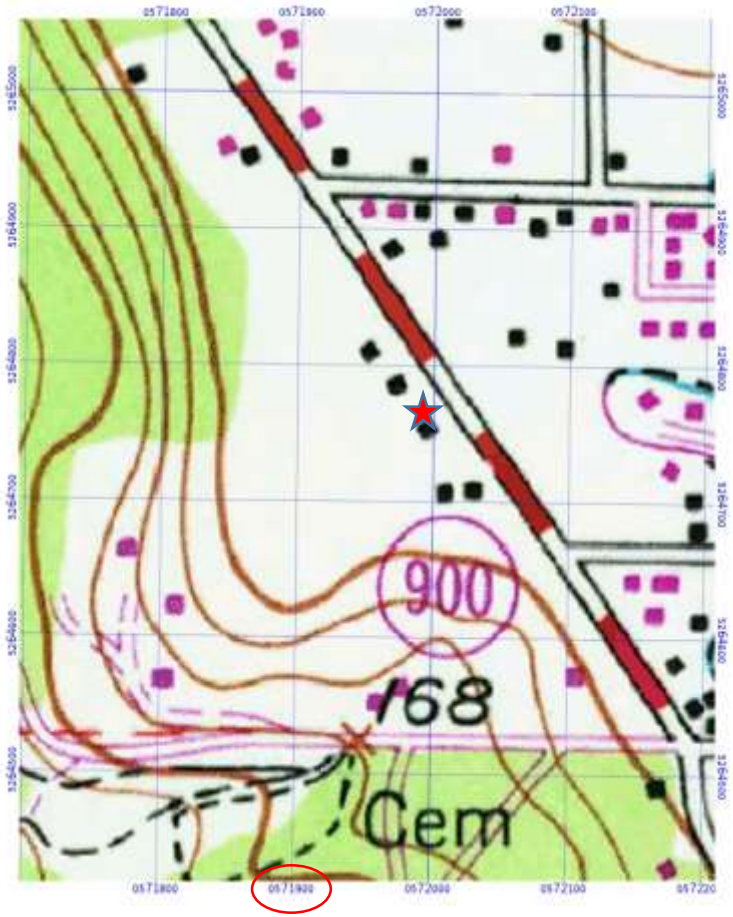
- Your position is expressed using the UTM Grid
- For example, Eastside Fire and Rescue Headquarters (where course B is usually held) is located at

  10 T 0571974E 5264772N

- The 10 represents the Zone number. Zones represent sections of longitude 6° apart
- The T represents the Row letter. Rows increase from South to North, beginning at the South Pole

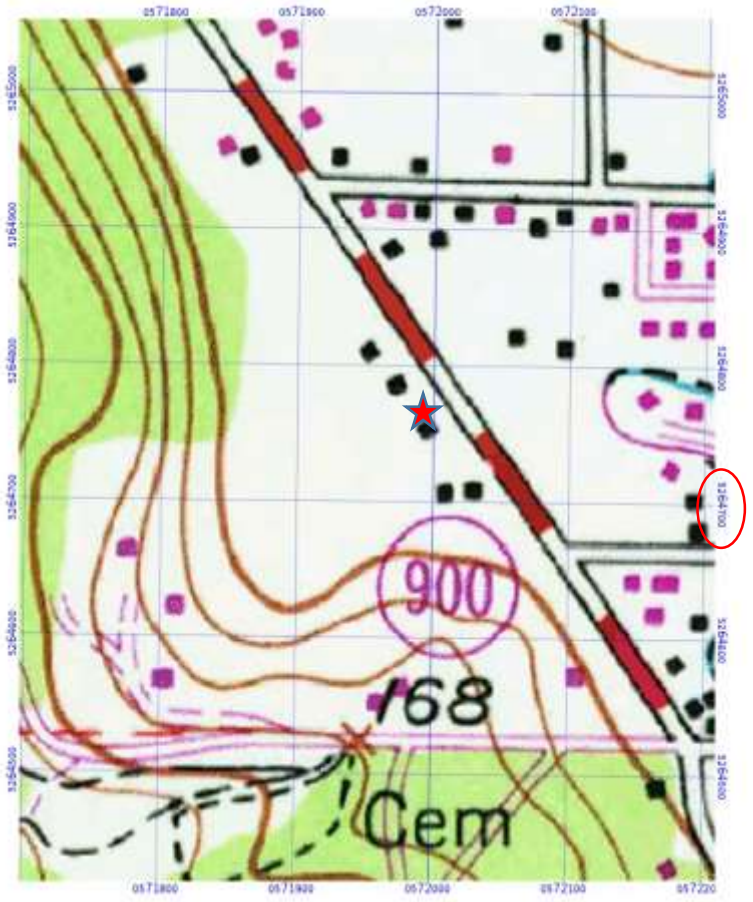
UTM Positions (cont)

- The Easting is the position in the East-West direction
- The first four numbers (0571) represent the closest “Easting line” to the location. You can find this number along the bottom of the UTM Grid
- The last three numbers (974) represent the meters east from the 0571 line



UTM Positions (cont)

- The Northing is the position along the North-South direction
- The first four numbers (5264) represent the closest “Northing line” to the location. You can find this number along the side of the UTM Grid
- The last three numbers (772) represent the meters North of the 5264 line



UTM

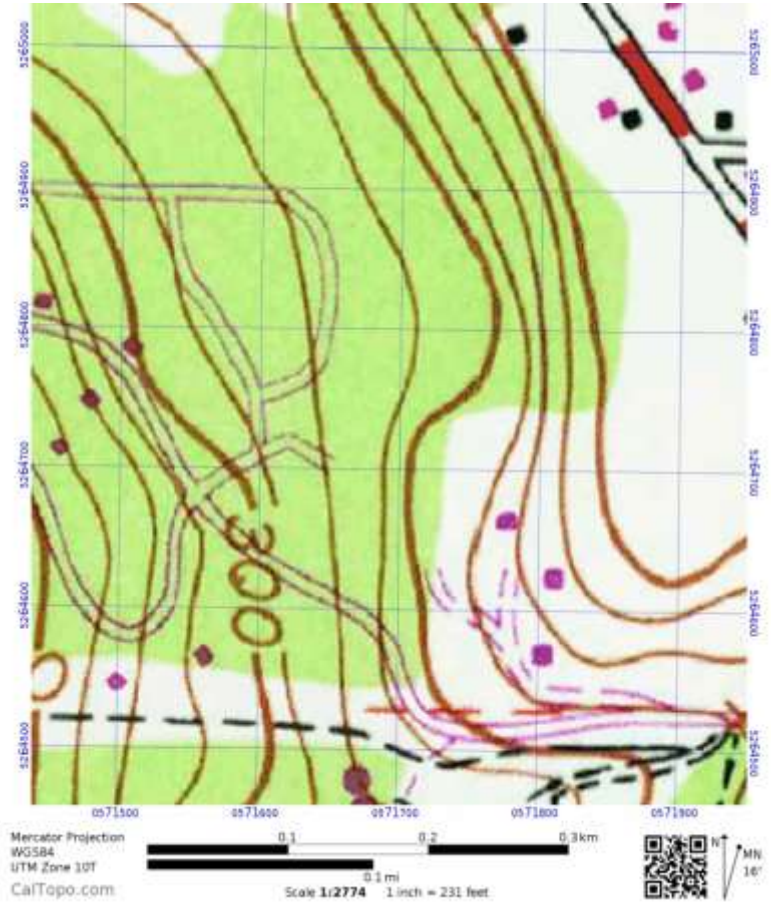
- Advantages
  - Easy to plot
  - Easy to calculate distances between two locations
- Disadvantages
  - Not common outside of government entities
  - UTM grid discrepancy exists. This isn’t too relevant for King County, but you’ll learn more about this in class
  - Metric distances aren’t as popular in the States
  - Not the default for most cell phones and GPS devices/applications

Scaling and Plotting

- In the following slides you will learn how to
  - Determine the scale of your map
  - Locate True North
  - Plot Lat/Long coordinates
  - Plot UTM Coordinates

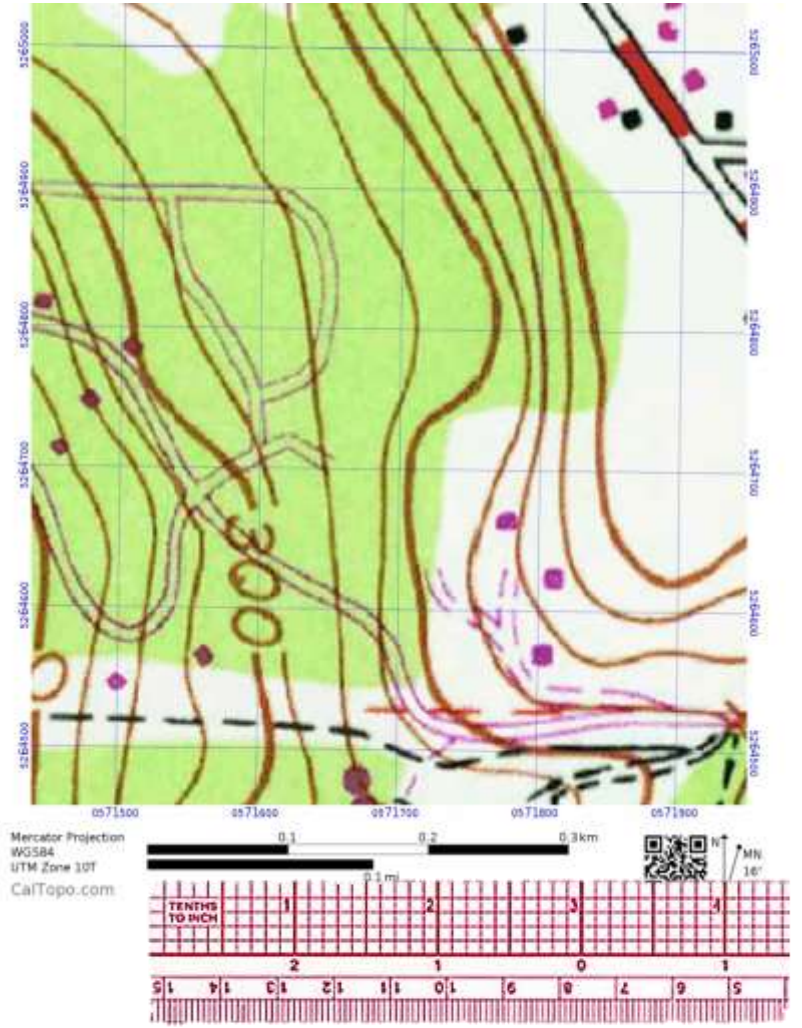
Determining Scale

- One method to determine your scale is to just find it on your map
- For the map to the right, the scale is 1 in = 231 feet
- Be careful when using printed scales; they are usually associated with a certain page size. If the page has been shrunk/enlarged, the printed scale no longer works



