

## Estimating Slope

Slope is used by the operations section in several different ways: to estimate the amount of time it takes to construct a fireline; to determine whether or not a dozer, engine, or hand crew can work in a specific area; to calculate pump pressure needed to reach a location; and to calculate fire behavior characteristics, such as rate of spread.

On incidents, slope is the degree of inclination or steepness and it is usually expressed in percent. A one percent slope indicates a rise or drop of one unit over a distance of 100 horizontal units. For example, a one percent slope rise would indicate a one foot rise over a 100 foot horizontal distance. Slope can be calculated using a topographic map or it can be determined in the field with a clinometer (see Chapter 4, Using a Compass and Clinometer).

To calculate slope using a topographic map, you will need to determine the following:

- Vertical Distance (also referred to as Rise) – This is the difference in elevation between two points; it is calculated by subtracting the elevation of one point from the elevation of the other point.
- Horizontal Distance (also referred to as Run) – This is the distance from one point to the other and is calculated by measuring distance with a ruler and applying the map scale. For example, if the map scale is 1:24,000 and the distance between the two points when measured with a ruler is ½ inch, the horizontal distance would be 12,000 inches or 1,000 feet.

Slope can then be calculated using the slope formula:

$$\frac{\text{Vertical Distance}}{\text{Horizontal Distance}} \times 100 = \% \text{ Slope}$$

Another way to write the slope formula is:

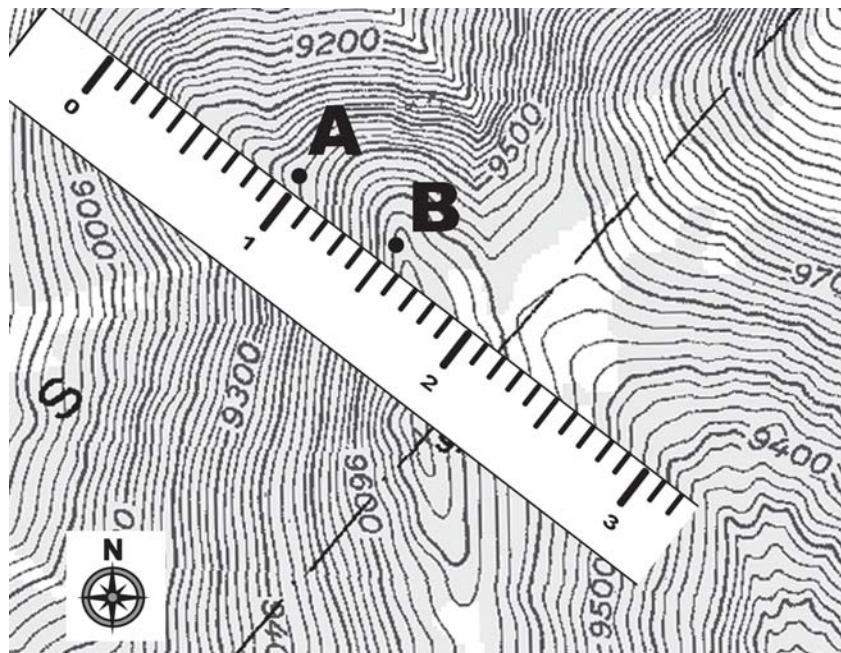
$$\frac{\text{Rise}}{\text{Run}} \times 100 = \% \text{ Slope}$$

There are a number of slope calculation aids in the form of tables that show the relationship between map scale and contour interval. Be careful when using slope calculation aids because they are tailored to specific map scales and contour intervals.

Follow the steps in Table 2-2 to estimate the percent of slope between the two points on the topographic map below.

**Table 2-2. Steps to estimate slope between two points.**

Steps	Directions
1	Determine the contour interval of the map (40 ft.).
2	Determine the elevation of point A (9480 ft.). Then determine the elevation of point B (9680 ft.).
3	Determine the vertical distance (or rise) between the two points by subtracting the elevation of point A from the elevation of point B (200 ft.).
4	Use a ruler to measure the horizontal distance (or run) between the two points ( $\frac{1}{2}$ inch). Use the map scale (1:24,000) to convert the $\frac{1}{2}$ inch into feet (1000 ft.).
5	<p>Compute the percentage of the slope using the slope formula:</p> $200 \text{ ft.} \div 1000 \text{ ft.} = .20$ <p>Slope is 20%</p>

