Module 9: Suppression, Communication, and Mop-up

Topic 1: Introduction

Module introduction

Narration Script: Just about everything you do in the wildland fire service is designed to prepare you for the moment when you get the call to report for duty. You grab your gear, drive to the base, and get your briefing and assignment by Command. Last week, you went to a grass fire next to a road. Today the call is a wildland fire in a remote area. It's time to put your training to the real test.

As you drive to the scene, you gather more information and begin thinking about your response. What kind of conditions are you going to find? Will you have enough water? Which attack strategy might be most appropriate? In other words, how are you going to handle *suppression*, *communication*, *and mop-up*? It's time to do what you joined up for—to fight and manage fires—always remembering to provide for safety first.

Fire suppression methods introduction

Now it's time to find out what you'll actually be doing on the *fireline***. This module introduces you to the many** *suppression* **techniques you have at your disposal to** *control* **and extinguish** *wildland fire***.**

This is a broad (and deep!) module where you'll find information on:

- **Breaking the fire triangle**
- **Fire suppression techniques and safety**
- **Supporting** *heavy equipment* **operations and** *airdrops*
- **Communications**
- *Mop-up* **and** *patrol*

A wildland response can make for a long day, week, or even a month. This module will help you prepare for getting the job done.

Narration Script: While there are an almost limitless number of ways to fight a wildland fire, you need to use those that maximize the safety of personnel and make the best use of resources. There is more to suppression, communications, and mop-up than we can cover in this module alone, but this info will give you a good grounding in the concepts and techniques required for a Firefighter Type 2.

Topic 2: Breaking the Fire Triangle

Fire triangle introduction

Maybe you never thought you'd be using the laws of chemistry and physics when you got into the *wildland fire* **fighting business, but that's exactly what you'll be doing when working to bring a fire under** *control***.**

In this topic, you'll put on your science hat and refresh your memory on some key aspects of *fire behavior* **including:**

- *Fire* **triangle components**
- **Breaking the fire triangle**

Narration Script: Believe it or not, fire management is as much science and smarts as it is muscle and brawn. However, unlike the controlled atmosphere of the classroom lab, you'll be out dealing with the real thing, so you better understand how it works! This topic will cover the all-so-important basics of the fire triangle and aspects of the combustion process. If you have gone through the Introduction to Wildland Fire Behavior Course—or S190—this should be a quick review for you.

Fire triangle

Fire is actually a by-product of a larger process called *combustion***. In order for combustion to take place and produce fire, three ingredients are necessary:**

- **Oxygen**
- **Heat**
- *Fuel*

These three ingredients are the base for what firefighters call the *fire triangle*.

Read the following to review your knowledge of the fire triangle.

Oxygen Sources

Wildland fuels have an abundant supply of oxygen available in the air. A concentration of approximately 16 percent oxygen is required for combustion, but normal air contains 21 percent—more than enough for combustion to occur. In addition, some fuel materials contain sufficient oxygen within their makeup to support burning.

Rapid oxidation occurs in two forms:

- **Smoldering fires—ones that burn without flame and are barely spreading**
- **Steady-state fires (unchecked rapid burning)—steady-state fires are sometimes called free-burning fires**

Heat Sources

Heat sources sufficient to reach ignition temperature may come from:

- **Open flame**
- **Sun**
- **Lightning**
- **Hot surfaces**
- **Sparks and arcs**
- **Friction**
- **Chemical action**
- **Electric energy**
- **Compression of gases**

Fuel and Its Physical State

Fuel may exist in any of the three states of matter—solid, liquid, and gas. However, only gases burn. The initiation of combustion of a solid or a liquid fuel requires its conversion into a gaseous state by heating. During combustion, heat and chemical changes in the fuel cause fuel gases to evolve from the fuel. So, even though fuel and oxygen are present in the wildland, heat must be added to liberate the fuel gases and initiate the combustion process.

Fuels in Gas Form

Gas fuels can include:

- **Natural gas**
- **Propane**
- **Butane**
- **Hydrogen**
- **Acetylene**
- **Carbon monoxide**

Fuels in Liquid Form

Liquid fuels can include:

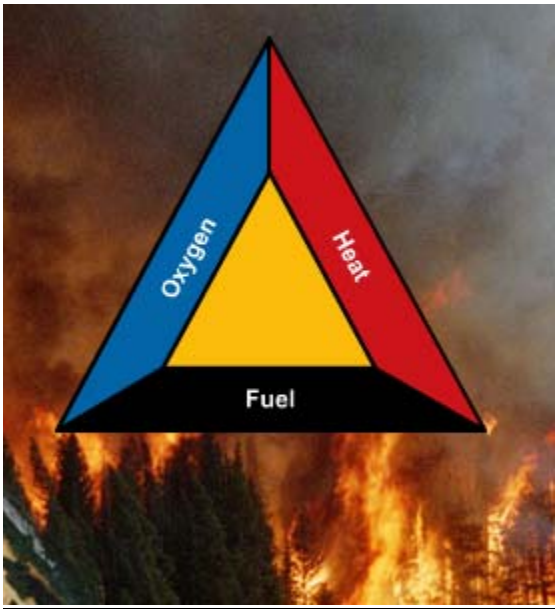
- **Gasoline**
- **Kerosene**
- **Turpentine**
- **Alcohol**
- **Cod liver oil**
- **Paint**
- **Varnish**
- **Lacquer**
- **Olive oil**

Fuels in Solid Form

Solid fuels can include:

- **Dust**
- **Coal**
- **Wood**
- **Paper**
- **Cloth**
- **Leather**
- **Plastic**
- **Sugar**
- **Grain**
- **Hay**
- **Cork**

Narration Script: Let's start with a basic concept the fire triangle. There are lots of fuels—trees, branches, brush—in wildland areas, and fuel is obviously the foundation of the triangle. Fuel may exist in any of the three states of matter, but only gases burn. This means heat is required for fuel gases to form from wood and the other solid fuels you might find in the wildland. So, even though fuel and oxygen are present, heat must be added to free the fuel gases and begin the combustion process.



Caption: The fire triangle represents the three components required for a fire.

Breaking the fire triangle

You can control the combustion process (and extinguish the fire) by disrupting or removing one or more of the three required elements of the fire triangle. In other words:

- **Remove fuel**
- **Remove oxygen**
- **Remove the heat energy**

Read below about each method for more information.

Remove Fuel

Separating fuels or clearing a space of all surface fuels down to mineral soil (dirt containing little or no organic material) is a common way of controlling and extinguishing wildland fires. This is the basic idea behind the creation of any fireline.