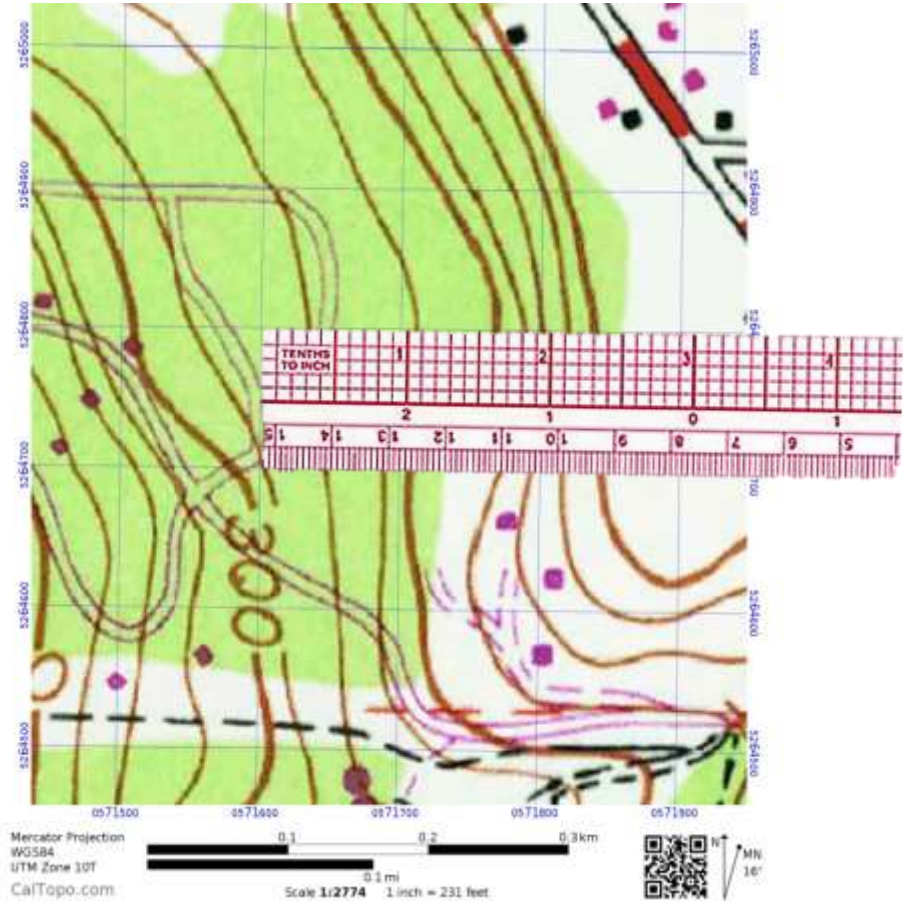
Determining Scale (cont)

- Another method to find your scale is to take your ruler and measure a known value
- The scale gives you a known value. The bottom black line of the scale represents 0.1 miles. If you measure the length of that black line with your ruler, you would get XX inches = 0.1 miles
- Divide both sides by XX and you will get 1 inch = YY miles
- This works the same with feet, meters, and kilometers
- For this example, the scale is 1.55 inches = 0.1 miles, or 1:0.065



Determining Scale (cont)

- Alternatively, you can take your ruler and measure the distance between two UTM lines
- By looking at the UTM lines given, you should recognize that 0571600 and 0571700 are 100 meters apart . If you measure the length between two grid lines, you would get XX inches = 100 meters
- Divide both sides by XX and you will get 1 inch = YY meters
- For this example, the scale is 0.95 inches = 100 meters, or 1:105.26

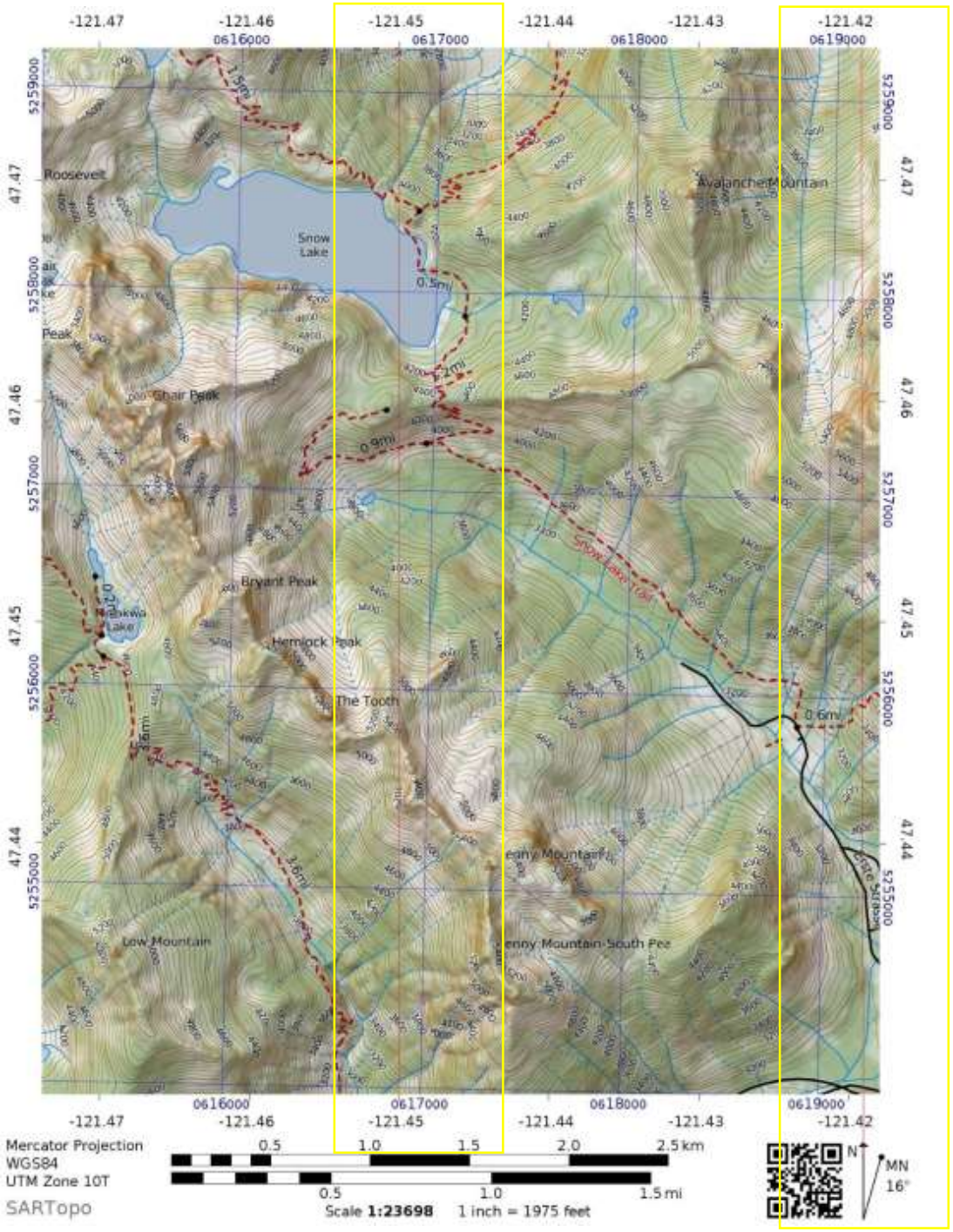


Notes about scaling

- Most maps show UTM lines to be 1 km (1000 meters) or 2 km (2000 meters) apart. Be sure to check your printed scale or the values of the UTM lines
- Be careful with using distances marked on maps between points of interest or trail intersections; these are approximations

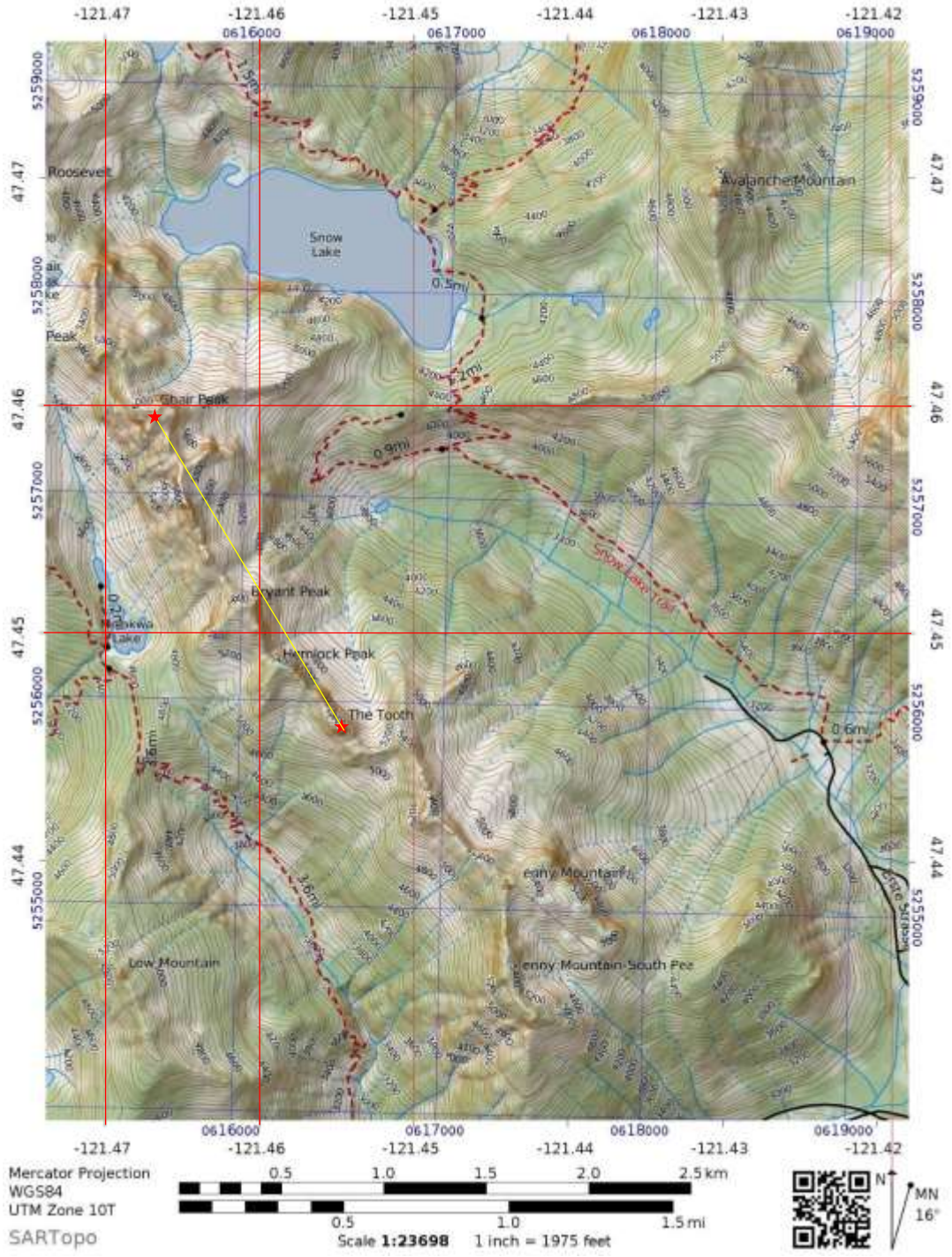
Locating True North

- Two methods to find True North
  - Extend the North line in the Map Legend
  - Connect Longitude lines
- Note: the north lines for the UTM grid DO NOT necessarily represent True North
- Note: The right and left edges of the map DO NOT necessarily represent True North either



Determining Bearings

- Lets try to find the bearing <u>from</u> Chair Peak <u>to</u> The Tooth
- Remember to connect your longitude lines, especially the ones adjacent to the point where you're starting to measure from
- Always connect the two points you're trying to find a bearing