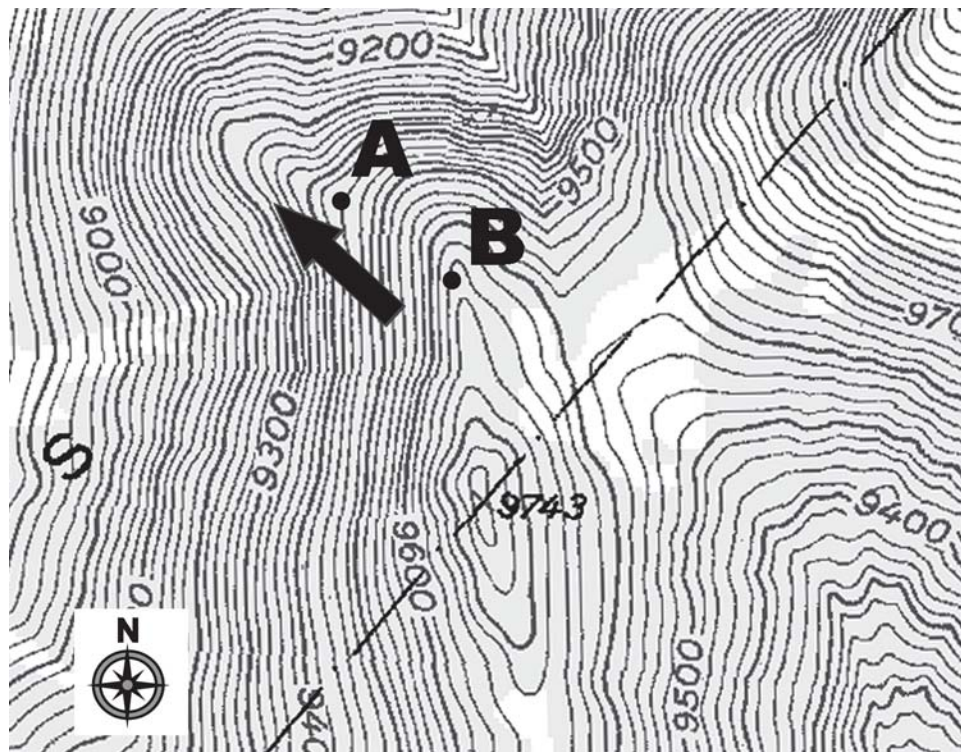


## Estimating Aspect

Aspect is the compass direction that the slope is facing. On a topographic map, use index contour lines (they will tell you the difference in elevation) and the north arrow to determine which direction the slope is facing. Follow the steps in Table 2-3 to estimate aspect of the slope between the two points on the topographic map below.

**Table 2-3. Steps to estimate aspect**

Steps	Directions
1	Determine the elevation of point A (9480 ft.) and point B (9680 ft.).
2	Since point B is a higher elevation than point A, the terrain is sloping from point B down to point A.
3	Use the north arrow on the map to determine which direction the slope is facing, which is northwest. The aspect is northwest.



## Estimating Acreage

Area can be expressed in square miles, acres, blocks, square feet, or any other square unit of linear measurement. This section discusses different methods for estimating acreage (area formula, dot grid, planimeter, comparison, and GPS receiver). Refer to the Fireline Handbook (PMS 410-1), Appendix A for additional information on estimating acreage.

### Area Formula

The most common method for calculating area is using the formula: length x width = area.

Area is always calculated in square measure, and the answer will be in square units (square feet, square yards, square chains). When calculating area, typical units of measurements include:

- Linear units of measurement

12 inches	=	1 foot
3 feet	=	1 yard
5280 feet	=	1 mile
66 feet	=	1 chain
80 chains	=	1 mile
3.2808 feet	=	1 meter

- Area units of measurement

1 acre	=	208 feet x 208 feet
1 acre	=	43,560 square feet
1 acre	=	10 square chains
640 acres	=	1 square mile
1 section	=	1 square mile*
1/2 section	=	320 acres*
1/4 section	=	160 acres*
1 hectare	=	2.4 acres

\*Generally the size, but may vary due to surveying deviations.

Following are three examples of how to estimate acreage using the area formula:

1. What is the acreage if the length is 2,640 feet and width is 1,320 feet? Remember that 43,560 square feet equals one acre.

**Table 2-4. Estimate acreage using feet.**

Steps	Directions
1	Multiply the length by the width to get the area: $2640 \text{ ft.} \times 1320 \text{ ft.} = 3,484,800 \text{ sq. ft.}$
2	Convert the 3,484,800 sq. ft. to acres: $3,484,800 \text{ sq. ft.} \times \frac{1 \text{ acre}}{43,560 \text{ sq. ft.}} = 80 \text{ acres}$

2. What is the acreage if the length is 5 chains and width is 10 chains? Remember that 10 square chains equals one acre.

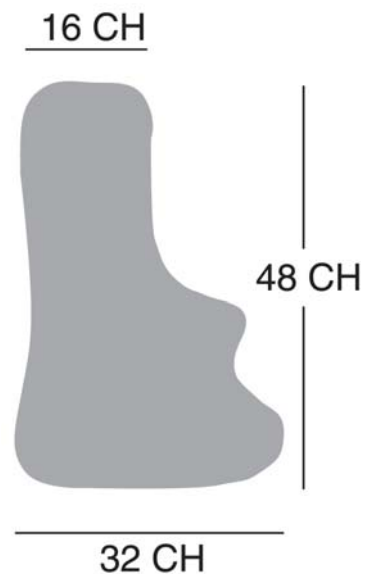
**Table 2-5. Estimate acreage using chains.**