Remove Oxygen

Wildland fires burn in the open air; therefore, attempting to restrict the oxygen supply to a fire (removing oxygen) is usually limited to smothering relatively small fires with dirt. Of course, make sure the dirt you use doesn't have a lot of flammable organic material in it, such as pine needles and dead leaves.

Remove the Heat Energy

Remove heat by applying water, dirt, retardant, or a combination of these. Cooling the fire with water or Class A foam is one of the most common and effective fire extinguishing methods. You can also remove heat during night mop-up by chunking the fuels, allowing them to burn down, and then spreading the hot materials to expose them to the cooler night air.

Narration Script: You figure it out—if fire requires fuel, oxygen, heat, how would you go about breaking the fire triangle and controlling the combustion process?

Knowledge Check 1

Matching—select the match you choose from the pull down list.

Usually you try to avoid breaking things, but when it comes to controlling combustion in a wildland fire, breaking the fire triangle is the right thing to do.

Match each way to break the fire triangle to the BEST method. You may use the steps to break the fire triangle more than once.

Remove fuel	Spray with Class A foam
Remove oxygen	Spray with Class A foam
Remove heat	Spray with Class A foam
Remove heat	Spray with Class A foam

The correct matches are as follows:
Remove fuel: Construct a fireline
Remove oxygen: Smother with dirt
Remove heat: Spray with water
Remove heat: Spray with Class A foam

Topic summary

In this topic, we gave you some basic fire concepts—most likely a welcomed refresher from your Introduction to Wildland Fire Behavior (S-190) course. We identified:

- **The fire triangle**
- **Breaking the fire triangle**

Understanding the principles behind the fire triangle is one ally in your pursuit of a well-managed fire.

Narration Script: A wildland fire has a seemingly endless supply of oxygen and an abundance of fuels to keep it going. The good news is that your brain will now easily identify the parts of the fire triangle keeping the blaze going—and now, perhaps the more challenging news is the need to put your muscles to work as you begin to break up the fire triangle and control the fire.

Topic 3: Suppression and Safety

Topic introduction

If you've gone through this course in the order it has been presented, we've discussed everything from tool use to how you'll travel to an *incident***. Now it's time to find out what you'll actually be doing on the** *fireline***. This topic introduces you to the many** *suppression* **techniques you can use to** *control* **and manage** *wildland fires***.**

In this topic, you'll discover such techniques as:

- **Fire attack methods**
- **Suppression techniques**
- *Control lines*
- **Water use**
- *Wet lines*

Narration Script: While there are countless ways to fight wildland fires, you want to use those that maximize the safety of firefighters and make the best use of available resources. There is more to suppression than we can cover here, but this topic will give you a good start toward understanding the strategies and techniques required to successfully control and manage wildland fires.

Fire control tactic factors

The suppression tactics implemented during *initial attack* **will be based on the location of the** *fireline* **in relation to the flame front. The tactics are forms of either** *direct* **or** *indirect* **attack that may be used singly or in combination with each other.**

When deciding the tactics to use in a particular situation, *Command* **will take into account:**

- **Actual or potential life hazards**
- *Exposures***—threatened property or** *resources*
- *Fuel* **types,** *moisture***,** *continuity***, and arrangement**
- **Current and expected weather, including temperature and especially** *wind*
- *Topography*
- *Anchor points*

Narration Script: If you've gone through the modules in the course in order, you should now be familiar with how you will use water and hand tools in fire suppression. Therefore, it is time to talk about the suppression tactics you will follow.

As an entry-level wildland firefighter, it's not your responsibility to determine fire control tactics during an initial attack, BUT you will be an active participant, and it doesn't hurt to know the responsibilities of the people above you. A well-planned initial response controls about 90 percent of all wildland fires. To ensure each incident you participate in falls within these odds, supervisors will determine the right fire-control tactics after a thorough scene size-up.

Direct vs. indirect attack

When you respond to a wildland scene, your *incident commander* **(IC) will assess conditions and determine the best way to attack the fire. Your job is to implement the chosen strategy.**

To understand how you fit into the big picture, learn the two primary attack methods used on wildland fires:

- **Direct**
- **Indirect**

You will investigate each method in turn.

Narration Script: Understanding the two primary attack methods—direct and indirect—will give you a better idea of how you fit in to the overall suppression effort.

Direct attack

In a direct attack, the IC determines if personnel and resources can safely work against the flames directly. One of the primary determining factors in direct attack is *flame lengths***. Normally, flame lengths of less than 4 ft. (1.2 m) can be fought directly with hand tools and** *handlines***. When working in this manner, keep one foot in the** *black* **and one foot in the unburned area. Flames up to 8 ft. (2.4 m) require** *heavy equipment* **or** *airdrops***.**

Some common direct attack techniques include:

- **Smothering or removing fuel with hand tools**
- **Spraying water in stationary or** *mobile attack*

Warning—Working from the Green

Some direct attacks can be performed from the green. However, any time you participate in an attack from the green, LCES must be in place! In these cases, make sure each firefighter knows where the escape routes and safety zones are located. Don't fall into "Watch-Out!" Situation 3—safety zones and escape routes not identified.

Narration Script: As you might expect, in a direct attack you bring personnel right up to the fire edge. If you can safely attack a fire directly, you may be sent into action with hand tools to remove fuels and smother burning fuels, handlines to knock down flames, and engines with pump-and-roll capability in one or more types of mobile attack.

Indirect attack

When flame lengths exceed 8 ft. (2.4 m), direct attack of any kind becomes impractical. In this situation, indirect attack is the only option.

Indirect attack requires firefighters to build control lines, either by hand, with mechanized equipment, with water (*wet line***), or by using existing natural or man-made** *barriers***. You**

then *burnout* **or** *backfire* **fuels between the control line and the oncoming** *fire edge***. On large incidents, you may be miles from the actual fire edge. On smaller incidents, you may be very close to the flame front.**

Narration Script: When a fire is too intense for you to go up against it directly, your IC's only choice is to pick a safe spot you can defend, build a control line, and then start removing fuels from the fire's path. This method sacrifices a certain amount of vegetation or other values, such as structures, but it is often the only option. You will learn more about building control lines and firing operations later in this topic.

Flank attack

Another tactic for fighting wildland fires is the *flank attack***, also referred to as a *flanking attack* or *flanking the fire*. The flank attack is used for moderately intense fires moving at a moderate** *rate of spread* **(ROS).**

Here's the skinny on flank attacks:

- **Start a flank attack at a secure anchor point on one or both** *flanks of a fire***, and work toward the** *head*
- **Attack the flanks directly or indirectly—the distance of the control line from the fire edge usually depends on** *fire intensity*
- **Attack the flanks simultaneously or successively, depending on fire conditions and resources available**
- **Aircraft can be one of the flank-attack resources when necessary**

Consider these safety concerns when performing a flank attack.