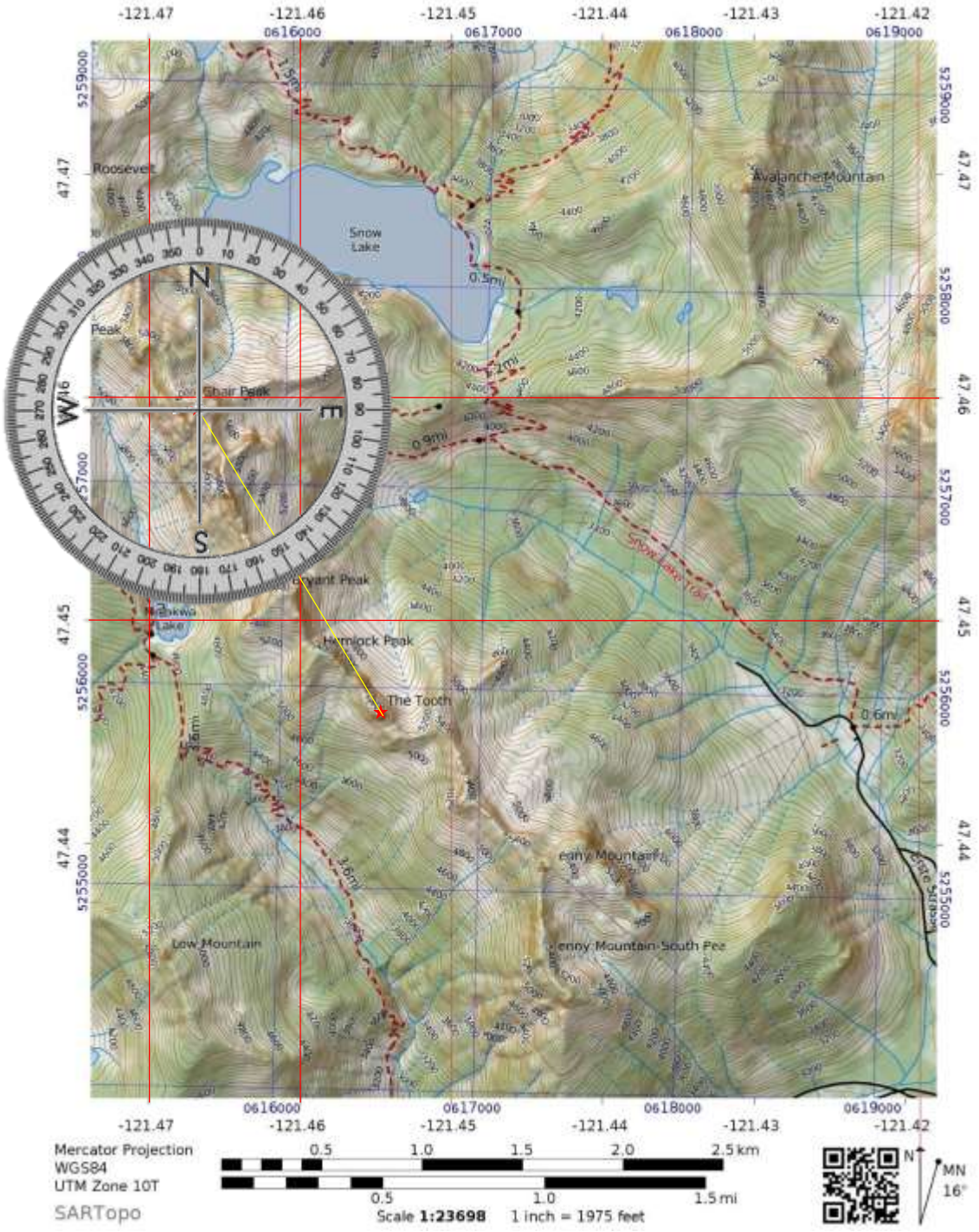


Determining Bearings

- Before you place your protractor, you'll want to draw a north/south and east/west line over your starting point. This will help you align your protractor
- We'll go over methods in class on how to be more accurate; for now, pick any method you'd like

Determining Bearings

- Reading the protractor gives you a bearing of 159° from Chair Peak to The Tooth
- The back bearing is 339°
- If you answer incorrectly, meaning you measured from The Tooth to Chair Peak, you would get a bearing of 339° and a back bearing of 159°
- Always be aware of where your starting and ending points are

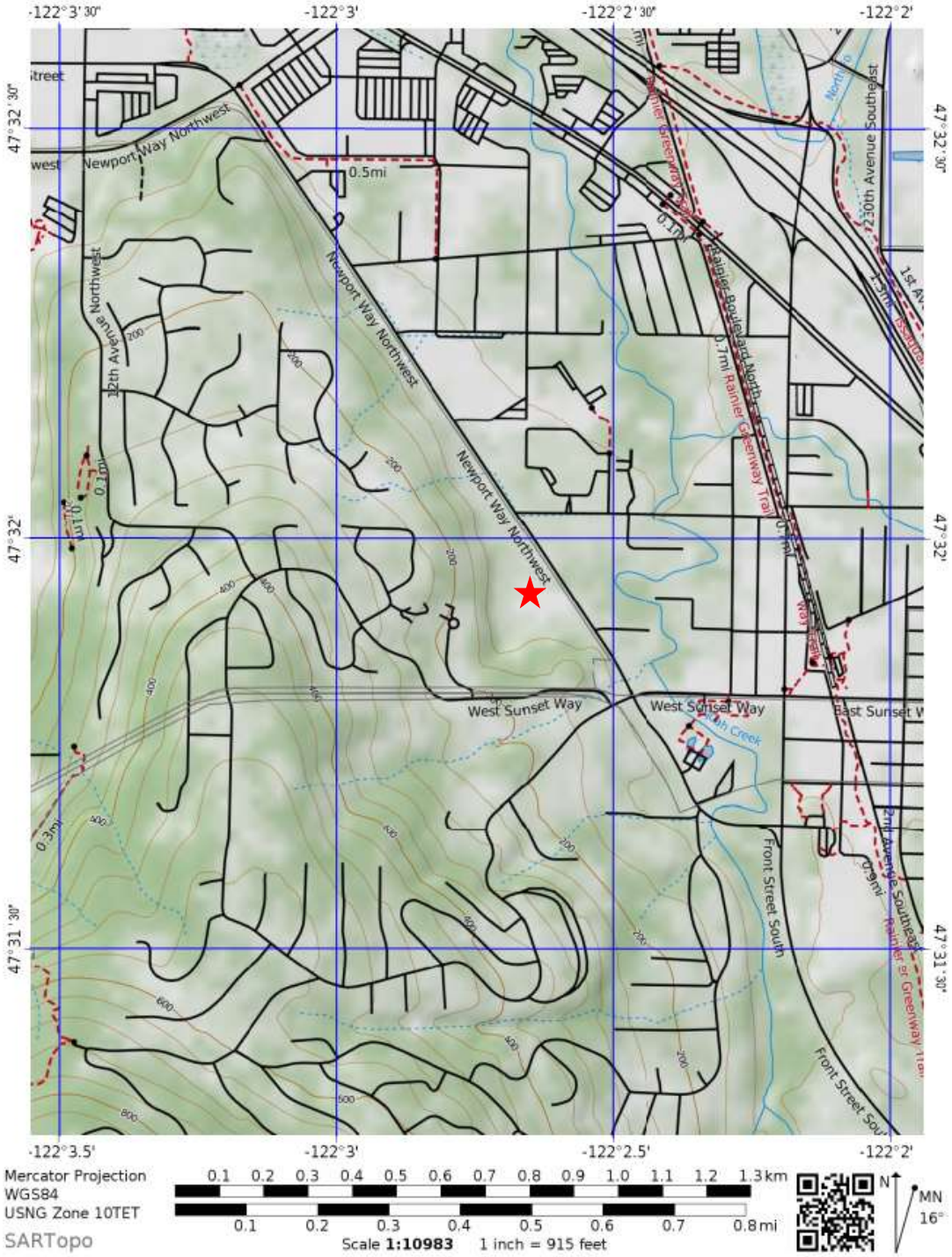


Plotting Latitude and Longitude

- Steps
  - 1. Connect all Latitude (Lat) and Longitude (Long) lines
  - 2. Determine scales for Lat/Long. NOTE! The scale for Lat is different from the scale for long, which is different from your scale for distance. Lat/Long are generally measured in degrees, minutes or seconds
  - 3. Determine your Northing
  - 4. Determine your Easting

