Chapter 6
Navigation and Field Mapping

In this chapter you will learn about:

- *Orienting maps*
- *Measuring a bearing on a map*
- *Plotting points on a map using latitude/longitude*
- *Plotting points on a map using UTM*
- *Estimating your own position location*
- *Estimating unknown position locations*
- *Estimating distance on the ground*
- *Field mapping*
- *Taking notes*

Navigation and field mapping skills will help you know where you are, where you are going, how you are going to get there, how long it will take, and when you will get back. Even in rough terrain and poor visibility these skills can help you get to your destination by choosing the best route with the least resistance. Always have a compass and map when navigating, do not rely only on a GPS receiver. Field mapping is also important because operational decisions are made based on the information on the field maps.

This chapter builds on what you learned in all the other chapters. It starts with how to orient a map. Then it outlines the steps on how to measure a bearing on a map, plot points using latitude/longitude and UTM coordinates, estimate your own position location, and estimate unknown position locations. Next it discusses the different methods for estimating distance on the ground, such as pacing. Finally, it addresses field mapping and note taking.

To complete the "Checking Your Understanding" section in this chapter you will need the following tools:

- Compass
- Protractor
- Engineer's 20 scale ruler
- UTM grid reader

Appendix C, Tools and Resources, has a copy of a protractor, engineer's 20 scale ruler, and UTM grid reader that can be photocopied on a clear plastic sheet. After photocopying, check to make sure the scale has not changed.

The methods described in this chapter are based on geographic north (not magnetic north) being the point of reference. In other words, the compass is adjusted for declination not the map.

Orienting Maps

Orienting the map to true north is key to navigating successfully. Orienting a map also gives you a general idea of your own location on the map. This section describes two methods to orient a map: topographical orientation and compass orientation.

Orienting a Map with Topographical Features

Table 6-1 describes how to orient a map with topographic features and is illustrated in Figure 6-1.

Table 6-1. Steps to orient a map using topographical features.

Steps	Directions
1	Find your approximate location on the map.
2	Select two prominent topographical features or landmarks that are visible to you and shown on the map.
3	Turn the map until the features on the map are in proper relation to the actual features in the field. The map is now oriented.

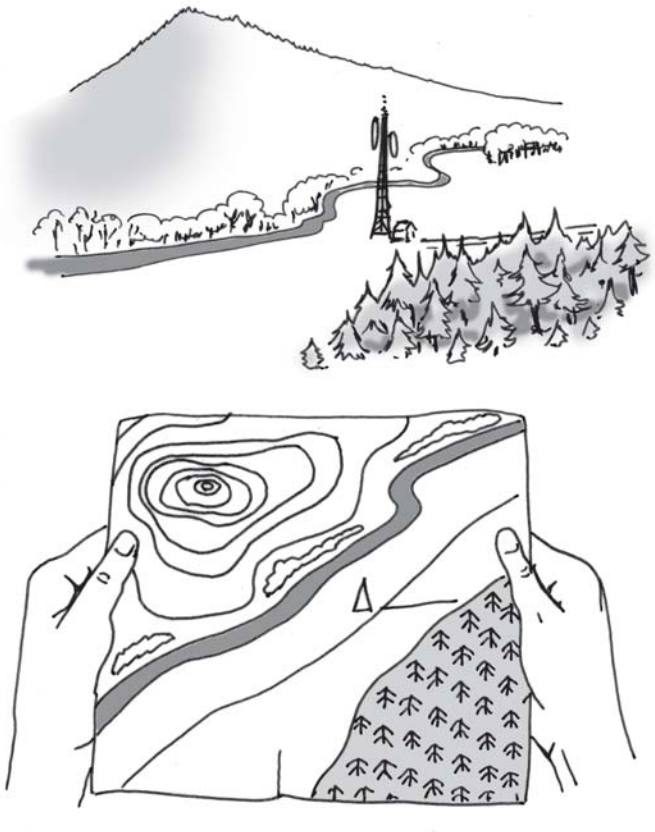


Figure 6-1. Orient a map using topographical features.

Orienting a Map with a Compass

If there are limited topographical features for orienting a map, then orient the map with a compass. However, adjust the compass for declination before using it with a map. One method for orienting a map with a compass is described in Table 6-2 and illustrated in Figure 6-2.

Table 6-2. Steps to orient a map using a compass.

Steps	Directions
1	Adjust compass for declination as appropriate. Make sure there is no local magnetic attraction.
2	Rotate the compass housing so north or 360º is at the index line or direction of travel line on the compass.
3	Place one side of the compass base plate along the right or left hand edge of the map. The direction-of-travel line must be toward the top of the map.
4	Carefully rotate the map and compass together until the needle is aligned with orienting arrow. The map and compass are now oriented.

Figure 6-2. Orienting a map with compass.

Measuring a Bearing on a Map

The main reason for measuring a bearing on a map is to help with navigation, for example:

- You know where you are on the map and you want to go towards the Incident Command Post (ICP), which is on the map, but it is several miles away over hilly terrain.
- You know where you are on the map and you want to go to a higher elevation for a better view of a potential safety zone, but you can't get there directly because of a wetland.
- You know where you are on the map and you want to go to the lookout, but you can't see it because of morning fog.

A protractor or compass can be used to measure a map bearing; a protractor is easier to use and more accurate than a compass. There are different types of protractors, but a common one is made out of flat clear plastic and is in the shape of a semi-circle with degree marks.

Using a Protractor to Measure a Bearing on a Map

Table 6-3 describes one method of how to measure a bearing using a protractor and is illustrated in Figure 6-3.