Steps	Directions
1	Multiply the length by the width to get the area: $5 \text{ chains} \times 10 \text{ chains} = 50 \text{ square chains}$
2	Convert the 50 square chains to acres: $50 \text{ square chains} \times \frac{1 \text{ acre}}{10 \text{ chains}} = 5 \text{ acres}$

3. What is the acreage for an odd shaped area that is 32 chains wide at one end, 16 chains wide at the other end, and 48 chains in length?

**Table 2-6. Estimate acreage for an odd shaped area.**

Steps	Directions
1	Multiply the length by the width to get the area: $48 \text{ chains} \times \frac{16 + 32}{2} \text{ chains} = 1152 \text{ square chains}$ <p>Note: To estimate the acreage for an odd shaped area, it is often necessary to take two or more measurements across the area and obtain an <u>average</u> length and width. The <u>average</u> width is obtained by adding the two different widths (16 + 32) and dividing by 2.</p>
2	Convert the 1152 square chains to acres: $1152 \text{ square chains} \times \frac{1 \text{ acre}}{10 \text{ chains}} = 115.2 \text{ acres}$







If a dot grid has no scale or you are working with a map where the scale is questionable, it will be necessary to calibrate the dot grid – which means you need to determine how many acres each dot represents. Table 2-7 describes how to calibrate a dot grid.

**Table 2-7. Steps for calibrating a dot grid.**

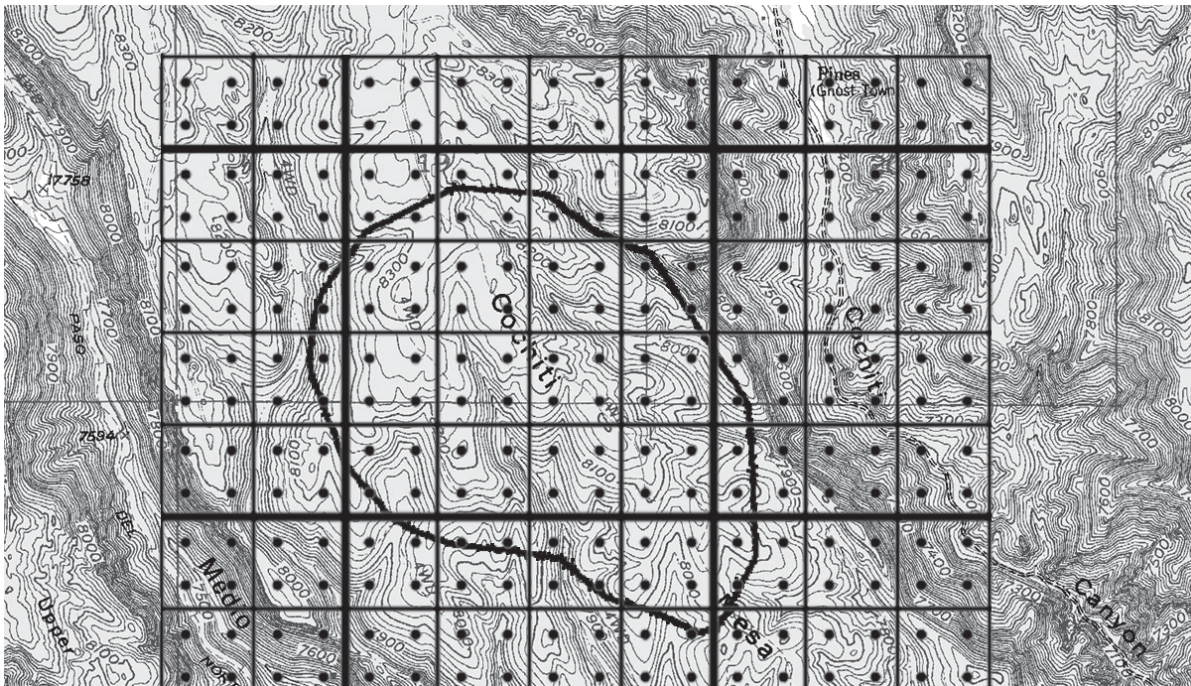
Steps	Directions
1	<p><b>Determine map scale.</b></p> <p>For this example, we will use a map scale of 1:24000 (1 inch = 2,000 feet).</p>
2	<p><b>Calculate acres per square inch.</b></p> <p>This will often involve using the conversion: 1 acre = 43,560 square feet.</p> <p>Example:</p> <p>1 inch = 2,000 feet</p> <p>2,000 ft. x 2,000 ft. = 4,000,000 sq. ft.</p> $4,000,000 \text{ sq. ft.} \times \frac{1 \text{ acre}}{43,560 \text{ sq. ft.}} = 91.8 \text{ acres per sq. inch}$
3	<p><b>Determine acres per dot.</b></p> <p>First determine the number of dots per square inch that are on the dot grid. For this example, there are 64 dots per square inch.</p> $\frac{91.8 \text{ acres}}{\text{sq. in.}} \times \frac{\text{sq. in.}}{64 \text{ (dots)}} = 1.434 \text{ acres per dot}$