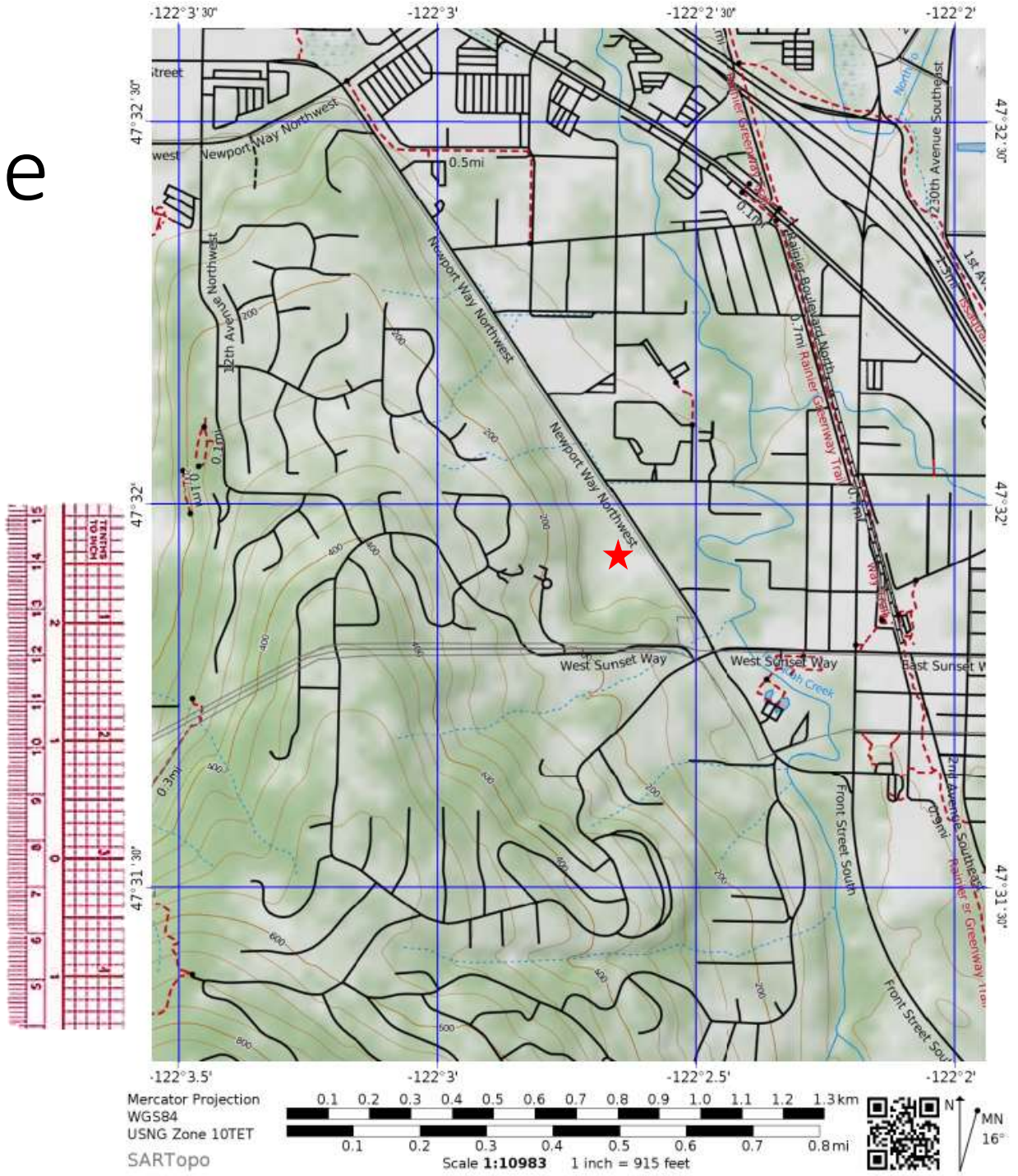
Connect Lat Long Lines

- This will make scaling and plotting a lot easier



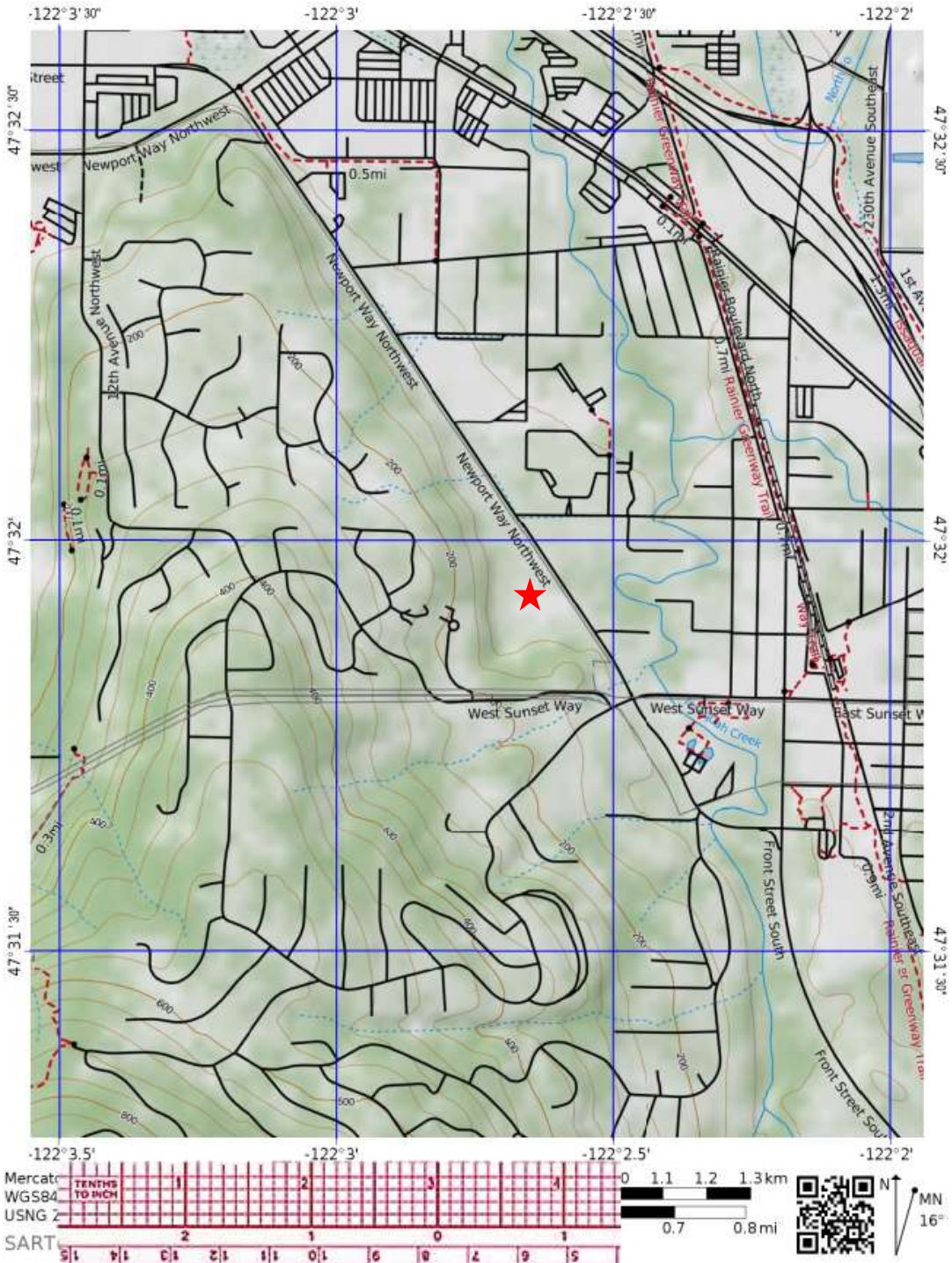
Determine Latitude Scale

- Using the provided ruler, we can see that the latitude lines are 30 seconds (or 30”) apart at a distance of 3.25 inches
- We can determine that 1 inch = 9.23”, or 1/10th of an inch = 0.923”



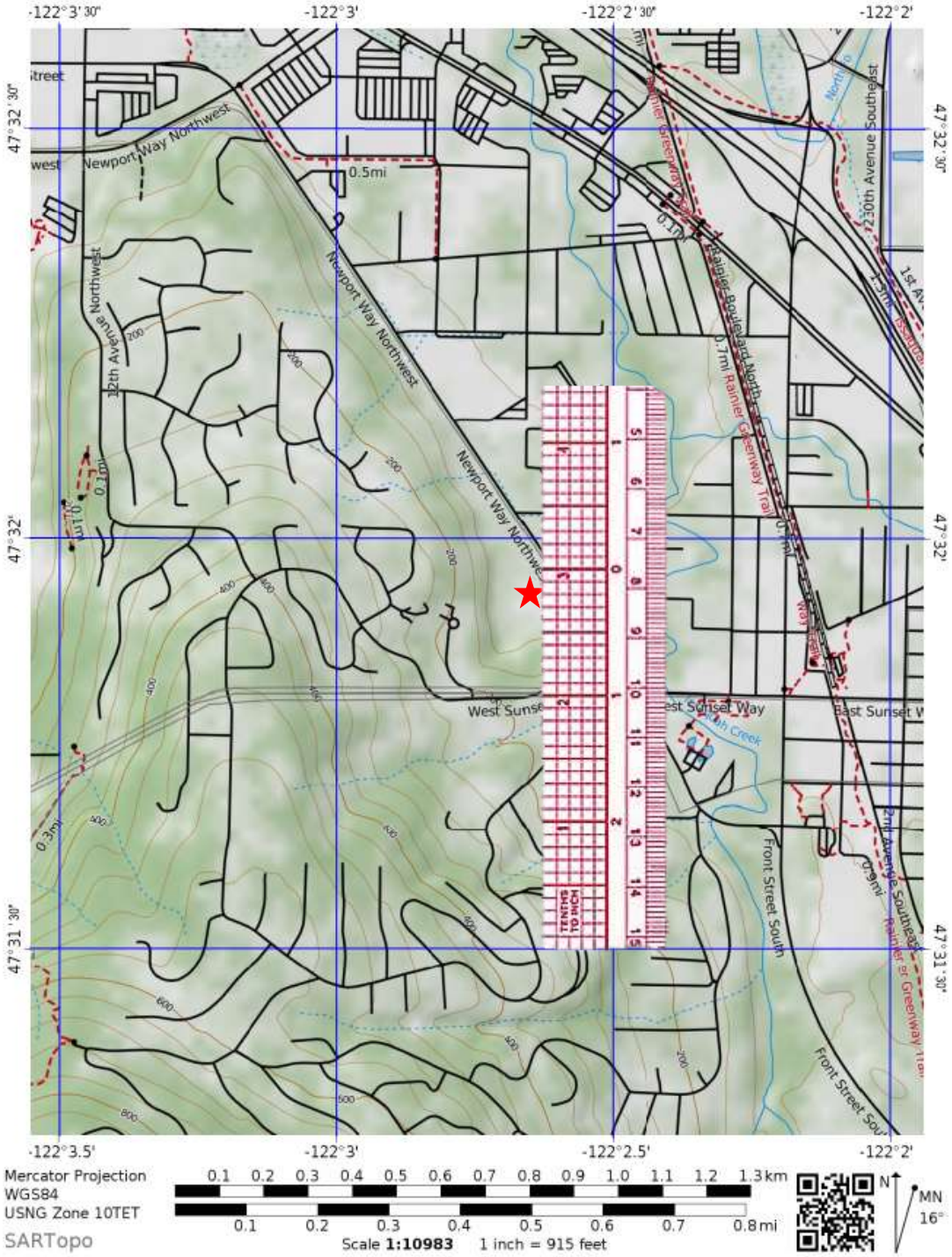
Determine Longitude Scale

- From the map and ruler to the right, we know that 30” longitude is equal to 2.2 inches
- Therefore, 1 inch = 13.6”, or 1/10th of an inch = 1.36”



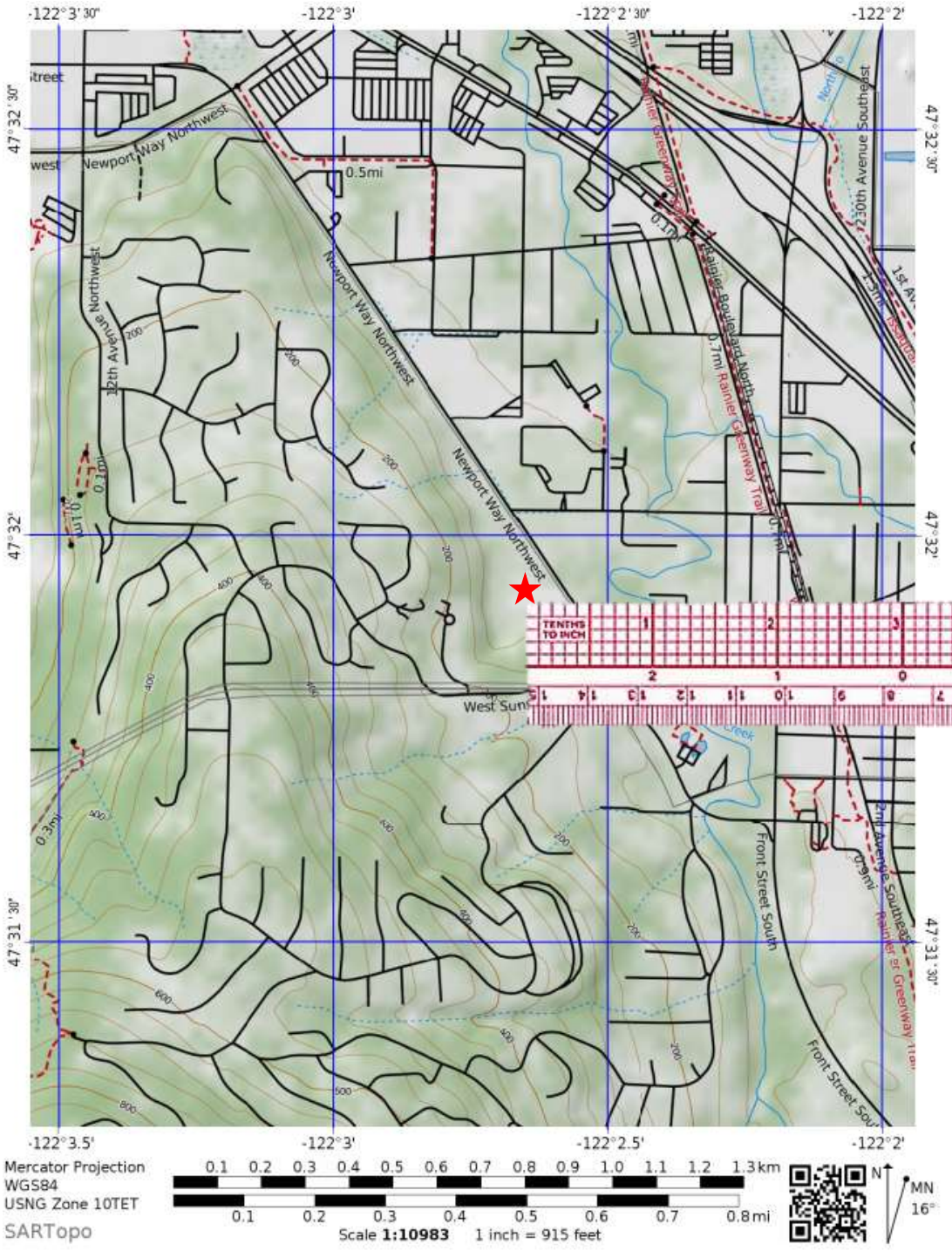
Measure Northing

- For the northing, we measure 2.8 inches
- 2.8 inches* 9.23” = 25.84 seconds
- We add this to the bottom latitude (47° 31’ 30”) to get a Northing of 47° 31’ 55.84”



Measure Easting

- For the Easting, note that we are measuring from the longitude line on the right
- Longitude get smaller (more negative) going from East to West (right to left)
- For the Easting, we measure 0.65 inches from the right longitude line
- 0.65 * 13.6” = 8.84”
- Since we are traveling west from the longitude line, we would add this to the value of the longitude line
- Your position would be -122° 2’ 38.84”