Table 6-3. Steps to measure a bearing on a map using a protractor.

Steps	Directions
1	Center the protractor over the starting point and orient 0º with true north (the 0º line needs to be parallel to edge of map).
2	Draw a line on the map from the starting point towards the destination. If you don't want to draw a line on your map align a string or ruler with the start point and destination point.
3	Read the bearing where the line, string or ruler intersects the protractor. This is the direction of travel to your destination.
4	Before using this bearing in the field, adjust the compass for declination.

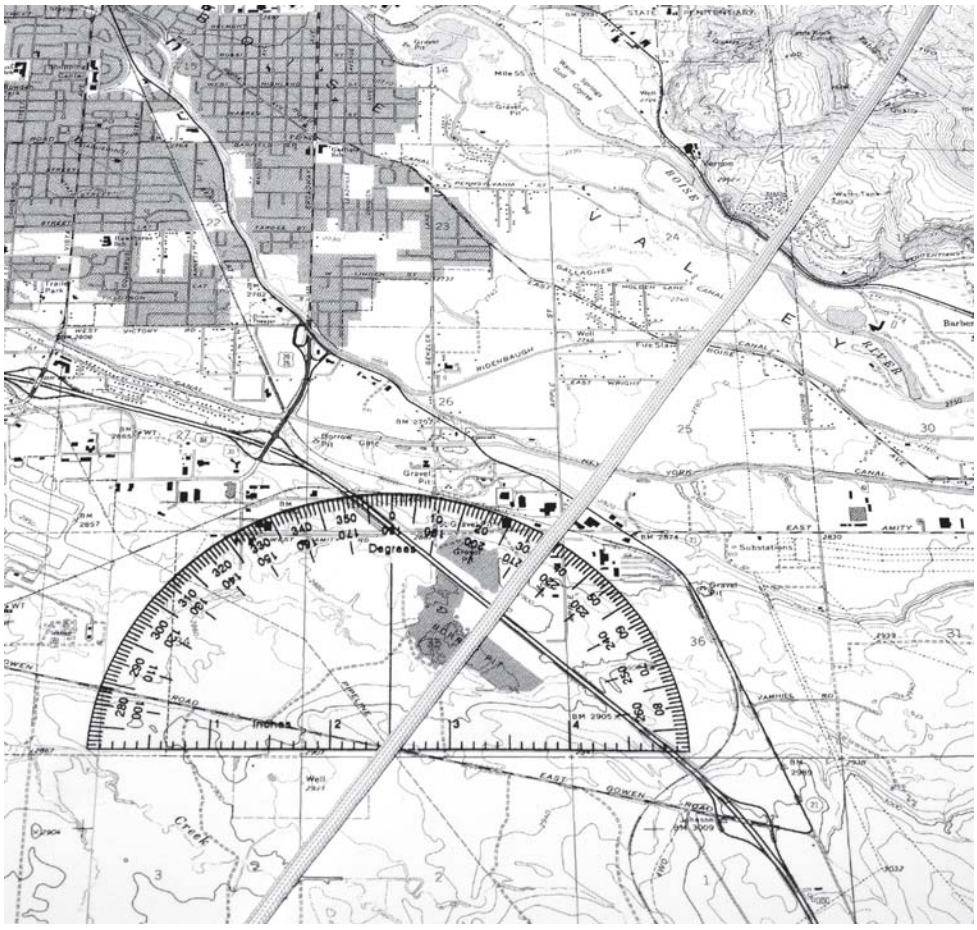


Figure 6-3. Measuring a bearing with a protractor.

Using a Compass to Measure a Bearing on a Map

A compass can also be used to measure a bearing on a map. One way to measure a magnetic bearing is described in Table 6-4 and illustrated in Figure 6-4. Table 6-5 describes one way to measure a true bearing.

Table 6-4. Steps to measuring a magnetic bearing on a map using a compass.

Steps	Directions
1	Adjust compass for map declination. Disregard the magnetic needle.
2	Place the compass on the map, where one edge of the base plate touches both the start point and destination point. The direction of travel arrow needs to point towards the direction of the destination.
3	Turn the compass housing so that the orienting arrow points to true north, parallel to map edge and longitude lines.
4	Read bearing at the index line. This is the direction in degrees of the magnetic bearing.

Figure 6-4. Measuring a bearing with a compass where the edge of the base plate touches both the start point (unimproved road) and destination point (lake that is east of spillway elevation 3008 point).

Table 6-5. Steps to measuring a true bearing on a map using a compass.

Steps	Directions
1	Set compass at 0º declination. Disregard the magnetic needle.
2	Place the compass on the map, where one edge of the base plate touches both the start point and destination point. The direction of travel arrow needs to point towards the direction of the destination.
3	Turn the compass housing so that the orienting arrow points to true north, parallel to map edge and longitude lines.
4	Read the true bearing at the index line.

Plotting Points on a Map using Latitude/Longitude

There are many ways to plot points on a map using latitude/longitude; this section describes one method. The grid system of intersecting lines that is used in the latitude/longitude coordinate system makes it easier to plot a point. Once you know how to plot points you can use the same method to determine the coordinates of a point. Examples of when you may need to plot a point on a map or determine the coordinates of a point include:

- To map the location of a safety hazard that is near the fire perimeter.
- To communicate the location of a potential drop site or water source.
- To map the location of a hot spot.
- To assist with navigation.

When working with latitude/longitude coordinates, it is very important to clearly communicate (verbally or written) the coordinates to other incident personnel. It is extremely easy to say the wrong latitude or longitude.