Table 2-8 describes how to use a dot grid to estimate the acreage of the fire illustrated below.

**Table 2-8. Steps for estimating acreage using a dot grid.**

Steps	Directions
1	Place the dot grid over the incident perimeter; the position of the dot grid isn't important.
2	Count all the dots that fall completely within the incident perimeter. Record the number.
3	Count every other dot that falls on the boundary of the incident perimeter. Record the number.
4	Add dot counts from steps 2 and 3. This cumulative number of dots represents the total area being measured. Multiply the total count by the area represented by one dot to arrive at the area measurement. In the example below, each dot equals 1.434 acres. $63$ (approximate dot count) $\times$ $1.434$ acres (area represented by one dot) = $90.3$ acres



## Planimeter

A planimeter is a tool that can be used to measure acreage on a map (Figure 2-17). Use the planimeter to trace around the perimeter a number of times to obtain an average acreage.



Figure 2-17. Planimeter

## Comparison

Another way to estimate the size of an area is by comparing it to areas of a known size. For example, if the area is entirely within a single section then it can be safe to assume it isn't more than 640 acres; if it is the size of a football field the estimate would be one acre.

## Global Positioning System (GPS) Receiver

Several models of GPS receivers have the ability to calculate area (acreage).



## Estimating Distances

Refer to the map scale for measuring distances on the map. On 7.5 minute quad topographic maps the engineer's 20 scale ruler is a nice tool because 20 graduations on the ruler equals 1 inch which equals 2,000 feet.

To calculate distances you will need a map wheel (Figure 2-18), string, paper with tick marks, or other measuring tool. A map wheel has a toothed wheel and as it moves it measures distances on maps. Set the map wheel's scale to match the map's scale and then roll the wheel along the route to be measured. Table 2-9 describes the steps to estimate distances using a map wheel.

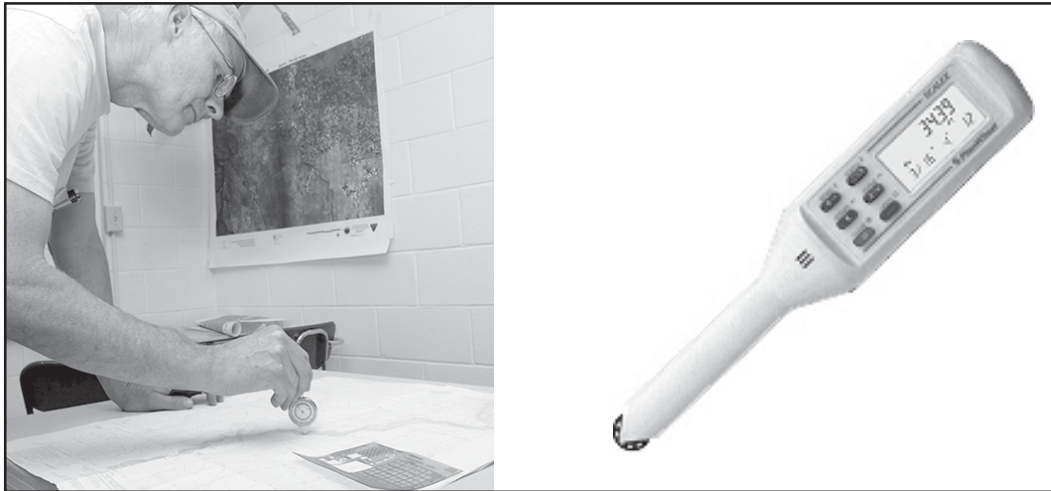


Figure 2-18. There are different types of map wheels.

Table 2-9. Steps for estimating distances using a map wheel.

Steps	Directions
1	Set map wheel to zero and calibrate using scale on the map.
2	Roll the map wheel along the distance to be estimated. Do this twice or more to get an average.