Notes about Lat/Long

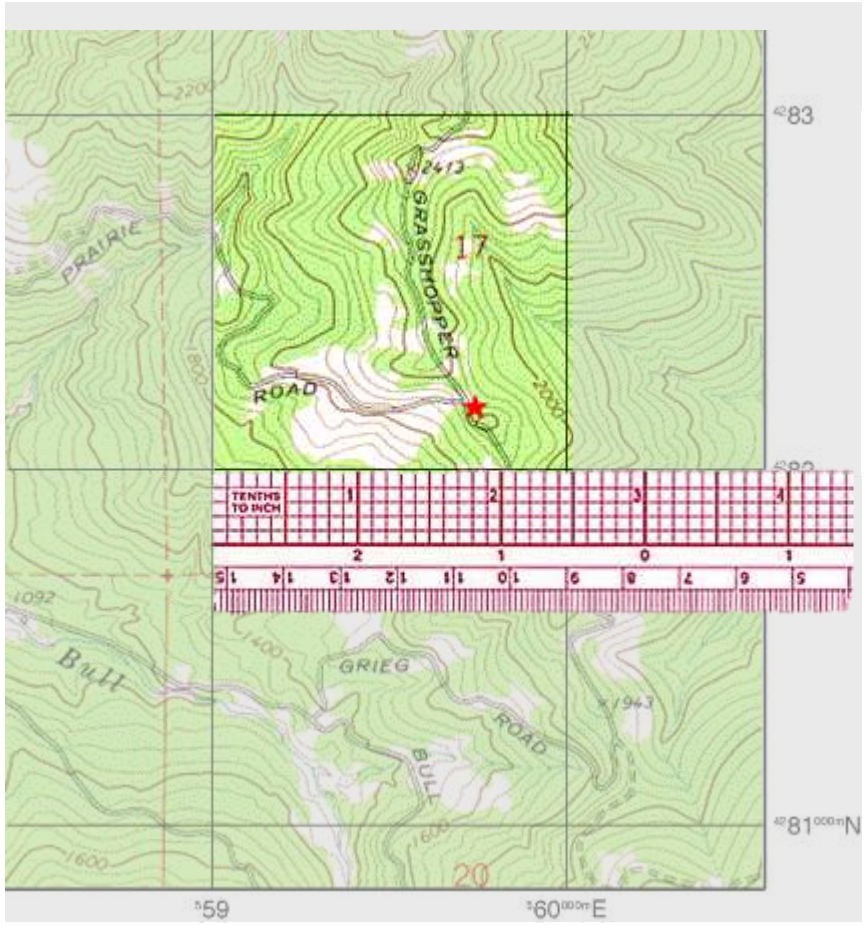
- Always provide your coordinates with all digits and values
- Using the previous Northing and Easting, you would report your position as
  - WGS 84 47°31’55.84” Northing, -122°2’38.84” Easting
- In Lat/Long, the Northing is reported before the Easting

Plotting UTM

- Steps
  - 1. Determine your Scale
  - 2. Determine your Easting
  - 3. Determine your Northing

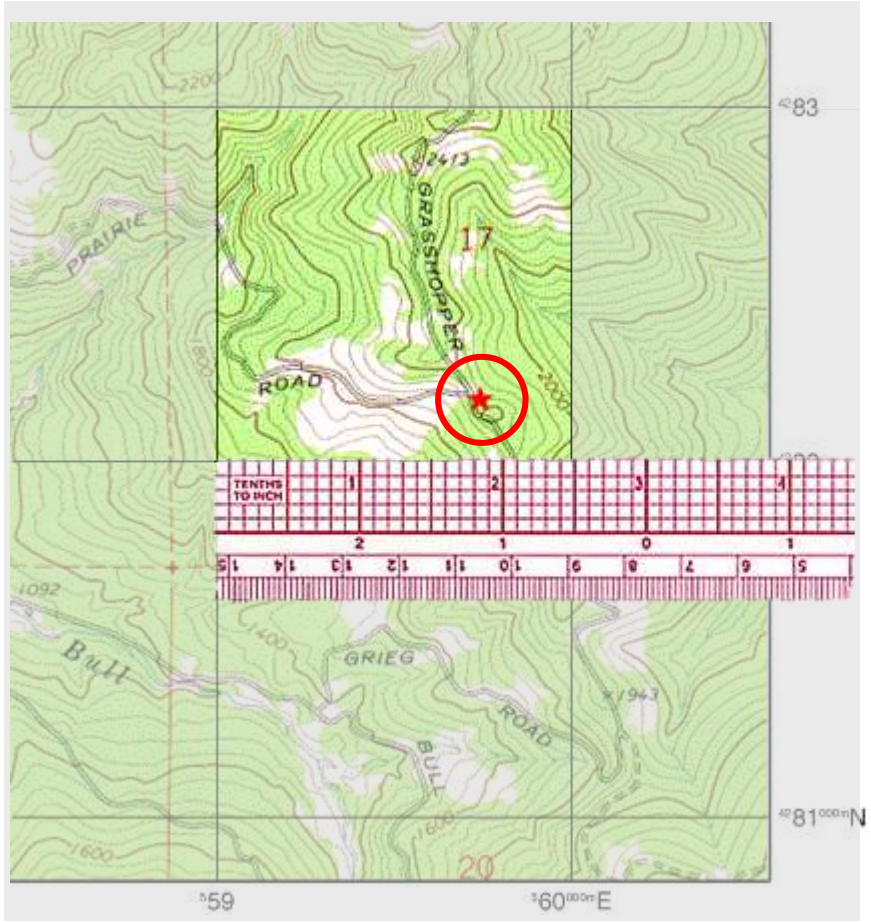
Determine Scale

- For this example, the distance is 2.5 inches
- Therefore, your scale is 2.5” = 1000m
- You can simplify this by dividing both sides by the value you just measured
- 1” = 400 m
- Since we’re using tenths rulers, divide each side by 10 to get the distance between each division
- $\frac{1}{10}" = 40\ m$



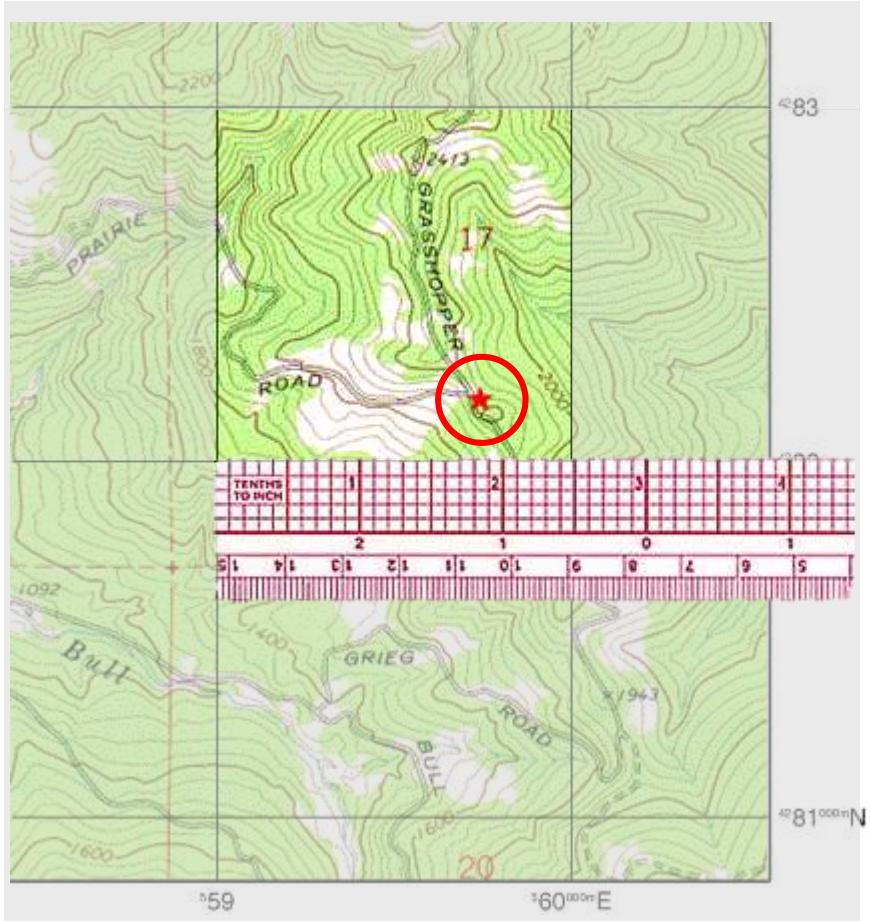
Determine Easting

- The red ★ star denotes the location you want to plot
- Place your ruler along the bottom line (4282) to measure the Easting



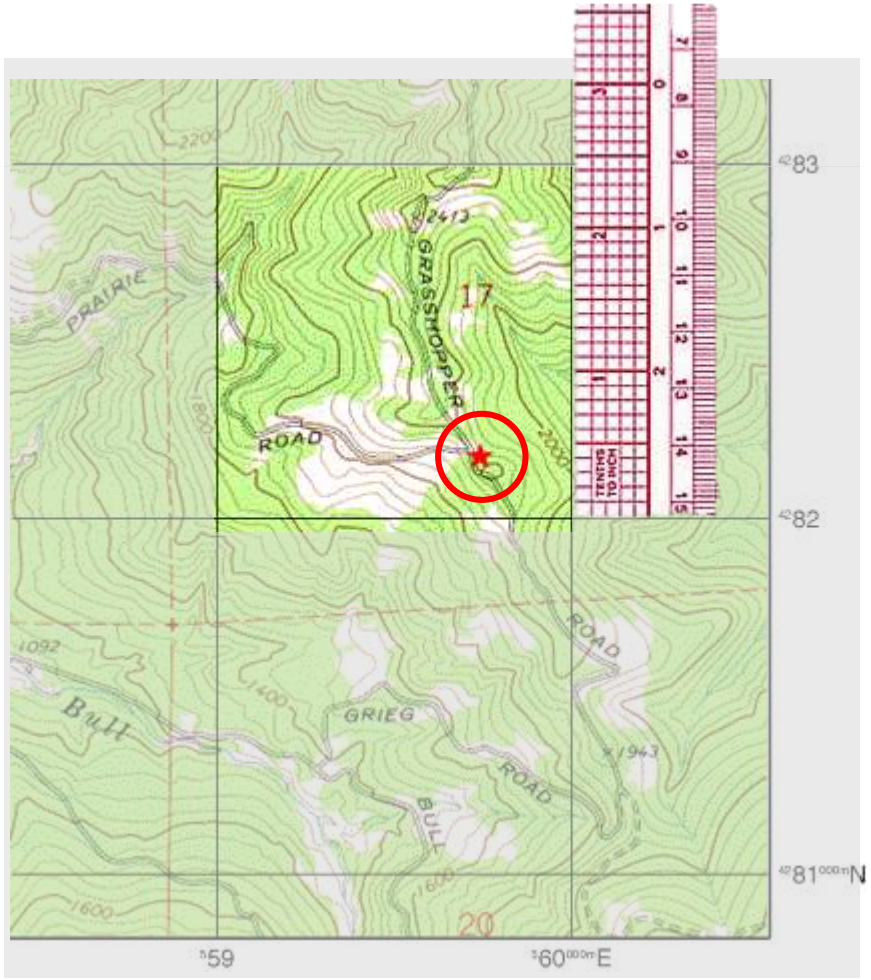
Determine Easting

- We can see that the point is approximately 1.85 inches, or 18.5 tenths from the left grid line
- Convert this to meters by multiplying your measured value by your scale
- $18.5\ tenths\ \times 40\ meters = 740\ meters$
- Add this value to the left gridlines value to get your Easting: 0559740 m



Determine Northing

- Repeat this to get the Northing
- Convert this to meters by multiplying your measured value by your scale
- $4\ tenths \times 40\ meters = 160\ meters$
- Add this value to the bottom gridline value to get your Northing: 4282160m
- Note: Map publishers often abbreviate their UTM grids. You may see 0560000, 559, $^{5}58$ for grid line labels.