The method described in this section is used only for points located in the northern hemisphere; if the point is in the southern hemisphere there is a different process.

Rulers

Two types of rulers, engineer's ruler and latitude/longitude ruler, are often used to measure latitude and longitude of a point or to plot coordinates. Graduation marks on the ruler may be in seconds, tenths of a minute, or other unit. With either type of ruler, latitude needs to be measured with the ruler oriented north and south; whereas for measuring longitude the ruler needs to be placed diagonally (since the distance between longitude lines is not constant).

- The **engineer's ruler** or scale needs to have 20 graduations per inch. The primary function of the engineer's ruler is to measure distance: 1 inch equals 2000 feet on a 1:24,000 scale topographic map. An engineer's ruler or scale, with 20 graduations per inch (Figure 6-5), can be used for measuring latitude/longitude on a 1:24,000 scale topographic map where each graduation is equal to 1 second.

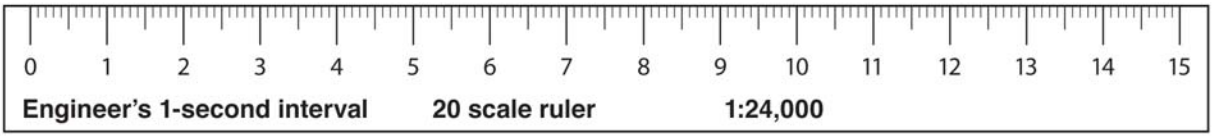


Figure 6-5. Engineer's 20 scale ruler (not to scale).

- The **latitude/longitude ruler** usually has minutes and seconds on one edge and decimal minutes on the other edge (Figure 6-6). These rulers are specifically made for different map scales and they come in different increments. Make sure the scale on the ruler matches the map scale.

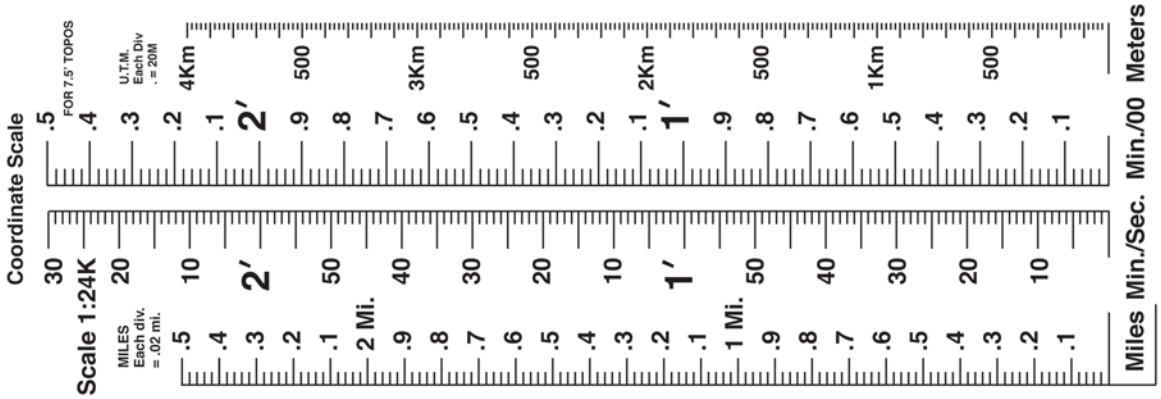


Figure 6-6. Latitude/longitude ruler (not to scale).

Plotting Latitude and Longitude

When plotting latitude/longitude, it may be helpful to draw the latitude/longitude lines on the map as illustrated in Figure 6-7. You can use these lines as a reference when plotting points.