- **Burn out the strip of unburned fuel between the line and the fire's edge as soon as possible during fireline construction**
- **Work in the black whenever possible—however, if lives or structures are at risk, your crew may have to attack from the green if they can do it safely**

Narration Script: We'll cover flank and parallel attacks next. These kinds of attacks can use direct or indirect strategies. Flank attacks work best for moderately intense fires moving at a moderate rate of spread. They're also the best alternative if a fire is too intense for a frontal attack with ground resources.

Parallel attack

Occasionally, you may need to fight a wildland fire using a *parallel attack***. When applying the parallel attack strategy, timing is everything. A control line is constructed as near to the fire's edge as possible while still allowing enough time to complete the line before the** *fire front* **arrives. For this reason, parallel attacks often employ mechanized equipment, such as tractor-plows and** *bulldozers***, because the line can be constructed more quickly.**

The parallel attack is similar to an indirect attack, but the control line is constructed much closer to the fire's edge, usually within 100 ft. (30 m). The area sacrificed to the fire is smaller than in an indirect attack.

Narration Script: The parallel attack is a chip off the old block to the indirect attack. The difference between the two is in the choice of tools to build the line. Parallel attacks often consist of mechanized equipment. Because bulldozers and tractors can build a line so much faster than a hand crew, the control line is constructed much closer to the fire's edge than in an indirect attack.

When to use a parallel attack

A parallel attack reduces the labor of *hand crews* **because a line can be constructed straight across indentations of the fire front, thus shortening the line. When performing a parallel attack, the area between the control line and the fire is usually burned out as the work progresses, or firefighters** *patrol* **the line to ensure that it is not breached when the main fire reaches it.**

Use a parallel attack:

- **Whenever a fire is too intense for direct attack**
- **When a fire's edge is so irregular that direct attack would result in an excessively long control line**
- **To keep the fire away from** *heavy fuels*
- **To encircle** *spot fires*

Knowledge Check 2

Matching—select the match you choose from the pull down list.

Match each attack method to the appropriate situation or technique. You may use each attack method more than once.

Direct	Moderately intense fire moving at moderate ROS
Direct	Moderately intense fire moving at moderate ROS
Indirect	Moderately intense fire moving at moderate ROS
Indirect	Moderately intense fire moving at moderate ROS
Flank	Moderately intense fire moving at moderate ROS
Parallel	Moderately intense fire moving at moderate ROS

The correct matches are as follows:

Direct	**Short flame lengths**
Direct	**Smothering**
Indirect	**Long flame lengths**
Indirect	**Line construction far from the fire edge**
Flank	**Moderately intense fire moving at moderate ROS**
Parallel	**Encircling spot fires**

Suppression techniques introduction

Once your supervisor or IC makes the initial decision whether the overall strategy will be a direct, indirect, flank, parallel, or combination attack, you may use a variety of techniques to suppress and extinguish wildland fires. Depending on the attack strategy and other factors, some of the techniques you'll use are:

- **Hotspotting**
- **Cold trailing**
- **Building scratch lines**
- **Fireproofing fuel**
- **Firing operations**
- **Building cup trenches**

You will examine each technique in this order.

Narration Script: Of course, when selecting the most appropriate suppression techniques, you must always consider firefighter safety first. You'll have to weigh your knowledge of suppression techniques with the situation you're in. So, while hotspotting and cold trailing might be safe and effective in some cases, they may not be in other situations. Until you are well trained and educated, your crew boss and IC will help you make those decisions—but be decisive and ask questions when you feel unsure of an assignment.

Hotspotting

Hotspotting **involves making a rapid attack on the hot-burning points of a fire's edge, such as rapidly developing fingers or other active parts of a fire that are threatening life or high-value property. Hotspotting is done prior to constructing control lines and is one of the more dangerous tactics because it is not initiated from an anchor point. Hotspotting is usually done by any available resources (with the proper experience) and should be done from within the black or by taking advantage of other natural barriers.**

Narration Script: For the linguists in the crowd, you might surmise that hotspotting is the act of looking for hot spots and you're right. Hotspotting allows firefighters building firelines to get close enough to attack the fire directly by cooling the fire's edge. Certain areas of the fireline might be hotter than others, and by hitting these areas early enough to slow the ROS, hotspotters help prevent the fire from "making a run."

Hotspotting is NOT for the inexperienced firefighter and even falls under the umbrella of Watch-Out Situation number 8, because hotspotting is done without the safety of an anchor point. Hotspotting is done only after careful evaluation by a supervisor and, of course, with an eye on the appropriate LCES.

Cold trailing

Firefighters *cold trail* **to try to improve their control of a partly dead fire edge by checking for hot spots and widening the line or cutting a new one if necessary. Cold trailing involves**

carefully inspecting and feeling with bare hands to detect any fire, digging out and extinguishing every hot spot, and even building new fireline around any live edges.

Narration Script: Cold trailing isn't actually "cold" at all. When firefighters cold trail, they inspect a fire edge looking for hot and still-burning areas, digging them out, and even digging new firelines if necessary.

Scratch line

When time is of the essence, you'll build a *scratch line*—and fast. A scratch line is a preliminary control line built as a quick measure to check the path of a fire that is spreading rapidly through *light fuels* such as dry grasses. Later, you can go back and widen a scratch line into a full fireline if necessary.

Fireproofing fuel

Fireproofing is in the vein of "an ounce of prevention is better than a pound of cure." By fireproofing, you reduce the chance of fuels igniting outside the control line by spraying them with water or chemicals or covering them with dirt.

Firing operations

Control lines work by keeping fuel away from the fire. Controlled burning does the same thing. In wildland fire operations, there are two ways to use fire to fight fire:

- **Backfiring**
- **Burning out**

While both backfiring and burning out are considered *firing* operations, and both eliminate unburned fuel between a fire's edge and a control line, they are used under different conditions.

We will cover each of these methods in turn.

Narration Script: Believe it or not, you *can* fight fire with fire. Backfiring and burning out are commonly used to widen line and deny fuel to a fire. Now we'll get into a few more details, but always remember that firing ops in the wildland environment are extremely dangerous and should only be performed by those with the proper training and experience.

Backfiring

Backfiring is an indirect attack method normally used to stop the spread of very intense wildland fires. It's a tricky procedure that takes place on the *downwind* side of a large fire (the active fire edge). The key is to use the natural indraft of the main fire to draw the backfire toward the main fire.

Although backfiring does widen the defense *perimeter***, it may also be used to change the force and direction of the** *convection column***. Because the effects of backfiring may influence fire conditions and require modification of the** *incident action plan (IAP)***, only highly trained and experienced firefighters may execute backfiring operations and only after being approved to do so through the chain of** *command***.**

Warning

Backfiring must be done *only* by trained and experienced personnel because it involves extensive burning under adverse conditions.