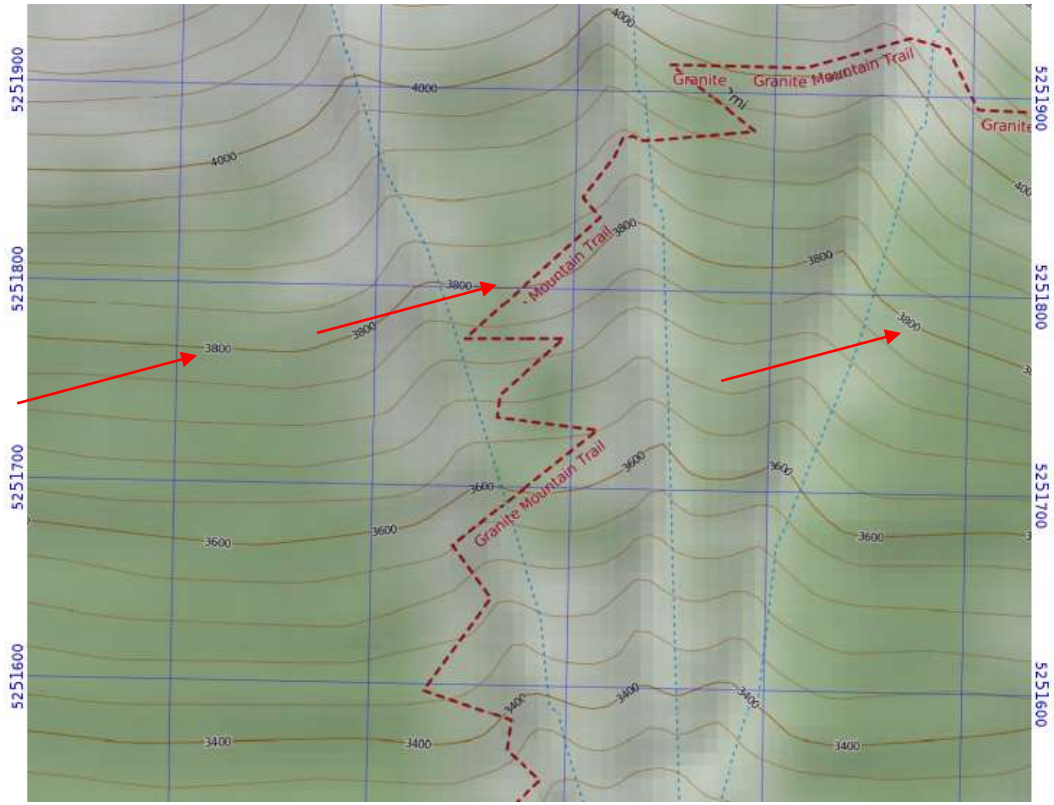


Notes about UTM

- Always provide your coordinates with all digits and values
- Using the previous Easting and Northing, you would report your position as
  - WGS 84 10T 0559740E 4282160N
- In UTM, the Easting is reported before the Northing

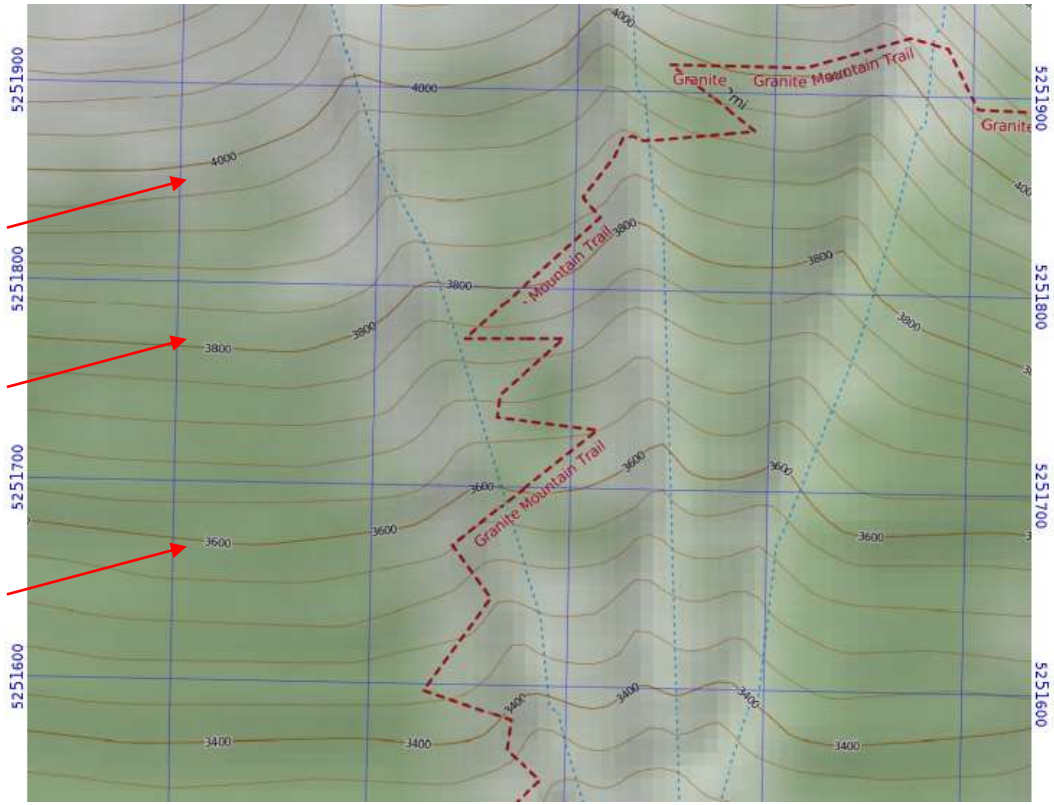
Contour Lines

- Contour lines are lines on a map that join positions of equal elevation (or height)
- For example, every point along the line 3800’ is at an elevation of 3800’



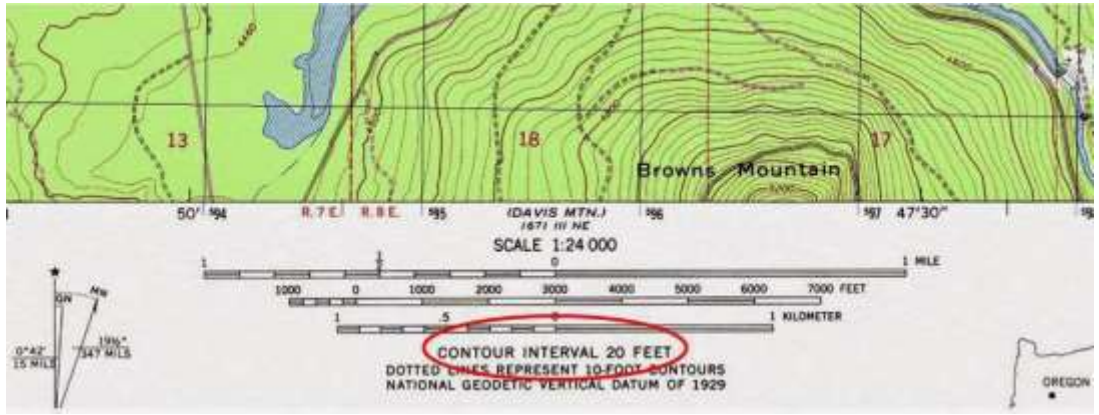
Contour Index

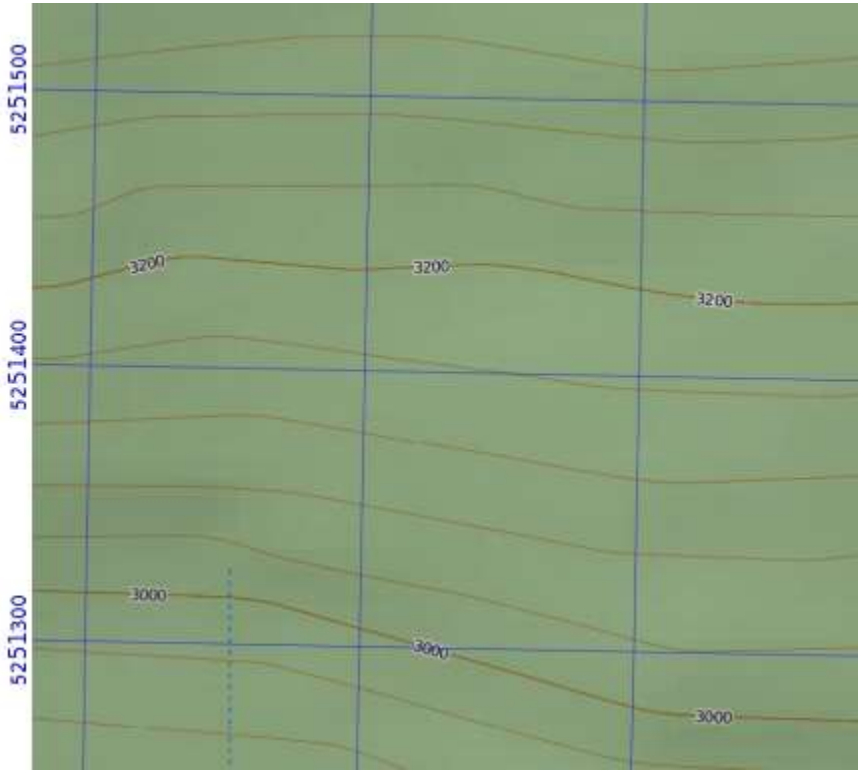
- Contour index(s) are bolded contour lines with the elevation defined
- These are spaced apart so the map is not cluttered with elevation marks on every contour line



Contour Interval

- Contour intervals is the distance between two adjacent contour lines
- Intervals are usually indicated near the scale of the map
- Intervals can be determined by looking at two contour indexes and dividing by the number of intervals between them
  - 200 feet / 5 sections = 40 feet per interval