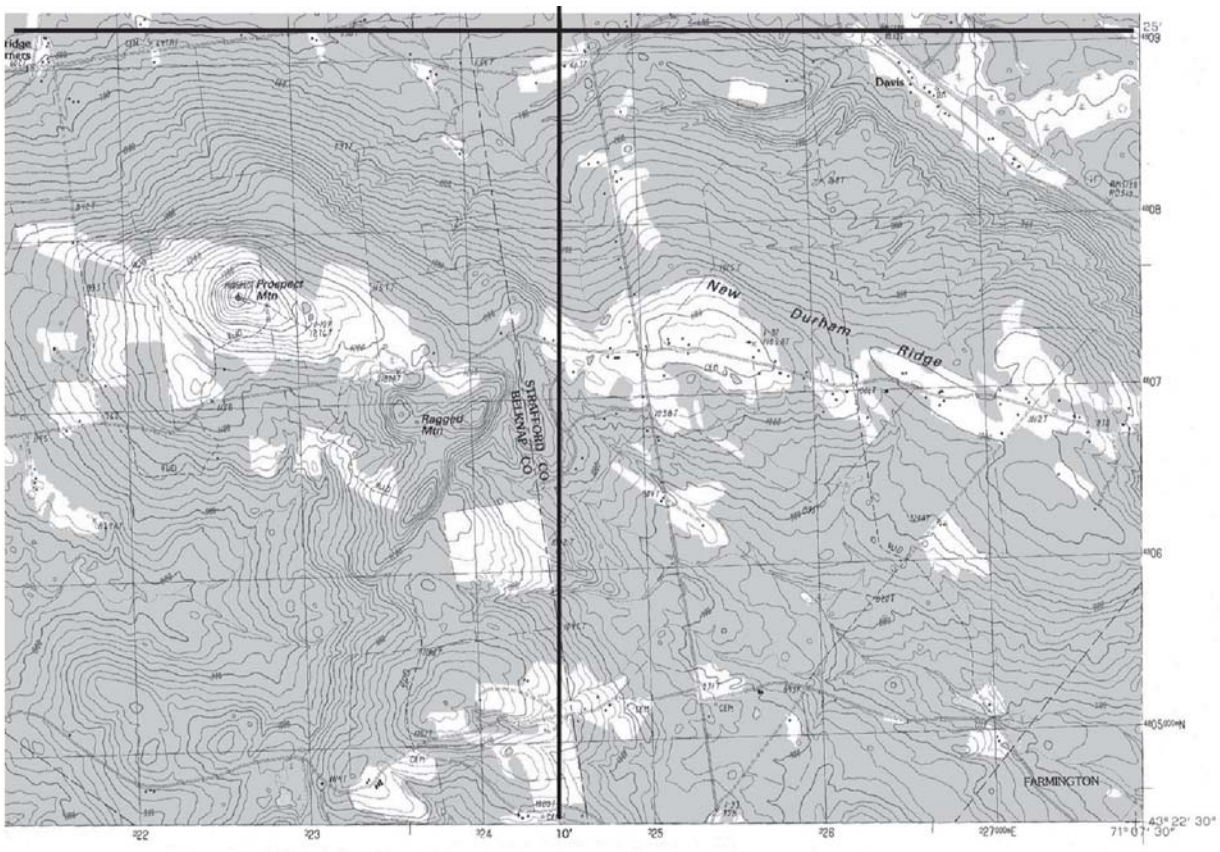


Figure 6-7. Draw the latitude/longitude lines on the map for reference when plotting points.

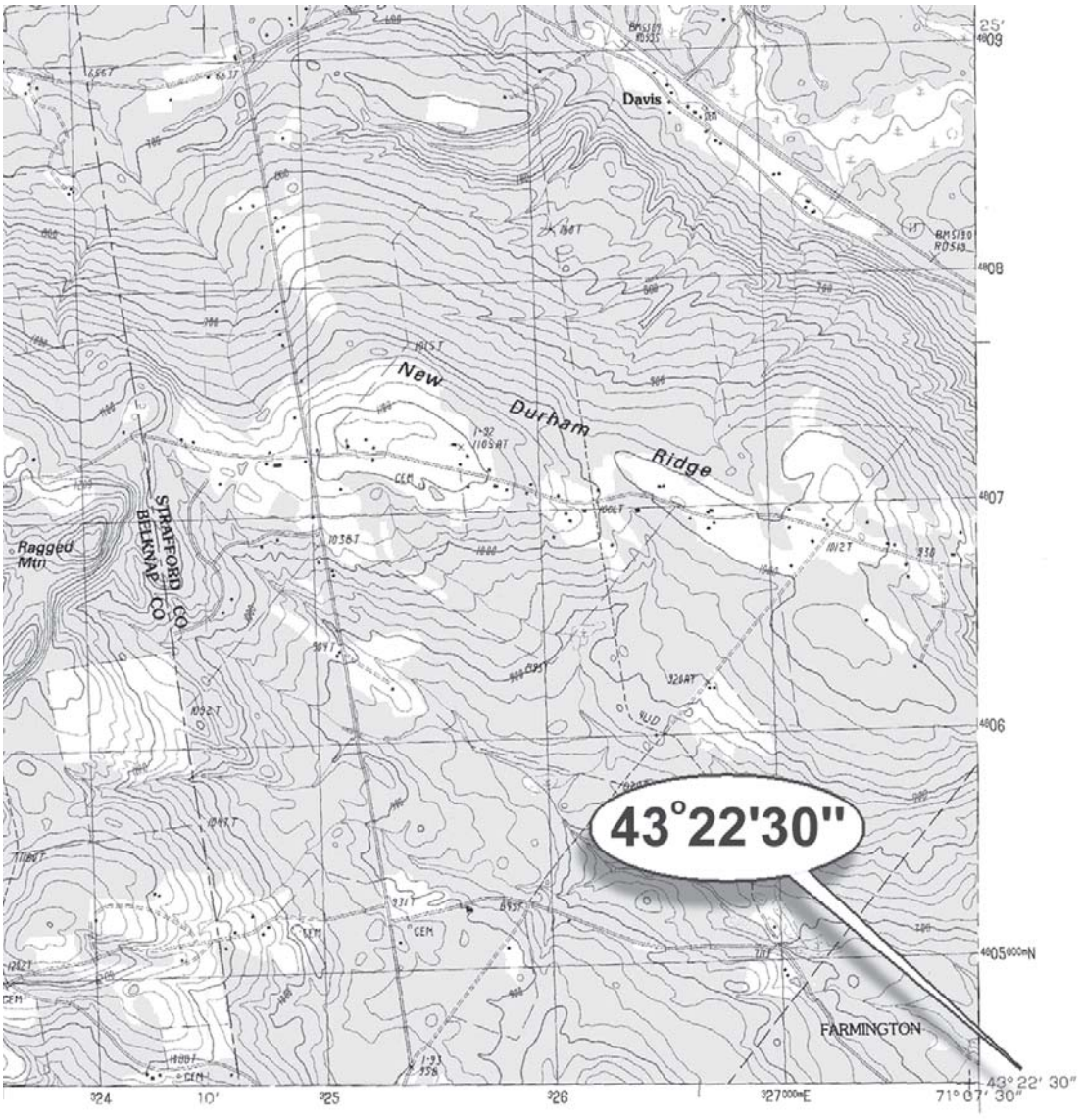
Tables 6-6 and 6-7 illustrate the steps for plotting the coordinate 43°-23'-45" latitude and 71º-08'-36" longitude. An engineer's ruler (each graduation equals one second) is used in the illustrations.