## Estimating Percent Contained

To estimate percent contained, use this formula:

$$\frac{\text{Completed line distance}}{\text{Perimeter distance}} \times 100 = \text{Percent contained}$$



# Checking Your Understanding

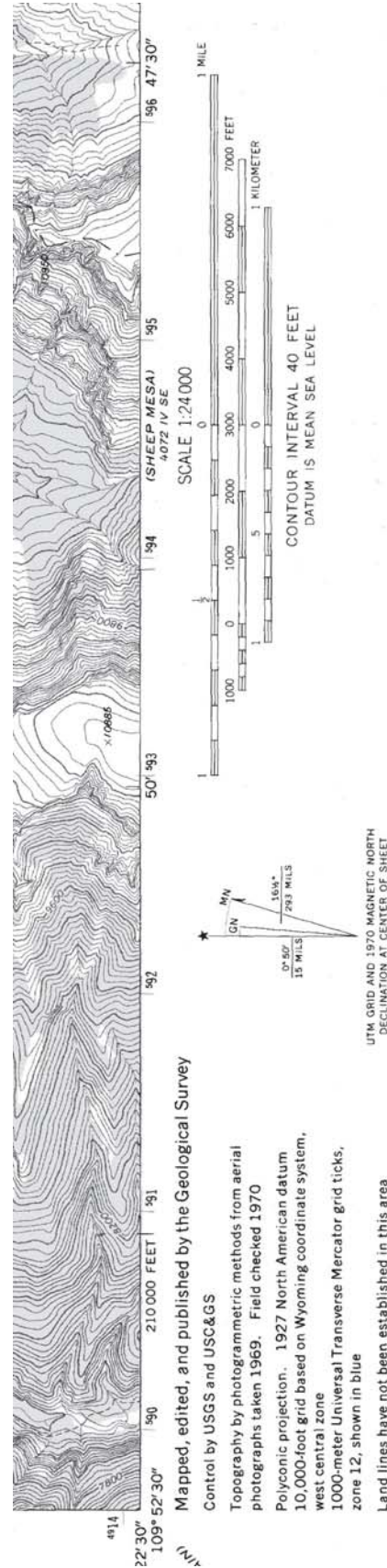
Answers to “Checking Your Understanding” can be found in Appendix B.