Narration Script: Backfiring is not for amateurs or even the Type 2 Wildland Firefighter. But you need to understand the principles involved. Backfiring uses a lot of fire that has to be laid down in just the right place at just the right time. Smoke from a backfire should be drawn away from the control line and toward the main fire.

Keys to backfiring success

To help ensure a successful backfiring operation, the officer in charge should:

- **Obtain current weather data or spot forecast**
- **Obtain current** *fire behavior forecast*
- **Establish an anchor point for the operation**
- **Use a wet line, road, stream, or constructed control line**
- **Establish exclusive tactical communications**
- **Ensure all personnel, including adjacent resources, are aware of the backfiring operation**
- **Make sure that there are sufficient resources on scene to do the job safely and in control**
- **Ensure personnel safety by observing LCES**
- **Patrol the control line to check for** *spotting* **across it**

Narration Script: Besides getting permission from the Ops Chief or IC, the person in charge of backfiring must rely on judgment and experience to decide when conditions would make a backfire impractical or unsafe. If you are working on a line where backfiring may take place, it pays to know some of the factors that go into a successful burn.

Burning out

Burning out is an essential component of control line construction. The control line is considered incomplete until there is no fuel between the fire and the line.

Use burning-out operations to:

- **Widen a control line**
- **Eliminate islands of unburned fuel**
- **Create** *escape routes* **and** *safety zones*

Burning out normally takes place on a much smaller scale than backfiring. Unlike backfiring operations, burnout operations conducted by qualified personnel do not necessarily require Command approval although it is a good idea to keep them informed.

Narration Script: Burning out can be a real labor-saver when you're cutting line by hand. Particularly in light fuels, why hack away with a McCleod if you can get the same effect by simply walking along with a drip torch? Fire is a handy tool to widen control line, get rid of potentially dangerous islands in the black, and create escape routes and safety zones. Safety and following proper technique are still key.

Burning-out factors

It should not surprise you that the safety and effectiveness of burning-out operations depend on three primary factors:

- **Fuel**
- **Weather**
- **Topography**

Read the following to find out how to have a successful burnout.

Fuel

Keep your fuels in mind. Particularly:

- **Light, patchy fuels—may not burn cleanly and may leave islands of unburned vegetation.**
- **Heavy, highly compact fuels—may burn too intensely and spread too slowly to create the kind of firebreak needed to stop the main fire. Burning out in heavy fuels may also generate more heat than available resources can handle, causing the fire to spot across a control line. In this case, burning out would do more harm than good.**

Weather

Watch your wind speeds and direction. High winds can drive a burnout away from the main fire, but there are no established rules for determining the maximum safe wind speed for burning-out operations. Whenever possible, burn out with the wind, but keep topography issues in mind, too.

Topography

Whenever possible, burn out from the top of a slope toward the bottom or against the wind, depending on the more dominant factor.

Blackline concept

Whether your *crew* is using direct, indirect, flanking, or parallel attack strategies, forming a blackline is the goal of burnout operations. By burning out, you're trying to ensure that

fuels and heat remain inside the control line in an effort to prevent the fire from making a run at the line. Fuels remaining between the main fire and the control line are burned out, or allowed to burn to the control line—thus the term "blackline." Establishing a blackline helps ensure the safety of firefighters and the security of the control lines.

Cup trench

If you're working a fire in steep terrain, building a cup *trench* **(sometimes called an** *underslung line***) is useful if you can't relocate the line. If a fire is uphill from the control line, a cup trench can help prevent burning debris from rolling down the** *slope***, across the control line, and igniting fuels on the other side of the line.**

Stay alert! Building an underslung line is one of your *tactical* "Watch outs!" in the Incident Response Pocket Guide (IRPG). You can access the complete IRPG in the resources accompanying this course.

Narration Script: If you find yourself in a situation where you're fighting a fire on a steep slope and your control line is below you, digging a cup trench will aid in catching any burning debris rolling downhill.

Caption: An example of a cup trench.

Knowledge Check 3

Matching—select the match you choose from the pull down list.

Match each fire suppression technique to its appropriate use.

Cup trenching	Creates emergency control line, especially in light fuels
Fireproofing fuel	Creates emergency control line, especially in light fuels
Firing operations	Creates emergency control line, especially in light fuels
Hotspotting	Creates emergency control line, especially in light fuels
Creating a scratch line	Creates emergency control line, especially in light fuels
Cold trailing	Creates emergency control line, especially in light fuels

The correct matches are as follows:
Cup trenching: Keeps burning debris from rolling across control line
Fireproofing fuel: Prevents fuel outside the control line from burning
Firing operations: Eliminates fuel between fire edge and control line
Hotspotting: Attacks parts of a fire threatening life or property
Creating a scratch line: Creates emergency control line, especially in light fuels
Cold trailing: Finds hotspots along a partly dead fire edge

Control line, fireline, and anchor point

Before we continue to the actual methods for line construction, take a quick review of the terms control line, fireline and anchor point.

- ***Control line* refers to all constructed or natural fire barriers. It's also used to describe the treated fire edges used to contain the fire.**
- **A *fireline* is any cleared strip or portion of a control line where flammable material has been removed by scraping or digging down to** *mineral soil***.**
- **The *anchor point* is any good place where you can start constructing a fireline. Generally, a fire barrier is a safe anchor point. Using an anchor point minimizes the chance of being outflanked by the fire while the line is being constructed.**

Narration Script: The terms control line, fireline and anchor point are closely related, so let's look at them together.

The terms control line and fireline are basic to any discussion of attack methods, and they are often confused with the term "fire edge." "Control line" refers to all constructed or natural barriers. Previously constructed features can include road and canals. Natural barriers can include streams, lakes, ponds, rock slides, and areas of sparse fuels. The term "fireline" applies only when you are dealing with a portion of a control line where flammable material has been removed by scraping or digging down to mineral soil.

There are a number of other terms used in various regions to describe different types of lines. Among these terms are *hand lines*, *machine lines*, *wet lines*, *retardant lines*, *detonation cord*

lines, and *blacklines*. As you can imagine, some of these terms indicate both the line's method of construction and its width.

When you start building a fireline, however, it must always be started from an "anchor point," such as a road, lake, pond, stream, earlier burn, rock slide, or a cliff. This type of barrier provides a safety point for you that will keep you from getting outflanked by the fire.

Threats and hazards to control lines

No discussion of fire control lines would be complete without mentioning the threatening hazards to their integrity.

Once you've completed the control line, keep it secure by *mopping up* **inward from the line to prevent the fire from jumping the line in one of these ways:**

- **Spotting**
- **Rolling debris**
- **Creeping**
- **Radiant heat**

Read the following about each threat to make sure your firelines are not threatened.