Table 6-6. Steps for plotting the latitude coordinate 43°-23'-45"

Step	Directions
1	On the map below, find the latitude lines that are identified with tick marks.

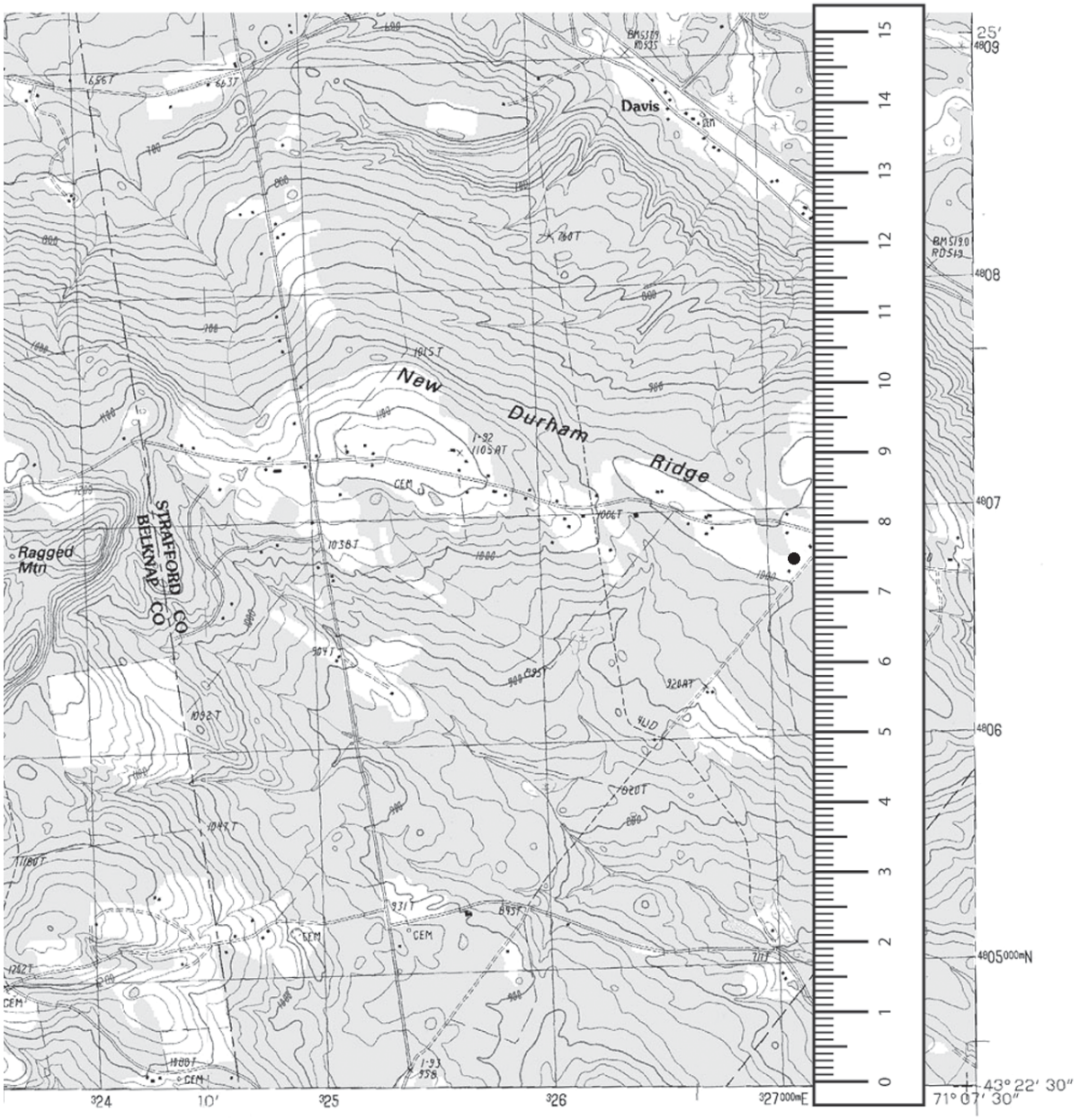
On this map there are two latitude lines identified with tick marks.

Step	Directions
2	Identify the first latitude line that is south of the given latitude coordinate. Determine how many minutes and/or seconds the southern latitude line is from the given latitude coordinate. To do this, subtract the southern latitude line coordinate from the given coordinate: 43° 23' 45" (given coordinate) – 43° 22' 30" (southern latitude line coordinate) 1' 15" or 75" (difference) The resulting number of minutes and/or seconds is referred to as the "difference" and will be used in step 3.



