

## **Intermediate Wildland Fire Behavior, S-290**

### **Pre-Course Work**

The pre-course work is designed to ensure that students come to class with a basic understanding of the fire environment in order to learn Intermediate Fire Behavior concepts.

The pre-course work is divided into seven parts that correspond to questions on the pre-qualifying test. Complete the pre-qualifying test using the information on the Student CD.

When you have completed the pre-qualifying test, mail it back to the course coordinator in the provided envelope. You must receive a passing score of 70% or higher to be considered for admittance to the course.

## **Part 1 – Basic Firefighter Math**

**Objective:** Define and apply the concept of ratios and percentages.

A **ratio** is a proportional relationship of one value to another such as the ratio of gas to oil in a chain saw fuel mix. Ratios can be written as a fraction ( $\frac{1}{2}$ ) or in ratio notation (1:2). The value of a ratio is the division of the first number by the second number.

Example: A chain saw manufacturer specifies that the proper fuel mix is 32:1, which means, one unit of 2-cycle oil is added to 32 units of gas.

Ever hear the phrase, “Do not exceed a two to one (2:1) work/rest ratio?” This means for every two hours worked, one hour of rest (or off-shift time) is provided.

If you work a 16 hour shift, how many hours of rest are you supposed to have?

**Answer:** 16 hrs worked, 24 hours available in a day.  
24 hours – 16 hrs = 8 hrs of rest time available.

Does this meet the 2:1 ratio?

By applying work hours to rest hours as a ratio:

16 hrs/8 hrs is the ratio, and by simplifying (dividing each by 8) we get 2/1 or 2:1, or 2x.

Note that 2x indicates a two-fold increase, or two times the original value. This makes it easier to visualize in the fire environment.

As part of a map scale, a representative fraction is also a ratio. Common 7.5 minute topography maps have a representative fraction of 1:24,000, which means every 1 unit of map distance is equal to (represents) 24,000 units of actual ground distance. Note that a common unit of measure when working with representative fractions is inches.

A **percent** compares things to one another, or the amount less than or greater than a common base of 100 (70 right answers out of 100 possible = 0.7 or 70%). We then relate this percentage to some threshold or relevant value to give meaning. For example, we know that a 10% slope is a slight incline, not terribly difficult to walk up. But a 70% slope is steep, requiring much more energy to climb. To determine a percent, you divide the ratio fraction and multiply by 100. What is the percentage if you score 37 correct answers out of a possible 48?

**Answer:  $37/48 = .771 \times 100 = 77\%$  (rounded).**

Slope is expressed as a percentage and determining slope percent is based on a ratio by applying this formula:  $\text{Slope\%} = \text{rise (in elevation)}/\text{run (horizontal distance)} \times 100$  between two points. **Note that run is always a flat map distance, not the incline distance you would walk from one point to another.**

Given a rise of 500 feet in elevation and a horizontal distance between two points of 1200 feet, we plug these numbers into the equation and can determine slope %.

**Answer:  $500 \text{ feet rise}/1200 \text{ feet run} = .416 \times 100 \sim 42\%$  (rounded).**

To test your understanding, answer the questions under Part 2 of the pre-qualifying test.

## **Part 2 - Maps**

Part 3 contains excerpts from the Map and Compass publication located on the Student CD.

### **Objectives:**

- Identify important elements found on a map legend.
- Identify features commonly found on topographic maps.
- Determine aspect from a topographic map.

A map is designed for the purpose of permitting you to visualize a portion of the earth's surface, drawn to a specified scale, with pertinent features properly positioned to facilitate planning and organizing operations. Maps, although drawn to a scale, are not absolutely accurate because they represent a curved and uneven surface on a flat piece of paper. Furthermore, photocopying, scanning, or other graphic reproductions can further skew a map. Care must be taken to ensure that the map you are using reflects true map distance to ground distance measurements.

### **There are three basic types of maps:**

#### **1. Planimetric Maps**

Planimetric maps show the positions of features without showing their relationship to the hills and valleys of the land. They can include rivers, lakes, roads, boundaries, or other human-made, symbolic features. For example:

##### **a. Common road maps**

Road atlas, street maps, and Thomas Guides.

##### **b. Specific area maps**

Preplan maps, floor plan maps, storm drain, sewer and water system maps.

##### **c. Schematic maps**

Agency maps (unit, aviation, resource, district response maps).

## 2. Topographic Maps

Topographic maps show both the horizontal and vertical (relief) positions of features. Topographic maps are often referred to as quadrangles or quads, for example:

### a. Contour maps

These are the most common method of representing the shape and elevation of the land. A contour is a line of equal elevation on the ground that delineates the same elevation above or below a specific reference elevation, usually sea level.