1. What is the fractional scale and declination of this map? If you are using a GPS receiver, what datum would you use?

Fractional scale: \_\_\_\_\_

Declination: \_\_\_\_\_

Datum: \_\_\_\_\_

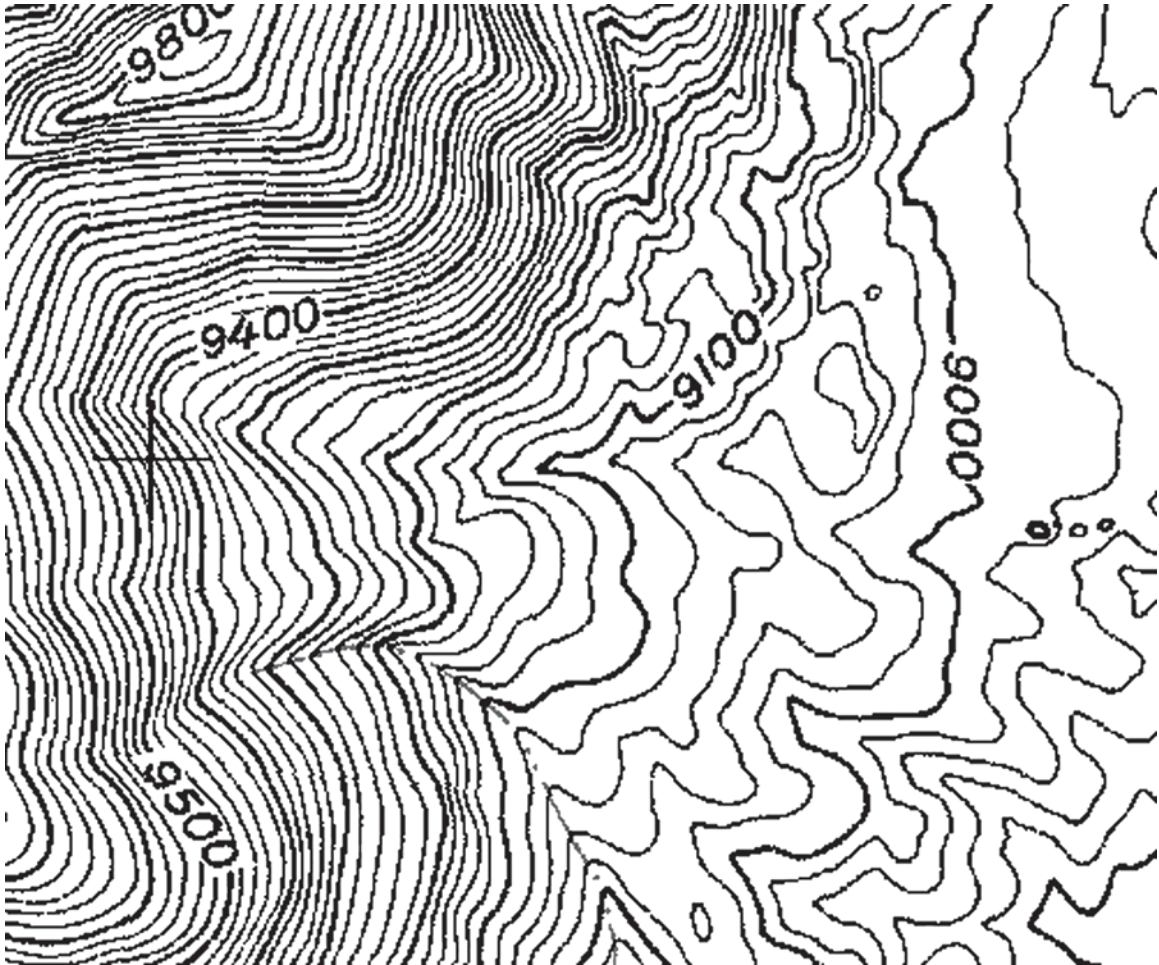


THIS MAP COMPLIES WITH NATIONAL MAP ACCURACY STANDARDS  
FOR SALE BY U. S. GEOLOGICAL SURVEY, DENVER, COLORADO 80225, OR RESTON, VIRGINIA 22092