Spotting

Spotting can happen when wind gusts and convection columns pick up embers and carry them across control lines. These embers may land in unburned fuel, igniting small spot fires outside the control lines.

Rolling Debris

Burning debris on steep terrain may roll downhill and across constructed lines, igniting unburned fuels on the other side of the control lines. Position your lines to avoid these hazards or use cup trenches when appropriate.

Creeping

Fire can creep along buried root systems, peat, and other organic material. Control lines must be built to mineral soil, water level, or permafrost to prevent fire from creeping underneath the lines.

Radiant Heat

Radiant heat can be generated from the buildup of unburned fuel inside or immediately next to the control line. These fuels may ignite and become hot enough to radiate heat and ignite fuels on the other side of the line. Clearing this unburned fuel or fireproofing it with water, foam, or dirt may help control this control line hazard.

Narration Script: You'll use control lines to help contain a wildland fire and keep yourself and other firefighters safe, but you must recognize that control lines can be jeopardized by several hazards. While you're on the fireline, it's easy to have tunnel vision with the work at hand, so poke your head up and evaluate your surroundings now and then to pay attention to the security of the control line. Communicate any hazards to fellow crewmembers.

Control lines

An understanding of attack methods is required background to any discussion of control lines. But now that you have that information, it is time to move on. Making effective control lines is critical to any attack.

Start your tour of control lines by looking at:

- **Location**
- **Anchor points**
- **Width**

You will investigate each issue in turn to begin gaining some control.

Narration Script: Now that you have the necessary background, we're going to approach fire attacks indirectly—via control lines, that is. Cutting line is a big part of a wildland firefighter's job. Why, even after conducting a successful direct attack, you usually throw a control line around the fire perimeter just to be safe. But before we get into the nitty gritty of fireline construction, take a look at some basic considerations of location, configuration, and size.

Line location

The IC must take several considerations into account when deciding where to place a control line in relation to the fire edge. For example, how extreme is the *fire behavior* **and will firefighters be using an** *offensive* **or** *defensive* **strategy?**

Crews should construct the control line based on the predicted rate of spread (ROS) and fire behavior. They should place it as *close* to the fire edge as safety permits. At the same time, however, they must place it *far* enough away from the fire so that the line can be completed, burned out, and held before the fire is expected to reach it.

Some of the issues related to control line location include:

- **Safety**
- **Line shape**
- **Environmental impact**

Read the following to see what the IC will direct you to do.

Safety

To ensure operational safety, the IC will consider the use of mechanized equipment for line construction where possible and will direct you to:

- **Plan for the safety of personnel and equipment—always use LCES**
- **Allow enough time for forces not only to build lines but also to do other needed work, such as felling snags and burning out**
- **Eliminate possible hazards from the fire area and provide a safe distance between lines and hazards that must be left in place**
- **Follow downhill fireline construction guidelines (we will cover this in just a bit)**

Shape

When defining the control line shape, the IC will direct you to:

- **Keep the line as short and straight as practical**
- **Select the easiest routes for control—without compromising line effectiveness or sacrificing excessive area or values**
- **Encircle areas where spot fires are numerous and burn out unburned fuels**
- **Avoid undercut or underslung lines (lines below a fire on a slope) and sharp turns in the line; if these types of lines are used, make sure the trench is deep enough to catch rolling materials**

Environmental Impact

When working in sensitive areas, the IC will direct you to:

- **Use line construction methods to minimize environmental effects**
- **Follow agency or organization policy**
- **Employ Minimum Impact Suppression Tactics (MIST) in wilderness areas involving the use of hand tools only**

Narration Script: The burden is on the IC to make sure the control line isn't too close to—or too far from—the approaching fire edge. It's a balancing act!

Anchor points

All control lines must have an *anchor point.* The anchor point prevents a fire from burning around the end of the control line and possibly outflanking fire fighting crews.

An anchor point is usually not a constructed fireline, but it could be a:

- **Road**
- **Bare field**
- **Stream**
- **Cliff**
- **Previously burned section of the fire**

- *Hose lay*
- **Secured aerial** *retardant drop*

Warning—Anchor Points

Starting fireline construction from an anchor point is critical to firefighter safety. Remember "Watch-out!" Situation 8—constructing line without safe anchor point.

Narration Script: You wouldn't do a ladder raise on deep mud would you? No, you would want to make sure you have solid footing. In the same way, make sure your control line has solid footing—a good anchor point. It's so important; it's one of our "Watch-out!" situations.

Fireline width introduction

When building a fireline, width is all relative:

- **A few feet in sparse** *surface fuels***, such as** *duff* **or light grass**
- **A few yards in heavier fuels and in severe burning conditions**

When constructing a fireline by hand, save time and conserve your energy by making the line only as wide as necessary. Anything that affects how a fire burns must be considered when deciding how wide the fireline must be. But absent other factors, use two general rules to determine line width:

- **1 1/2 times the height of the burning fuels**
- **2 1/2 times the height of the flames**

Narration Script: We'll talk about the individual factors that determine the width of fireline in a moment, but for now, let's focus on a few common-sense considerations and rules of thumb. Remember that regardless of your line width, you need to burn out the fuels between the control line and the fire's edge, particularly in medium to heavy fuels.

When considering how wide to make the line under a forest canopy, use the height of the surface fuels that are burning, not the height of the trees in the canopy as the basis for your calculation. Of course, you should be ready to change the width of the fireline if conditions change, such as wind, weather, time of day, and topography. The decision regarding line width in any specific situation should be made by a supervisor or experienced firefighter based on whether direct or indirect attack tactics are being used.

Fireline width considerations

The most important factors in determining fireline width are:

- **Fuel**
- **Slope**
- **Weather**
- **Part of fire**
- **Fire intensity**

Read the following to learn more about each factor.

Fuel

Wider than normal control lines are needed for:

- **Fuels containing flammable oils, such as chamise, pine, palmetto, and juniper—these fuels burn hotter than other fuels**
- **High and dense fuels**
- **Heavy fuels, such as logs and snags—these fuels are slower to ignite but burn hotter and much longer than light fuels**
- **Dry fuels burn hotter and faster than fuels with high moisture content**
- **The closer and more continuous the fuels, both horizontally and vertically, the greater the chance for combustion and fire spread—watch out for heavy fuel loading and ladder fuels**

Slope

For lines constructed *above* a fire burning on a slope, the steeper the slope, the wider the line must be. For lines constructed *below* a fire burning on a slope, two factors are critical:

- **Width of the line**
- **Depth of the trench that must be built to catch rolling materials**

The steeper the slope, the deeper the trench must be. When crews backfire in areas subject to extreme fire behavior such as on steep slopes, fireline width should be at least two times the fuel height.