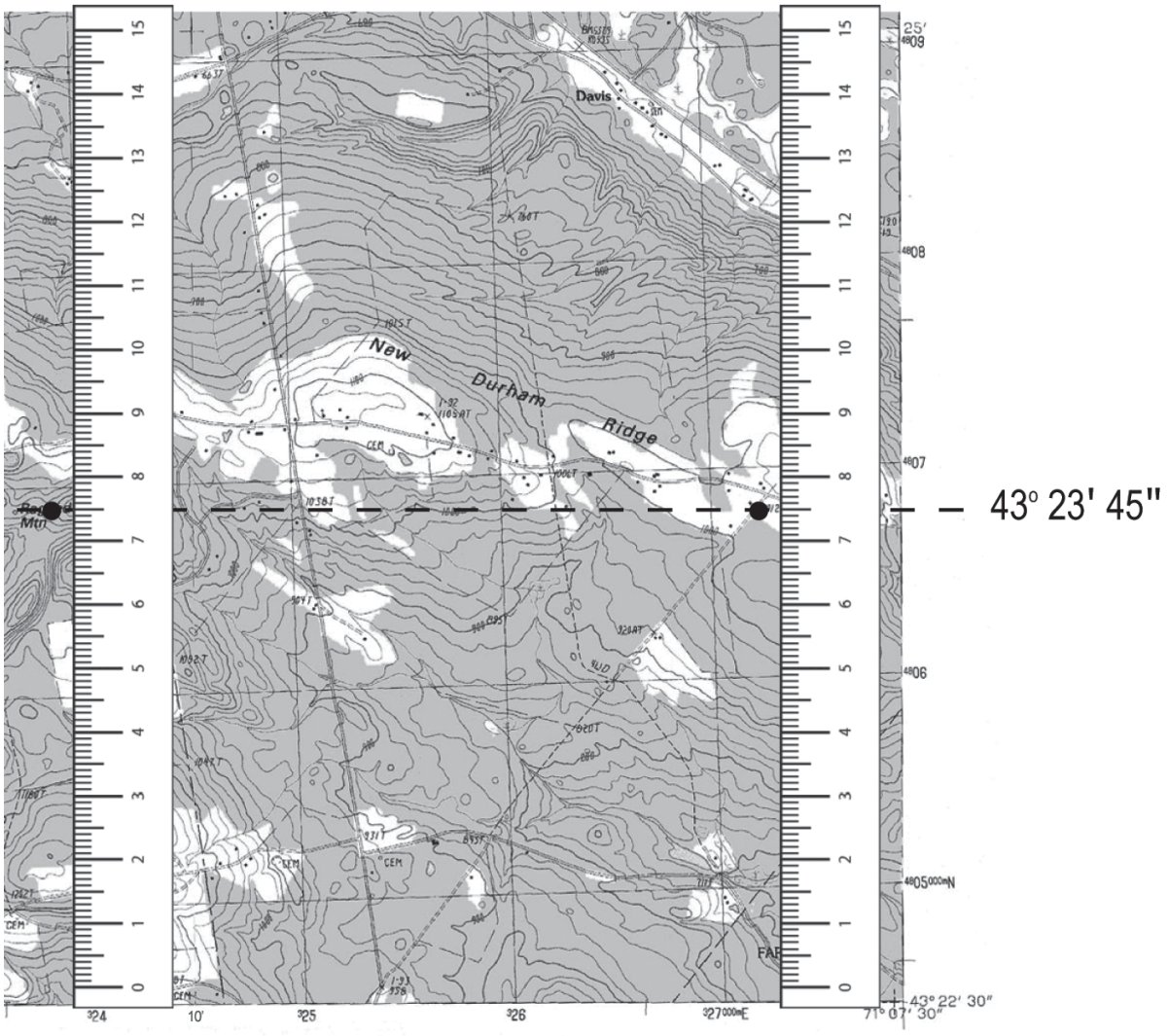
The first latitude line south of the given latitude coordinate is 43° 22' 30". It is 1'15" or 75" from the given coordinate.

Step	Directions
3	Verify that the scale on the ruler matches the map scale. When measuring latitude orient the ruler north to south. On the right side of the map, place the ruler with the "0" on the southern latitude line. Then, measure the "difference" (as determined in step 2) on the ruler and mark this point. Repeat this on the other side of the map.



Measure the difference (1'15" or 75") on the ruler and plot the point.

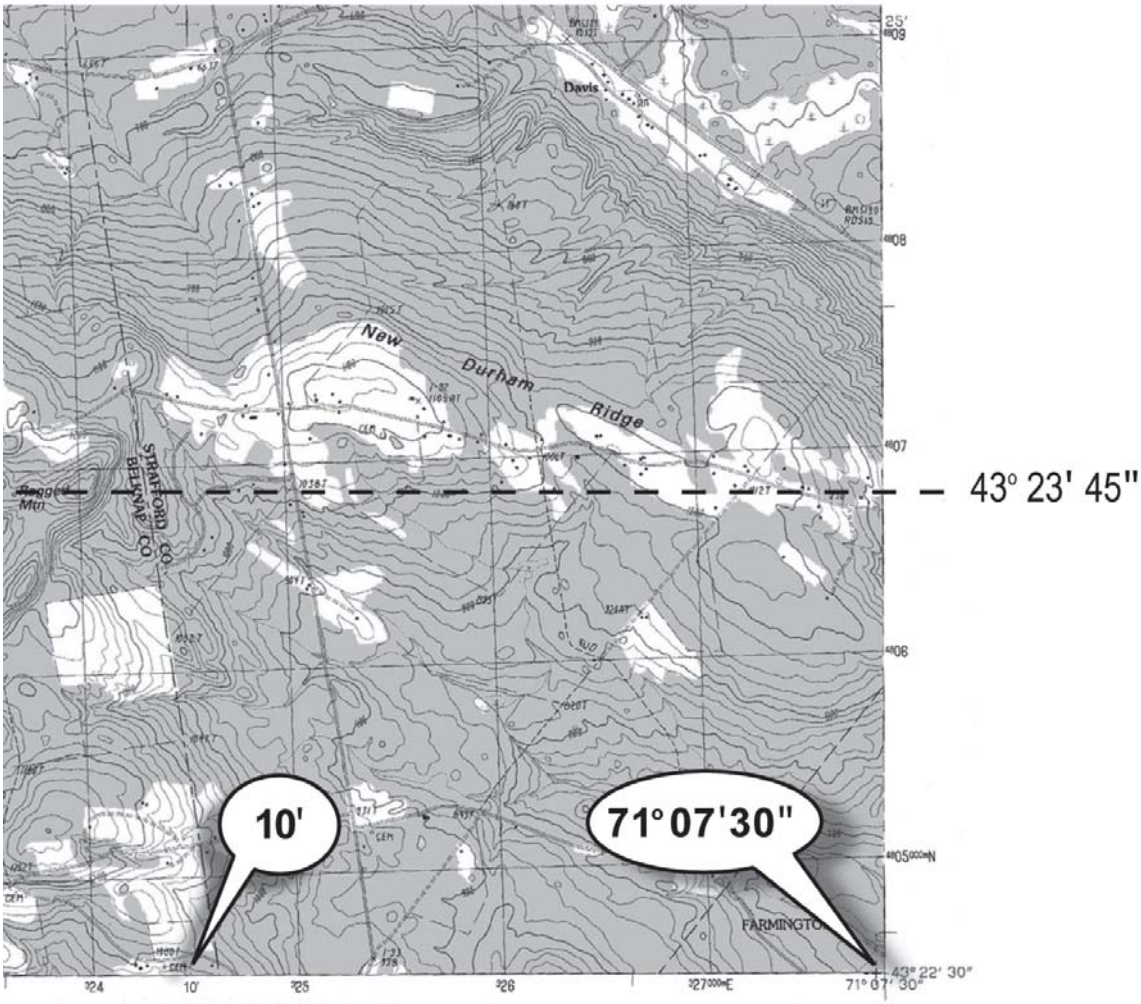
Step	Directions
4	Draw a line connecting the two points.