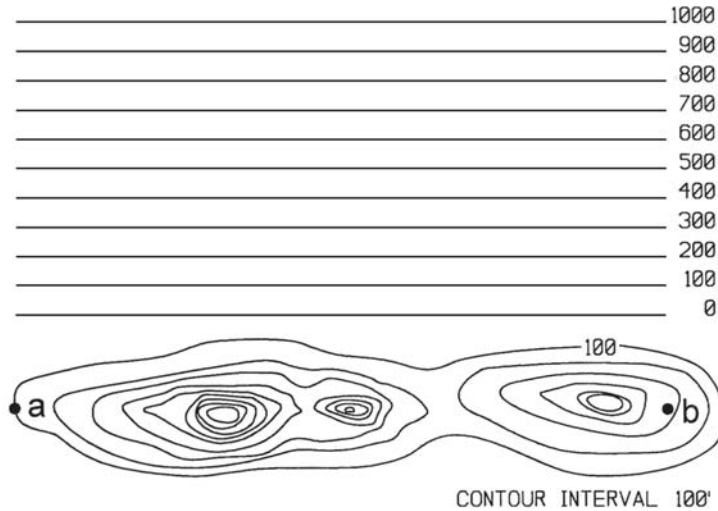


3. Calculate the contour interval for this map.



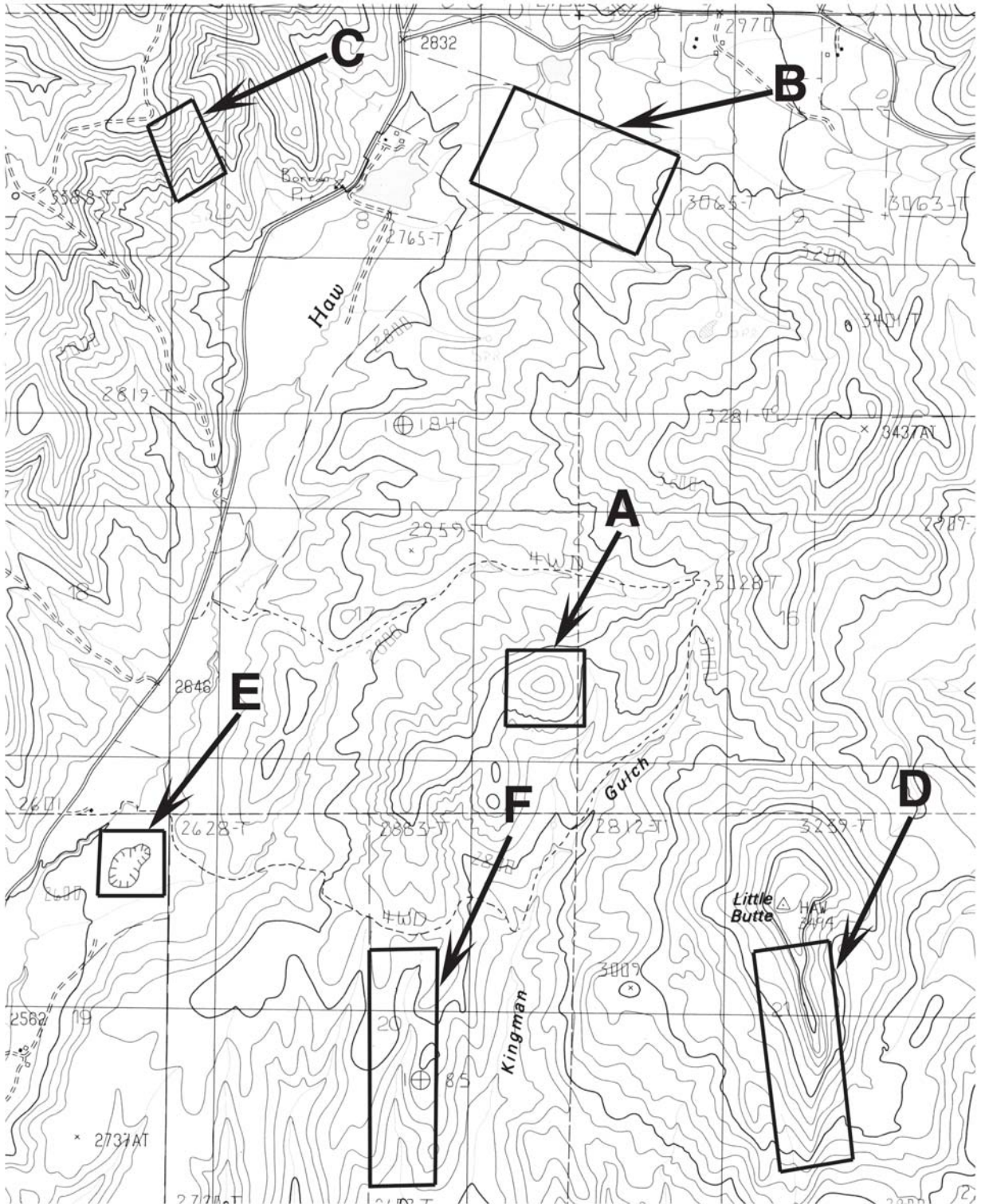
Contour interval: \_\_\_\_\_

4. Draw a profile (similar to a line graph) of the land from point “a” to point “b.” Elevation lines are marked in 100-foot increments. Hint: The elevation rises from the 100-foot contour line.



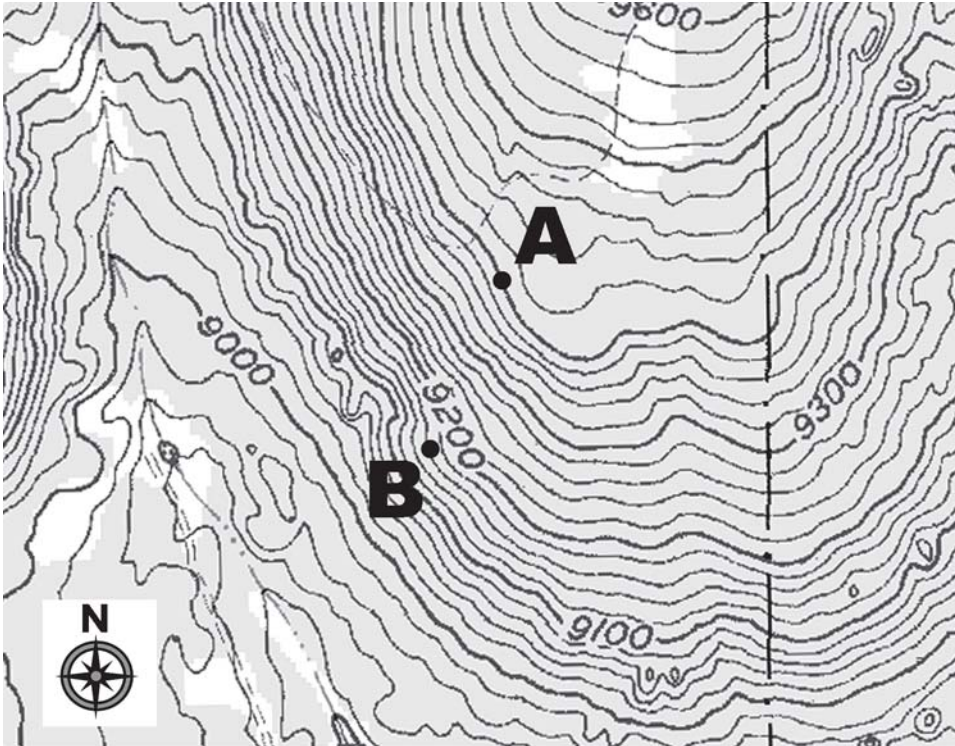
5. Use the map on the next page to identify the topographic feature inside the rectangles lettered A - F with one of these characteristics: stream, hilltop, steep terrain, ridge, depression, and flat terrain.

- A. \_\_\_\_\_
- B. \_\_\_\_\_
- C. \_\_\_\_\_
- D. \_\_\_\_\_
- E. \_\_\_\_\_
- F. \_\_\_\_\_





6. Estimate the percent slope between A and B. What is the aspect of the slope between A and B? The scale is 1:24,000 (1 inch = 2000 feet).