Weather

Temperature, humidity, and winds (both natural and convective) affect fuel moisture. Together, these factors affect the width of fireline required. In general, the higher the temperature, the lower the humidity and fuel moisture will be. The lower the fuel moisture and the stronger the winds, the more intensely a fire burns, and the wider the fireline must be. Increases in wind will increase the amount of oxygen available and preheat fuels, increasing the chances for combustion and fire spread.

Parts of Fire

Because fires generally burn with different intensities at the head, flanks, and rear, each part may require a line of different width. Generally, line width must be:

- **Widest at the head**
- **Narrower along the flanks**
- **Narrowest at the heel (until the wind changes!)**

Fire Intensity

The amount of heat produced by a large fire is generally greater than that produced by a small fire in the same fuels and burning conditions. A large fire, therefore, usually requires a wider line than a small fire.

Knowledge Check 4

Multiple choice—check the box of the answer(s) you choose.

As you can see, a lot of thought goes into the position and width of control lines. Let's see if you can put some thought into this question.

Identify THREE true statements about control lines.

- ☐ **Anchor points are required only in medium or heavy fuels.**
- ☐ **The control line should be at least 1 1/2 times the height of fuels.**
- ☐ **One factor in control line position is whether offensive or defensive strategy is used.**
- ☐ **The control line should be of uniform width all around a fire's perimeter.**
- ☐ **The control line should be kept as short and straight as possible.**

The correct answers are one factor in control line position is whether offensive or defensive strategy is used, the control line should be kept as short and straight as possible, and the control line should be at least 1 1/2 times the height of fuels.

General fireline construction issues

From general, strategic issues we now move into the actual fireline construction. You build firelines using hand tools or mechanized equipment to remove surface and *subsurface* **fuels down to mineral soil. At the same time, be sure to break the continuity of any** *aerial fuels* **over the line to make them unavailable to a fire.**

Regardless of how you're building your line, there are a few general items to keep in mind during construction:

- **Fuel and topography considerations**
- **Effective construction tips**

You will examine both of these issues in turn.

Narration Script: And now we get down to some specific line construction tips. These pearls of wisdom apply to both building line by hand and with heavy equipment.

Fireline construction considerations

Three common considerations for building fireline related to fuel and topography include:

- **Fuel concentrations**
- **Snags and aerial fuels**
- **Slopes**

Read the following to learn more about effective fireline.

Fuel Concentrations

Be sure to break up and disperse concentrations of *surface fuels*, also called *jackpots of fuel*, especially those close to the control line. For example, a pile of brush located inside but adjacent to the control line is a potential source of a hot spot or slopover. The same type of pile located outside the line is a good bed of fuel—a spark from a fire could start a rapidly developing spot fire.

Snags and Aerial Fuels

Cut down snags and other standing aerial fuels near the line. Do this before burning out if there is time. If these fuels are charred or burning, fell them into the *black*; if they are unburned, fell them into the *green* outside of your control line.

Control Line on a Slope

When building control line on a slope below a fire, also called an *underslung line*, trench or undercut the line to stop materials such as logs, pine cones, or yucca plants from rolling into unburned fuels and spreading the fire. A good trench has an earthen berm on the downhill side to stop burning materials. To stop a fire that is burning upslope, construct a control line just over the ridge on the other side. Locating the line here uses the effect of slope on fire behavior to decrease the possibility of the fire jumping the line.

Narration Script: So how are firelines actually constructed? Normally, they are created either by hand crews or by heavy equipment. In either case, the principle is the same—disrupt the continuity of fuels by scraping down to mineral earth. A few things to keep in mind include: fuels you need to disrupt can be surface, sub-surface, or aerial; be sure to clear fuel concentrations away from your line; drop any burnt aerial fuels and dangerous snags into the black; and if you are dealing with fire coming up slope, don't try to fight it on that slope. A smart firefighter would put the control line just beyond the ridge.

Effective fireline construction tips

Constructing an ineffective fireline wastes time, energy, and resources. To be effective, always build your fireline according to these guidelines:

- **Make the line wide enough to be effective, but no wider**
- **Clear the line down to mineral soil where practical**

- **Scatter charred or burning material into the black**
- **Throw cut, unburned fuels into the *green* (unless needed for burning out)**
- **Cool adjacent fire with water or dirt to increase line effectiveness**
- **Wet down or cover rotten logs and stumps near the line with dirt**
- **Burn out the fireline *while* line construction proceeds, commonly called "bringing fire with you"**

Narration Script: Keep these helpful tips in mind for building good control line. Cutting line is hard work and often tough on the environment—don't do more work or more damage than you have to.

Knowledge Check 5

Matching—select the match you choose from the pull down list.

There are a few universal truths associated with control line construction. Let's see if you've seen the light.

Match each control line element to the MOST appropriate action.

Fuel concentrations	Broken up and scattered in the green
Snags	Broken up and scattered in the green
Control line below fire	Broken up and scattered in the green
Control line above a fire	Broken up and scattered in the green
Control line in general	Broken up and scattered in the green
Downhill fireline	Broken up and scattered in the green

The correct matches are as follows:
Fuel concentrations: Broken up and scattered in the green
Snags: Dropped into the black
Control line below fire: Trenched and bermed
Control line above a fire: Placed just over the ridge
Control line in general: Made no wider than necessary
Downhill fireline: To be avoided, if possible

Downhill fire fighting

From general, strategic issues we start going downhill—*downhill* fireline construction, that is. Downhill fireline construction goes against the grain of some of your safety training and should *not* be attempted unless there is no tactical alternative. However, your crew leader or supervisor may decide to establish a downhill line or hose lay with fire and unburned fuel below you.

When this occurs, your supervisor will consider several guidelines from each of these viewpoints before making a decision to fight the fire downhill:

- **Scouting and preparing the crew**
- **Preparing the area**
- **Constructing the line**

You will examine each guideline in turn in the next few sections. But first, consider this warning.

Warning—Downhill Fireline Construction

Use extreme caution when constructing downhill line in steep terrain and fast-burning fuels. Use other attack methods whenever possible. Additionally, *never* attempt downhill line construction when a fire is burning directly below the proposed starting point. This is one of your "Watch-out!" situations. Remember "Watch-out!" Situation 9—building fireline downhill with fire below. Always follow your IRPG guidelines for downhill line construction.

Narration Script: Now we are going to start to go downhill. Sometimes your supervisor will order you to construct a control line DOWNHILL or extend a hose lay DOWNHILL toward a fire. This order may be given when the benefits of protecting life or valuable property outweigh the risks. This is very dangerous in fast-burning fuels and steep terrain because the fire may burn across the slope below and sweep uphill to trap you and your crew. A direct attack will be used wherever possible. If not possible, firelines should be completed between anchor points before being fired out.