### b. Shaded-relief maps

These are pictorial. They are shaded to simulate sunlight on the terrain. This shadow effect accentuates the shape of the physical features.

For fire behavior purposes, we generally work with topographic maps.

## 3. Orthophoto Maps

Orthophoto maps depict terrain and other features by color-enhanced photographic images. It is an aerial photograph of the land.

Some orthophoto maps are overlain with contour lines and other features commonly associated with topographic maps. These maps are corrected for scale and are the same size as U.S.G.S. quads.

## **Key map parts:**

Map Legend: A legend shows information needed to interpret a map. Each type of map has information represented in a different way relating to its subject matter. The legend can explain map scales, symbols, and color.

Map Scale: The map scale indicates the ratio or proportion of the horizontal distance on the map to the corresponding horizontal distance on the ground.

Representative Fraction (R.F.) Scale: Expresses the ratio of the map distance to the ground distance in like units of measurements. It is usually written as a fraction or ratio. A representative fraction is always written with the map distance as one. A representative fraction of  $1/24,000$  (1:24,000) means that one UNIT of measurement (inches, millimeters, feet, etc.) on the map is equal to 24,000 of the SAME UNITS on the ground. You CANNOT mix units in a representative fraction. If it is one INCH on the map, it is 24,000 INCHES on the ground.

Graphic scale (G.S.) or Comparison Scale: This is entirely different. It usually COMPARES map distances to the ground distance in DIFFERENT units of measurements. Usually a graphic scale is a line marked off on a map indicating so many inches or millimeters equal so many feet, kilometers, chains, or miles on the ground. A comparison scale of 1" to 2000 feet means that 1 inch on the map is proportioned to 2000 feet on the ground. We are comparing inches and feet which are DIFFERENT UNITS of measurement.

Table 9, found in the *Fire Behavior Appendix B* is a useful tool to easily see map scale conversion factors of various representative fractions.

Contour Lines: A contour line is a line on a map or chart connecting all points of the same elevation. Any point on a contour line is the same elevation as all the other points on the same line. In other words, contour lines connect points of equal elevation.

Contour Interval: This is the difference in elevation between two adjacent contour lines. On U.S.G.S. maps they could be drawn at any elevation, but in practice they are drawn at intervals of 1, 5, 10, 20, 40, and 80 feet. Occasionally you will find a map with a 25 foot contour interval or metric units, but not often.

Index Contour: To make the contours easier to read, every fifth one is printed darker and has the elevation marked every so often in the line. The thinner or lighter colored contour lines are called intermediate contours.

Contours have certain general characteristics. Following are characteristics which are not rules but guidelines that are helpful in many cases.

- Usually have smooth curves. Exceptions are large outcrops of rocks, cliffs, and fractured areas of the earth's surface.
- Are "V" shaped in stream beds and narrow valleys. The point of the "V" always points uphill or upstream.
- Are usually "U" shaped on ridges with the "U" bottom pointing down the ridge.
- Are usually "M" or "W" shaped just upstream from stream junctions.
- Tend to run perpendicular to streams.
- Tend to parallel each other, each approximately the shape of the one above it and the one below it.
- Do not cross or touch. Exception is overhanging cliffs.
- Do not fork.
- Never end on the map, only at the map edges and sometimes at overhanging cliffs.
- Indicate steep terrain by being closely spaced.
- Indicate a uniform slope by being equally spaced.
- Indicate depressions or pit by a hachured (short lines extending from the contour line at right angles) contour line joined forming a circle.
- Indicate elevation in feet above mean sea level in index contours.

### Contour characteristic terminology:

- Depression: A low place in the ground having no outlet for surface drainage.
- Hill: Naturally occurring mass of earth whose crest or summit is at a lower elevation than a mountain.
- Mesa: A flat-topped mountain bounded on all sides by steep terrain.
- Ridge: Long narrow elevation of land, often located on a mountainside.
- Saddle: Ridge between two hills or summits.
- Valley: Stretch of low land lying between hills or mountains and sometimes occupied by a stream.
- Slope: An inclined ground surface that forms an angle with the horizontal plane (flat ground). The degree of inclination, steepness, is also called slope.
- Aspect: The compass direction that a slope faces. By visualizing the contours on a topographic map, aspect can be determined even though the map is a flat surface. Widely spaced contours indicate a gentle slope, probably not a well defined aspect. But contours closely spaced indicate steep terrain and aspect can easily be determined.