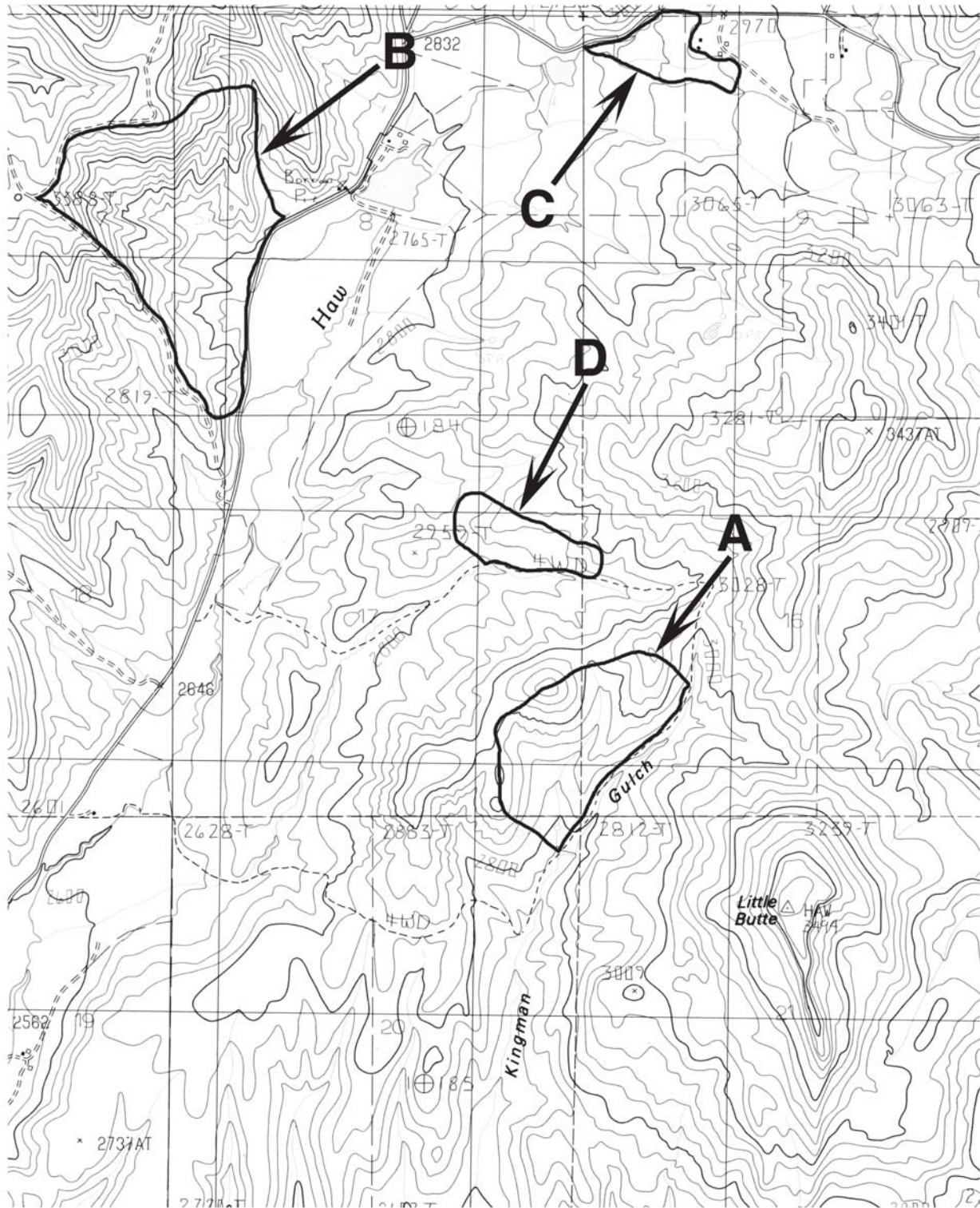
Slope: \_\_\_\_\_ Aspect: \_\_\_\_\_

7. Determine the equivalent unit of measurement for the following:

- A. 2.5 miles = \_\_\_\_\_ chains
- B. 1.5 chains = \_\_\_\_\_ yards
- C. 29,040 feet = \_\_\_\_\_ miles
- D. 3 chains x 20 chains = \_\_\_\_\_ acres
- E. 1/8 of a section = \_\_\_\_\_ acres

8. Use the map on the next page to estimate the acreage (in acres) within 10% accuracy (+ or -) of fires A - D.

- A. \_\_\_\_\_
- B. \_\_\_\_\_
- C. \_\_\_\_\_
- D. \_\_\_\_\_



**SCALE 1:24,000**