Scouting ahead of the crew

Command makes the decision to perform a downhill attack only after thoroughly scouting the situation and assessing the adequacy of resources to complete the assignment.

The supervisor should prepare for the safety of scouting personnel. Scouts must be supervisors of involved crews who are properly trained. If the scouts are working ahead of a crew in *brushy* terrain or unburned areas of dense vegetation, they should:

- **Carry a cutting tool and clear any vegetation that might hamper escape**
- **Post a *lookout* to warn of danger**
- **Maintain communications with the supervisor**

Preparing the crew

Before attempting to construct a fireline downhill, an experienced firefighter or fire officer takes steps to prepare the crew:

- **Establish communication between the crew working downhill and crews working uphill from below; when no crew can adequately observe the fire, establish communications among the crews, supervisors, and lookouts who are posted where the fire's behavior can be seen**

- **Ensure the crew will be able to rapidly reach a safety zone from any point along the line in case the fire suddenly crosses below them or increases in intensity**
- **Be aware of and avoid all "Watch-out!" situations, ensure full compliance with the "10 Standard Fire Fighting Orders," and use LCES**

Preparing the area

When the decision is made to attack a fire downhill, for the area surrounding the proposed fireline, the supervisor should:

- **Consider an airdrop along with keeping a loaded aircraft circling overhead**
- **Burn out or blackline the vegetation adjacent to a control line to widen and strengthen it as the line progresses, beginning from the anchor point at the top**

Narration Script: In preparing the area surrounding a downhill fireline, an airdrop can be used to knock down the fire. The supervisor should keep a loaded air tanker or helicopter circling overhead to provide additional protection for the crew. Burning out or blacklining the vegetation adjacent to the control line provides a continuous safety zone for the crew and reduces the likelihood of fire crossing the line.

Constructing the line

If your supervisor decides to attack the fire, the following guidelines apply to the downhill fireline construction or hose lay:

- **Downhill line construction or hose lay should not be attempted when the fire is present directly below the proposed starting point.**
- **The fireline should not be constructed in or adjacent to a** *chimney* **or chute that could burn out while your crew is in the vicinity.**
- **A downhill line or hose lay should be securely anchored at the top—avoid an undercut line whenever possible.**
- **A downhill hose lay must be made with 1 1/2 in. (38 mm) hose or larger. Hose must provide sufficient water flow to contain the worst-case fire conditions expected.**

Working safely during downhill fire fighting

Work safely when you are called on to do downhill hose lays or line construction:

- **Make sure your footing is secure and working positions are safe**
- **Walk, don't run—except if you have to get to an escape route or safety zone**
- **Watch burning or fire-weakened trees closely and pass them only on the uphill side and far enough uphill to avoid any potential fall hazard**
- **Patrol for spot fires from hot materials rolling down slopes and crossing the line**
- **Do not work directly above, below, or near machines while working on steep slopes**
- **Stabilize loose rocks along dozer cuts before working below them**
- **Work more than 10 ft. (3 m) apart and stagger yourself from other crew members when there is a danger of rolling rocks and logs**

Narration Script: Your supervisor has weighed the risks and benefits and decided on a downhill fire attack. Now, you have some things to look out for when doing downhill hose lays and line construction. Start by working safely.

Be alert to changing conditions

Be alert for changing conditions any time you are called on to do downhill hose lays or line construction:

- **Listen and watch for warnings from the lookout**
- **In fast-burning fuels, watch out for fast fire runs in any direction, at any time of day or night**
- **If cutting a line or laying hose across the head threatens to slow your access or potential retreat, change your *tactics* to use a flank attack, starting at a safe anchor point**
- **Maintain communication with your crew and supervisor**
- **Be aware of any weather changes**

Narration Script: During downhill line construction and hose lays, you need to be alert for changing conditions. These guidelines make sense not only for downhill attacks, but anytime you are doing line construction or hose lays—downhill, uphill, or on level ground.

Knowledge Check 6

Multiple choice—check the box of the answer(s) you choose.

Are you down with the guidelines for downhill fireline construction and hose lays?

All of these are TRUE guidelines, EXCEPT

- ☐ **Don't attempt these procedures when a fire is present directly below the proposed starting point**
- ☐ **Don't construct a fireline in or adjacent to a chimney or chute that could burn out while your crew is in the vicinity**
- ☐ **Always use an undercut line for downhill lines**
- ☐ **Always reference your IRPG for downhill line construction guidelines**

The correct answer is always use an undercut line for downhill lines.

Hand tool line construction safety

We continue to drill down on firelines by looking at constructing line with hand tools. Even though heavy equipment can construct a fireline much faster than hand crews, the use of hand tools for fireline construction is quite common. In remote, rugged or steep terrain, mechanized equipment is impractical, unsafe, or prohibited by environmental protection regulations.

Some safety tips for cutting control line by hand include:

- **Walk and work 10 ft. (3 m) apart**
- **Give a loud verbal warning—such as "tool coming through!"—when passing close to each other on a line, especially in smoke or darkness**
- **Control your tool throughout each stroke with stable footing, proper body position, and proper hand placement**
- **Use short strokes and avoid raising blades above your head**
- **If you see a potential threat, such as a rolling rock or a snake, simply yell "*Rock!*" or "*Snake!*" and point toward the threat**

Narration Script: Bulldozers are great, but some jobs still have to be done by hand. And before we get into specifics, it doesn't hurt to have a couple of safety reminders. You don't want to bury the head of your Pulaski in the foot of the person working next to you.

Hand tool crew organization

To make the best use of tools and personnel in various fuels, your IC has a few options for organizing hand crews. The two most common are:

- **One firefighter, one area**
- **Progressive line**

You will examine each type of crew organization in turn.

One firefighter, one area

The *one firefighter, one area* method assigns each crew member a few feet of the line. Each firefighter is responsible for completing that portion of the line before moving to another portion. There are two ways to accomplish the one firefighter, one area option for working the fireline:

- **Bumping up**
- **Leap frogging**

Crews often use these methods to construct a scratch line. The scratch line can be widened later into a full fireline.

Narration Script: There are two ways to make your "one firefighter, one area" moves on the fireline. The first is called "bumping up." When the last crew member in the tool order completes a portion of the line, he or she calls out, "Bump up!" Then the entire crew moves up the line to another portion. If the crew gets too far ahead of the last crew member, she will call out, "Hold and improve!" In this case, the other crew members will hold their position and continue to improve the line. Using these techniques eliminates the need for passing or "leap-frogging" withIN the crew. However, the leapfrogging technique is used when an ENTIRE crew completes their assigned portion and simply moves past other crews yelling, "Coming through!" Generally this technique is not used by individual crew members within an assigned portion of line.