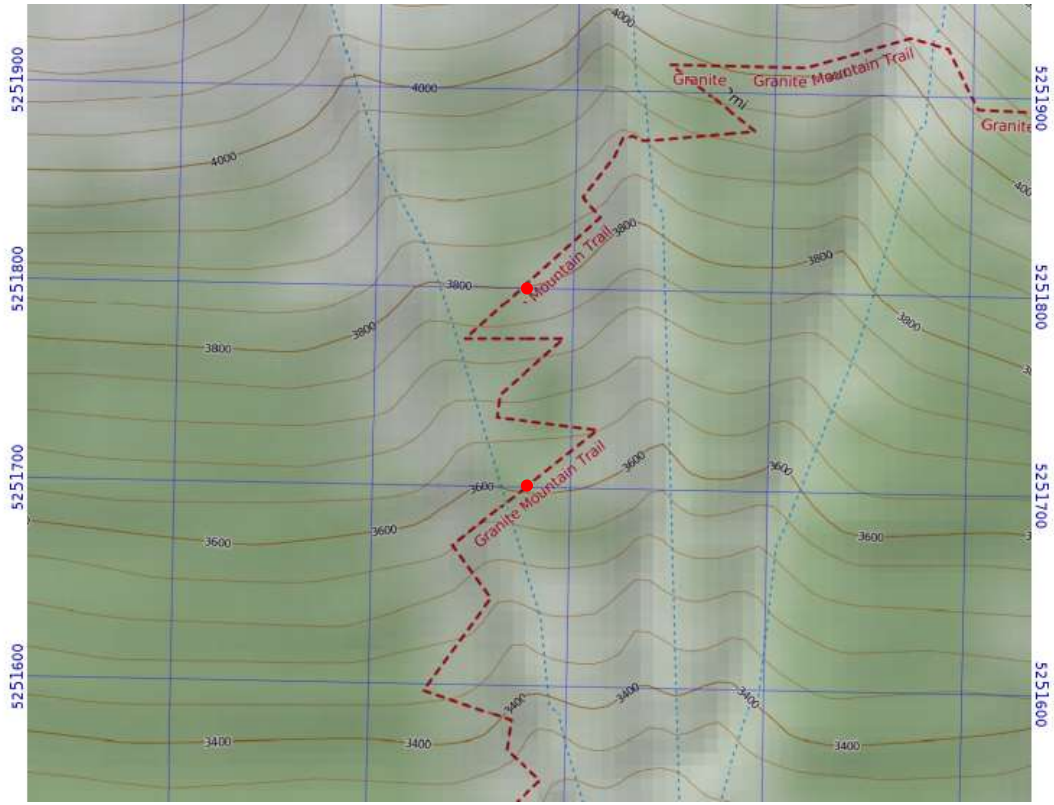


Reading Contour Intervals

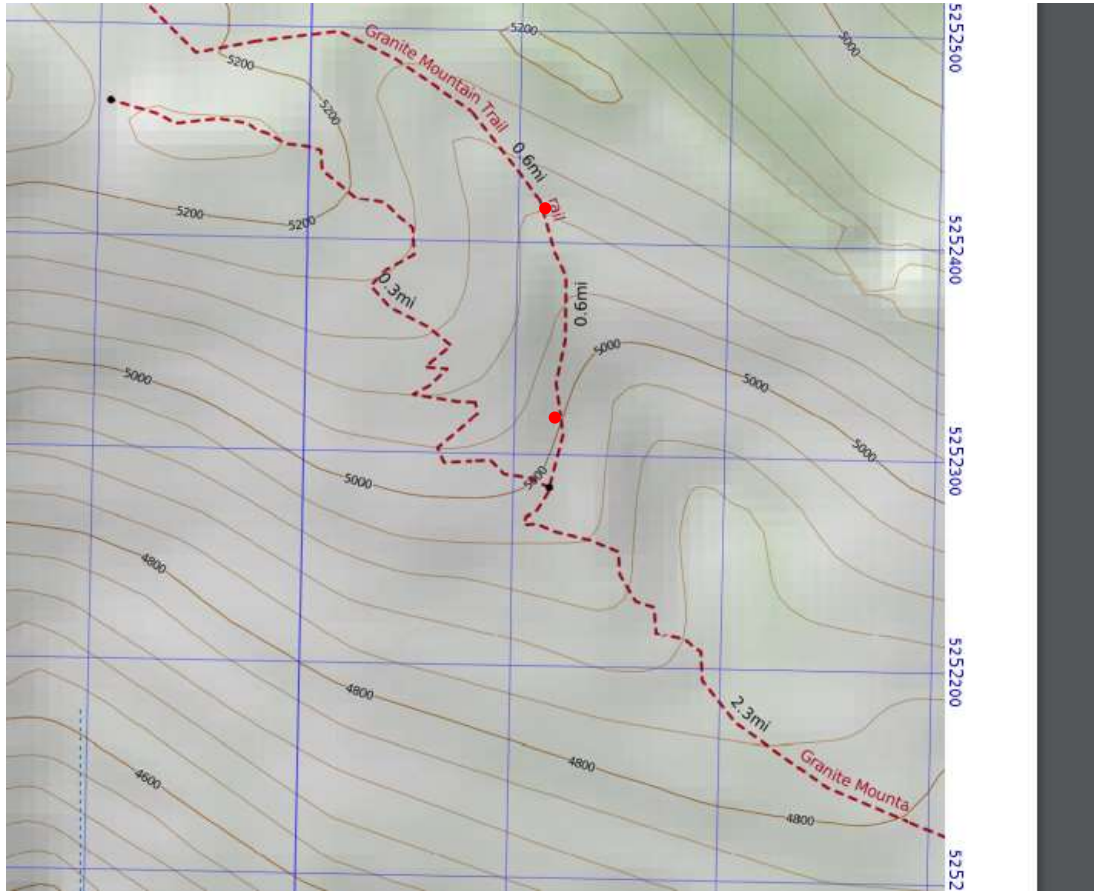
- Areas where contour lines are close together indicate terrain that is steep
- Areas where contour lines are farther apart indicate less steep or flatter terrain

Approximating Steepness

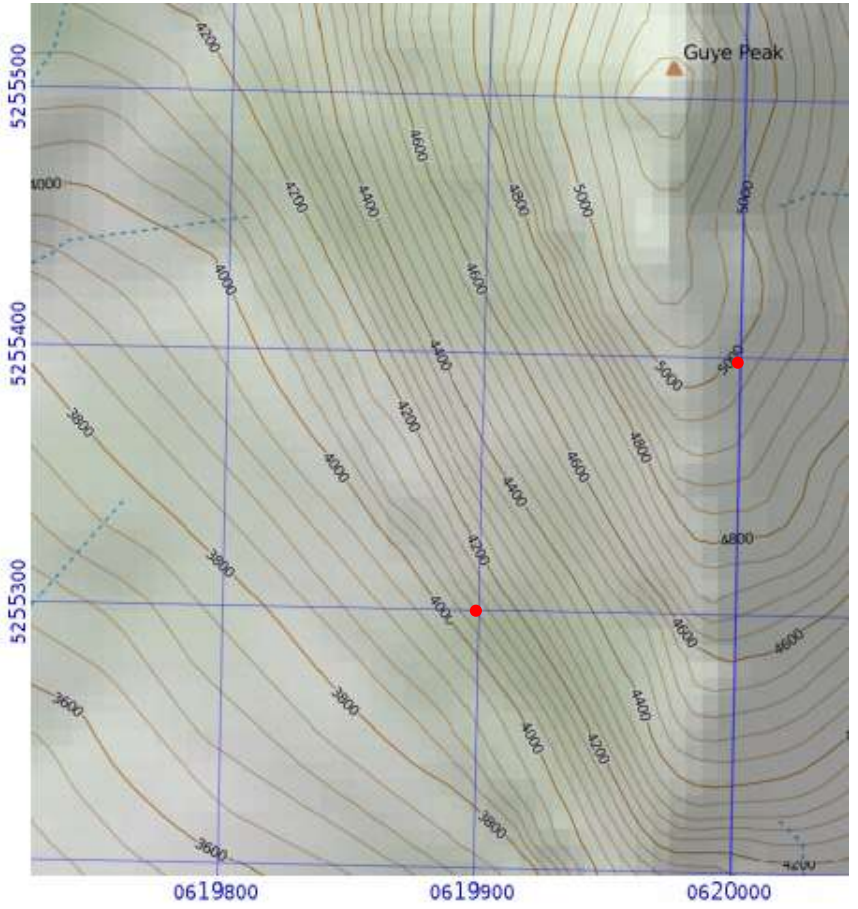
- You can estimate the angle of a slope by comparing the elevation gain to the distance you need to travel to make that gain
- For example, if you were to travel directly between the two red dots and not follow the trail, you would gain approximately 200 feet of elevation over 328 feet
  - The contour indexes are 200 feet apart, the distance between the UTM lines is 100 meters, or 328 feet
- $\frac{200\ feet\ gain}{328\ feet\ traveled}$ = 31°
  - There's a little bit of trigonometry involved with this calculation, don't worry about it, you won't need it for basic training



- Lets compare that to flatter terrain
- If you follow the trail between the red dots, you gain 80 feet in approximately 328 feet
- This slope is approximately 14°



- Finally, lets look at steeper terrain
- Here we go from elevation 4080’ to 4980’ (900 feet) in approximately 463 feet
  - Distance was calculated using trigonometry again, don’t worry, you won’t be using this method for basic training
- The angle of this terrain is approximately 63°

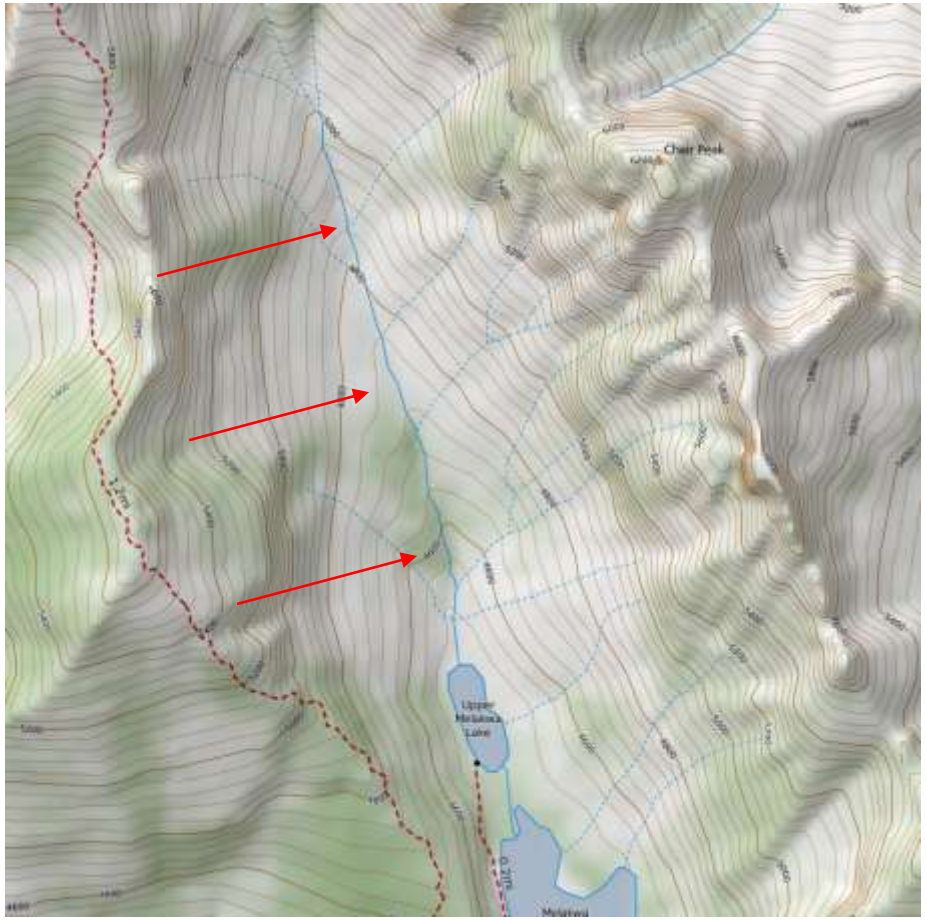


Terrain Types

- Some types of terrain you can see from a map

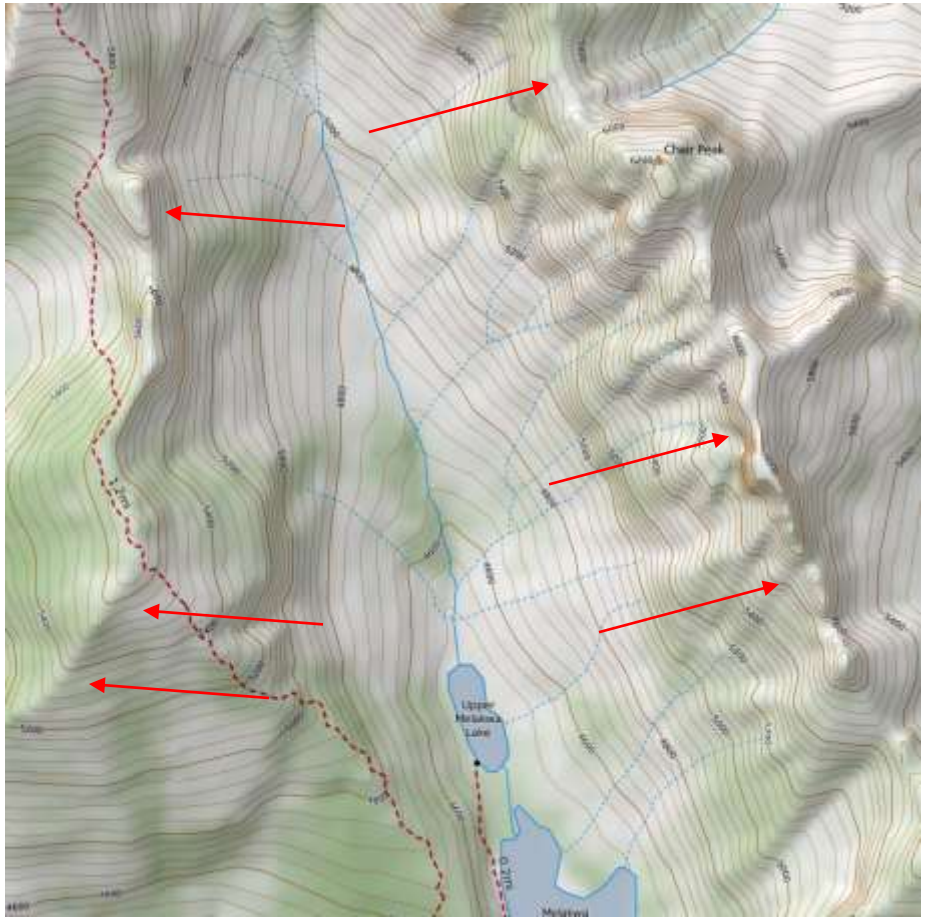
Valley

- Valleys are low areas between hills or ridges. They are longer than they are wide
- Great locations for water to travel
- Remember, water goes from areas of high elevation to low elevation