The latitude coordinate 43° 23' 45" is marked with the dashed line.

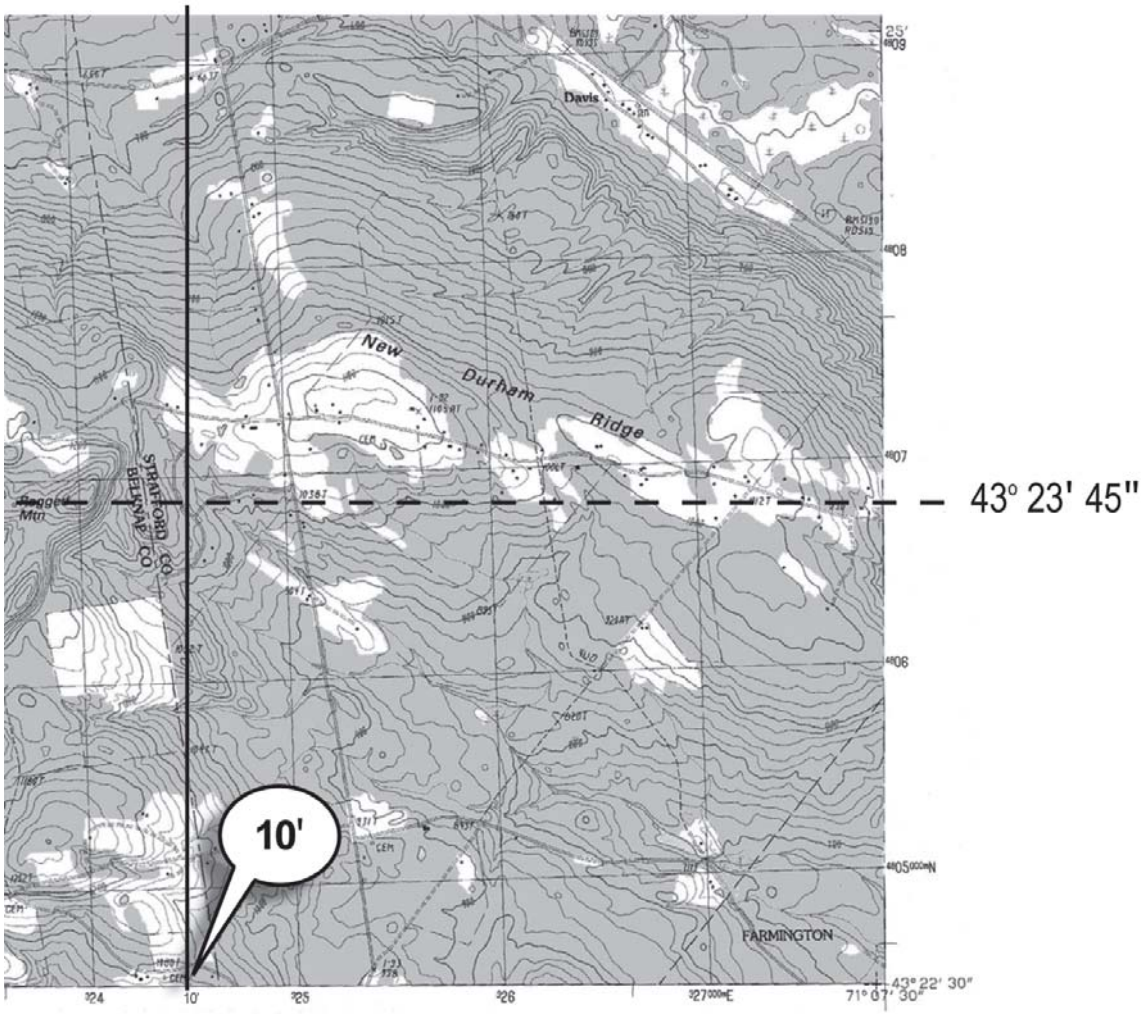
Table 6-7. Steps for plotting the longitude coordinate 71°-08'-36"

Step	Directions
1	On the bottom of the map, find the longitude lines that are identified with tick marks.