To test your understanding, answer the questions under Part 3 of the pre-qualifying test.



### **Part 3 – Fire Environment Visualization**

**Objective:** Identify common visual indicators used to estimate size and distance, and be able to relate to fire spread rate and flame lengths.

Determining distances from known points on a map is rather simple. But when you are in the field, it is another matter, unless you can relate to something known. How long are those flame lengths? Or how fast is this fire spreading? Obviously direct measurement is the most accurate way to make determinations. But how do you physically measure flame length on a high intensity fire? Is it important to know spread distance in feet or chains per hour? Using references in the field (something of known length or size) are very good aids to make calculated estimates of fire behavior. Learn to visualize the fire environment.

**Visualization tools:** What is the average canopy height of the trees? Telephone poles are about 30 feet tall. Fence posts are about 5 feet tall. How tall is the brush or grass you are standing next to, which is also the same fuel the fire is consuming? By relating flame length to the height of a known object, you can come up with a ratio to estimate. Example: Trees in the area are 40 feet tall. Flame lengths are one-half the height of the trees. Average flame length is about 20 feet (.5x the height of the trees in this example).

An effective way to estimate rate of spread is to know how much time it takes to burn between two known points. To determine spread distance, measure the distance between two points. Start timing when fire reaches the first point, and stop timing when fire reaches the second point. This establishes a ratio, which then can be mathematically applied to a unit of measure and time (ft/min, chains/hour, or miles/hour).

Other aids include using the odometer in a vehicle or by pacing to establish known ground distance. Range finders are useful if you have one. Barbed wire fence posts are about 1 rod (16.5 feet) apart. The distance between 4 fence posts then is 1 chain (66 feet). Although more variable, the distance between telephone poles is about 132 feet. On a larger scale and using a map, you can relate terrain features to distance and get a good idea of how quickly a fire is advancing.

Another hint: Most detection reports list a time of discovery. By estimating how far the fire has traveled upon your arrival and noting your arrival time, you can determine fire spread. But a word of caution: the fire environment is dynamic (changing with time and space). What occurred in the past may be of value, but may not apply to the current situation or what could happen in the near future. For safety reasons, base all your actions on current conditions, the forecasted expected conditions, and what the fire is doing (fire behavior).

Awareness and relationships tend to be more important than actual measurements. In this course you are going to learn more about fire events which don't require a lot of math or figuring. When is the next "Big Change" coming? Is it very little, such as a 2-fold (2x) increase, or is it a big change, such as a 60-fold (60x) change? When the change happens, are fire fighters at risk? Is there enough time to get to a safety zone when the change comes? Understanding the fire environment along with the magnitude of the "big change" is the key.

To test your understanding, answer the questions under Part 4 of the pre-qualifying test.

## **Part 4 – Basic Principles of Fire Behavior**

**Objective:** Understand basic fire behavior principles presented in S-190, Introduction to Fire Behavior.

To test your understanding, answer the questions under Part 5 of the pre-qualifying test.

## **Part 5 – Fuel Groups/Models**

**Objective:** Introduce student to fire behavior fuel groups and general fuel model characteristics within each fuel group.

Review the article, “Aid for Determining Fuel Models for Estimating Fire Behavior.”

To test your understanding, answer the questions under Part 6 of the pre-qualifying test.

## **Part 6 – Fireline Handbook - Appendix B**

### **Objectives:**

- Identify the four primary fuel groups as listed in Appendix B of the Fireline Handbook.
- Describe and interpret the Fire Characteristics Chart and Table 14.
- Read the Modified *Beaufort Scale for Estimating 20 Foot Wind Speed*.

Note how Appendix B of the Fireline Handbook is organized. The Fire Characteristics Chart is often referred to as a “hauling chart.” Within each major flame length group, a picture denotes what resource type is effective and can withstand fireline intensity. Table 14 helps to summarize interpretations of the “hauling chart.”

### **Using the Chart (example):**

Known rate of spread equals 10 chains per hour, and flame length is about 4 feet.

1. Draw a line across to where 10 chains intersects the 4 foot flame length curve.
2. Draw a line down to the x-axis (heat per unit area).
3. You now know the heat per unit area equals about 500 BTUs. Since there is a direct relationship between flame length and fireline intensity, you also know that the intensity is 100 BTUs, and at which point the fire is too intense to safely attack (direct) by firefighters.

Suppose there is a 10-fold change in rate of spread due to forecasted strong afternoon winds. In this situation, the chart is useful to estimate flame length and fireline intensity since heat per unit area usually remains constant.

To test your understanding, answer the questions under Part 7 of the pre-qualifying test.