Ridge

- Ridges are chains of mountains or hills that form a continuous, elevated crest for some distance

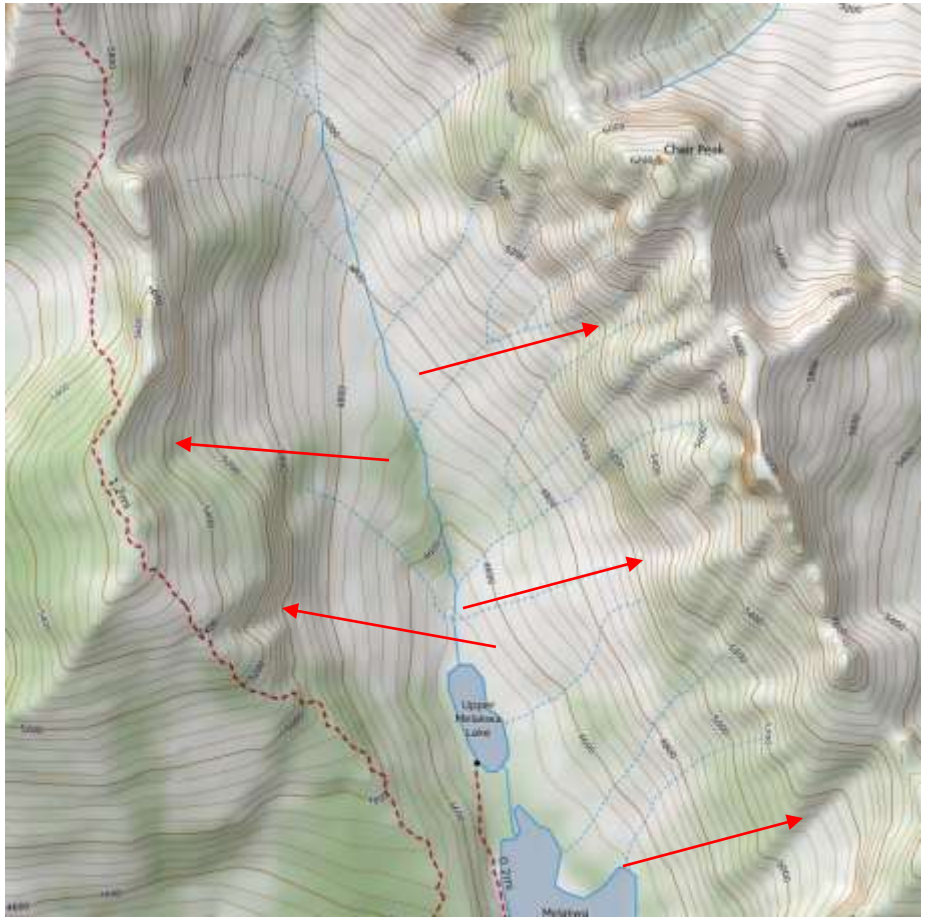


Peak or Summit

- A peak or summit is a point that is higher in elevation that all points immediately adjacent to it.

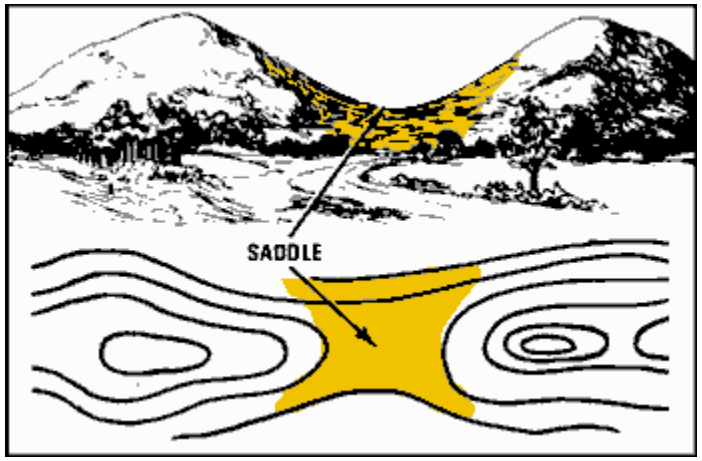
Gully

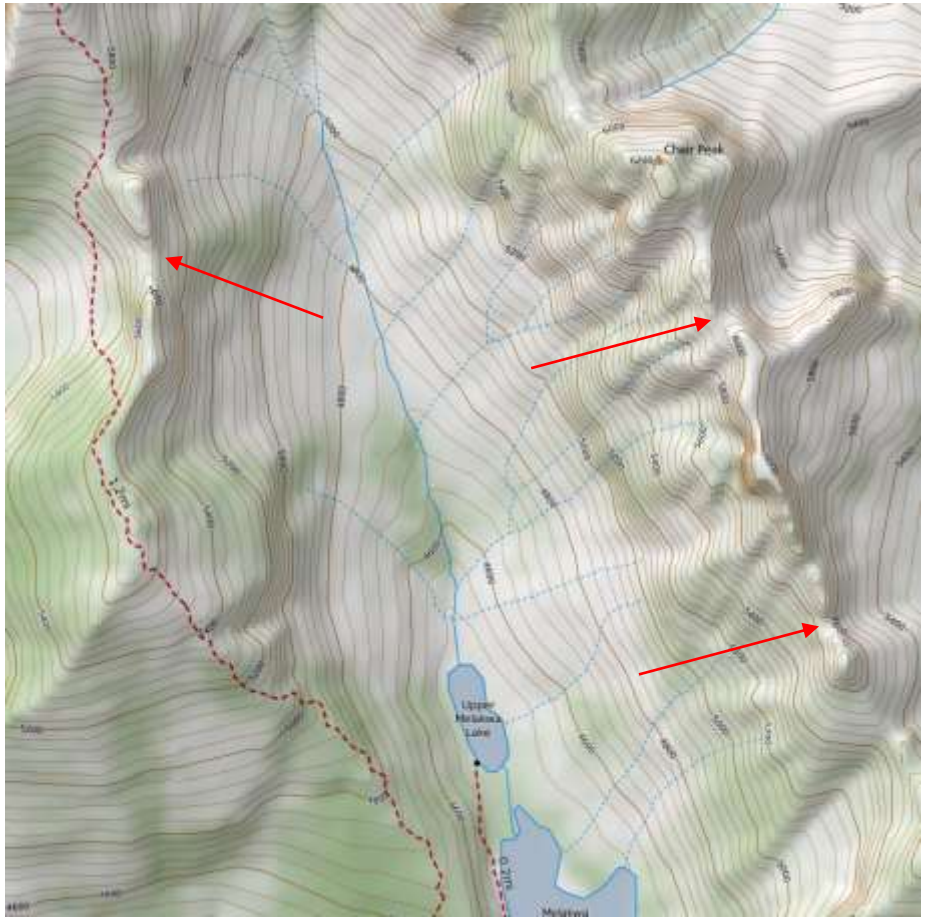
- Gullies, or draws, are small valleys formed by running water
- These can be a few feet deep or hundreds of feet deep



Saddle

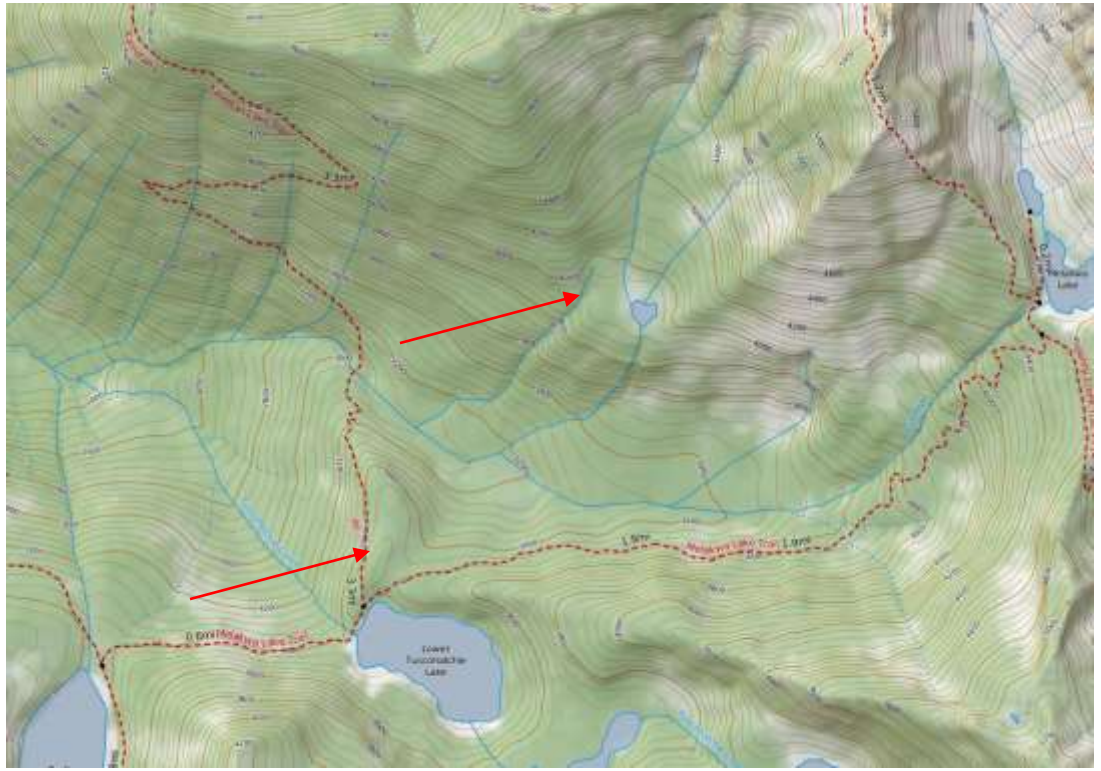
- Saddles, also known as passes, notches, or cols, are the lowest point between two area of high elevation





Plateau

- Plateaus usually consist of relatively flat terrain raised above the surrounding areas with one or more sides of steep slopes



Cirque

- A cirques, or bowls, are generally areas where a low area is surrounded on three sides by higher areas
- These can be found at the end of valleys

Homework Notes

- The homework can take a while to complete; anywhere from 1 to 10 hours. I highly suggest not waiting until Friday night to do your homework
- You can find a legend for the Green Trails map here: https://greentrailsmaps.com/navigation/maplegend
- The map is a subsection of the Green Trails 207S map. You DO NOT have to purchase this map. If you already have one, great, feel free to use it; if not, you can still complete the homework assignment
- For help, feel free to email me at courseb@kcesar.org. I'll generally try to respond within 24 hours. That being said, I will not be available Friday and Saturday before Course B. See the first bullet =)

Additional Resources

- The following are additional resources to navigate. None of them are quite like ESAR training, but they can make good practice for both mapping or field navigation
- KCSARA Navigation
  - http://academy.kcsara.org/Navigation password is “KingCountySAR” (case sensitive).
  - The KCSARA navigation training is different because they use different tools for determining location. Feel free to watch the videos, however, do not purchase the tools. They will not help you in Basic Training
- Mountaineers Navigation
  - https://www.mountaineers.org/learn/course-overviews/navigation
- Orienteering/Geocaching
  - http://cascadeoc.org/
  - https://www.geocaching.com/play