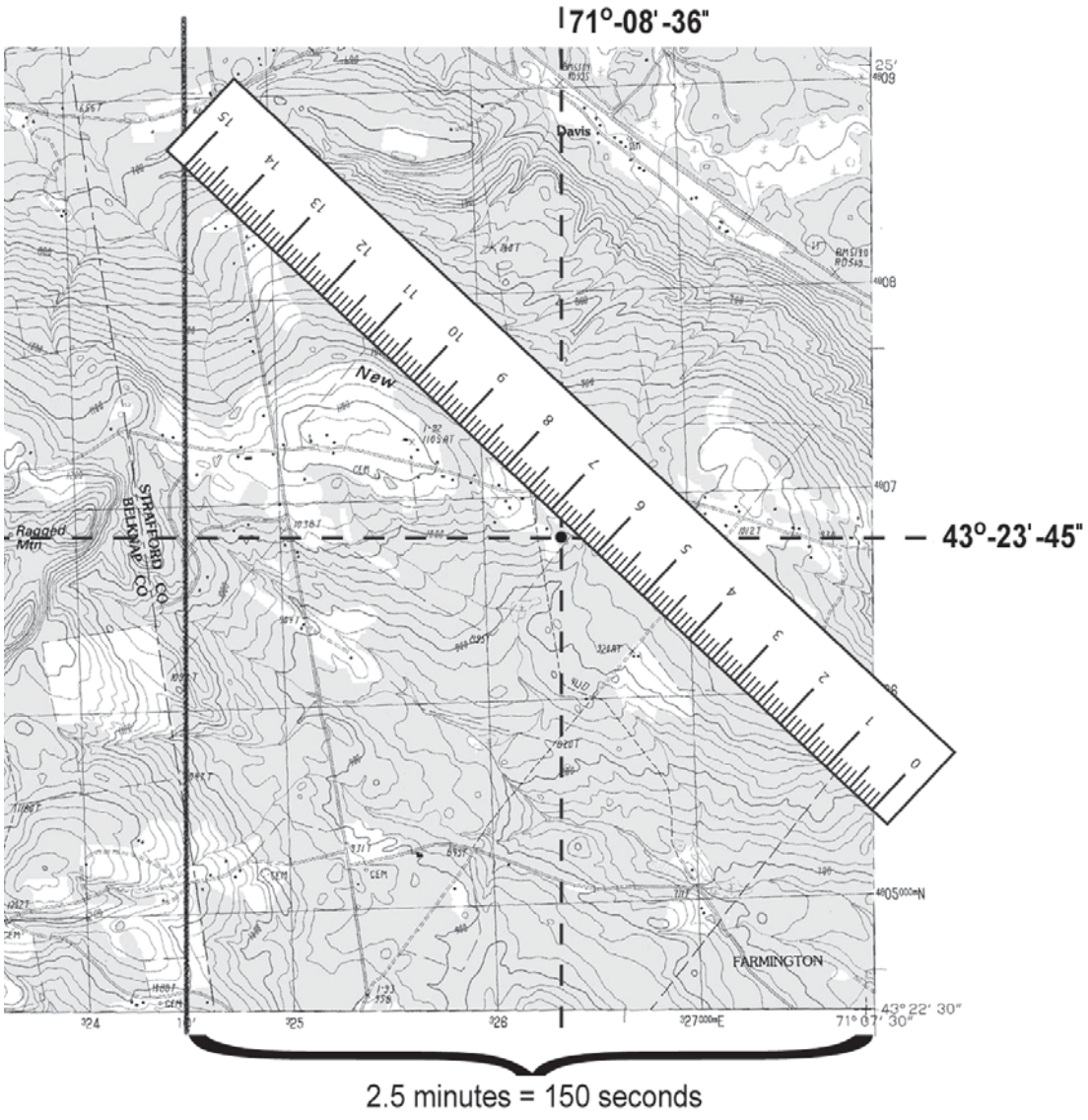
On this map there are two longitude lines identified with tick marks.

Step	Directions
2	Identify the first longitude line that is **east** of the given longitude coordinate and the first longitude line that is **west** of the given longitude coordinate. Draw these lines on the map because they will be used as a reference in step 3. Determine how many minutes and/or seconds the eastern longitude line is from the given longitude coordinate. To do this, subtract the eastern longitude line coordinate from the given coordinate: 71° 08' 36" (given coordinate) – 71° 07' 30" (eastern longitude line coordinate) 1' 6" or 66" (difference) The resulting number of minutes and/or seconds is referred to as the "difference" and will be used in step 3.



The first longitude line east of the given longitude coordinate is 71°-07'-30".
The first longitude line west of the given longitude coordinate is 71°-10'-00".

Steps	Directions
3	Verify that the scale on the ruler matches the map scale. When measuring longitude orient the ruler on a diagonal. Using the engineer's ruler, place the "0" on the eastern longitude line and place the "15" (150 seconds) on the western longitude line that is 2.5 minutes (150 seconds) from the eastern line. Slide the ruler vertically (keeping the "0" and the "15" graduation marks on their respective longitude line) until the "difference" (as measured on the ruler) lines up with the previously drawn latitude line. Mark this point – it represents the latitude and longitude coordinate.



The longitude coordinate 71º-08'-36" is 1' 6" or 66" from the eastern longitude line.
The point represents the coordinate: 43º-23'-45" 71º-08'-36"