Progressive line construction

With *progressive line construction* **(also called the *one-lick method*), the crew is arranged in a staggered line, and each member remains in position relative to the other members as the line construction progresses. Each member takes one stroke (*lick*) with the tool before moving one step forward to repeat the action. The crew works in unison until the line is completed. This method of line construction requires teamwork but promotes safety and efficiency because you never have to pass anyone else on the line.**

Narration Script: To make your progressive line moves on the fireline, the crew is arranged in a staggered line, and each member remains in position relative to the other members as the line construction progresses. Each member takes one lick with the tool, moves one step up the line, and then takes another lick. The crew keeps working in this manner until the line is done.

Tool order

Regardless of how a crew is organized, firefighters most often work along the line in what is called a *typical tool order*. **The type of fuel to be cleared dictates the order. No matter where you're working, the goal is always to cut effectively through the fuels and down to mineral earth.**

Fuels you might cut line in include:

- **Light**
- **Medium**
- **Heavy**

Read the following to learn more about each fuel type.

Light Fuels

In light fuels, such as pasture land or mowed field crops, all crew members may be best served by scraping tools such as McLeods, shovels, or swatters. Pulaskis may be used if needed to loosen hard soils.

Medium Fuels

In medium fuels, the typical tool order calls for:
1—Cutting tools such as brush hooks and saws
2—Followed by digging tools such as Pulaskis
3—Followed by scraping tools such as McLeods and shovels; use shovels to throw dirt for cooling a fire as well as scraping down to mineral earth

Heavy Fuels

In heavier fuels, your crew would be:
1—Led by members with chain saws or axes
2—Followed by brush hooks or Pulaskis
3—Followed by shovels and McLeods

Narration Script: Safe and efficient line construction depends on having the right tools for the job and using those tools properly. Some tools are more effective in certain fuel types than others, and knowledge of the fuel types and the topography at the fire will help you select the right tools. And as you learned in the Hand Tools Module, always inspect any tools you are issued to be sure they are sharp and in good condition.

Chain saws and leaf blowers

These last hand tools give crews a little mechanical advantage when building control line by hand:

- **Leaf blowers**
- **Chain saws**

Operators should always wear proper *personal protective equipment* **(PPE) when using these tools.**

Read the following to find out how these modern marvels can make the crew's life easier.

Leaf Blowers

If you need to cut the line through primarily dry leaf litter and duff, gasoline-powered leaf blowers can help. The blower easily scatters light, dry material to expose the bare soil beneath. Other firefighters carrying cutting and scraping tools may have to follow the blower operator to clear small bushes and clumps of grass from the line.

Chain Saws

Chain saws can make line construction much easier, but they must be used with care. Chain saws must be operated by crew members having appropriate training and PPE

Knowledge Check 7

Sequencing—select the number from the pull down list to put the items in the correct sequence

You're working in heavy fuels and you want to get the most out of your hand crew.

Place these tools in the correct tool order from leader to clean-up.

Shovels	1
McLeods	1
Chain saws	1
Brush hooks	1

The correct order is chain saws, brush hooks, shovels, and McLeods.

Use of water introduction

Cutting control line and burning out break the fire triangle by removing fuels. Another common way to disrupt the fire is remove heat, such as in wet line construction. We're talking about water here, in case you hadn't figured that out.

If you went through the Water Use Module, you learned that water, *foam*, and other additives have a variety of uses on the fireline. Many of the fire-control tactics you use on the fireline depend on water (with or without additives) as the primary extinguishing agent.

Narration Script: OK, now that we've got control lines and firing out of the way, we can finally begin talking about H_2O. Beyond cutting line, spraying water is the primary means of controlling wildland fire. If you've got the water, use it! In this section, we will introduce how water is used to build wet line.

Tactical uses of water

You'll probably be spraying H_2O when:

- **Making the initial attack**
- **Cooling hot spots to permit a direct attack**
- **Holding or strengthening control lines for burning out and backfiring**
- **Extinguishing spot fires**
- **Protecting exposed structures**

Narration Script: When laying a wet line during direct attack, use a straight stream or narrow fog pattern to knock down hot spots. But take care that you don't scatter burning fuel across the control line in the process. Direct your hose stream ahead and slightly inward toward the black so that any embers or burning fuel are blown into the black and not into the green.

Wet line introduction

You've seen line cut down to mineral earth and you've seen fire. Now it's time to talk about another type of control line—the wet line. A wet line is usually considered to be a temporary fireline created by water, foam, or *retardant***. Using water to construct a wet line can be a handy tool for quick *indirect* attack as well.**

Warning—Wet Line Limitations

A wet line by itself will not reliably stop an advancing fire. It is *not* a control line. For a wet line to be effective, you must burn it out to a regular control line or follow up with a fireline cut to mineral soil.

Narration Script: As you've seen so far in this topic, a lot of fires are put out without water. Now we turn our attention to using water and agents to assist in suppression. Laying down wet line is as simple as spraying water in the right location with an appropriate pattern and then following up with fire or hand tools to take the line down to mineral earth.

Wet line construction

You can build wet line with plain water, foam, or retardant from hoselines, helicopters, or *air tankers***. Any adjacent fuels are then burned out to widen the line. Just as with a direct attack, you always follow up a wet line by hand crews who construct a complete control line.**

As with any attack strategy, there are several considerations to ensure your wet line will work. In this case:

- **Additives**
- **Line location**
- **Nozzles and patterns**

You will examine each of these issues in turn.

Narration Script: For your wet line to be all it can be, consider using additives as well as placing and laying the line down correctly.

Wet line additives

Using water in conjunction with *penetrants* **is a common practice when building wet line. Water alone may not sufficiently wet:**

- **Fine fuels**
- **Duff**
- **Grasses**

Class A foam, **for example, is excellent for laying a wet line from where you want to start a burn out. When you use penetrants, the advantages are that you will extend your water supply and you can clearly see where the line is.**

Caption: An example of Class A foam.

Wet line location

The same factors that determine where you build control line should be taken into account when determining the location of your wet line. The distance required between the main fire and the wet line depends on:

- **Fire behavior**
- **Fuel types**
- **Topography**
- **Weather conditions**

Place the wet line far enough ahead of the flame front so you have time to burn it out and create an effective line before the fire reaches it.

Wet line nozzles and spray patterns

So how do you lay down a wet line? Normally it's just a matter of walking along slowly and weaving your nozzle back and forth to create a saturated area of the desired width.

Wet line construction requires proper techniques and selection of nozzles and spray patterns. The methods for wet line construction are the same as those used for direct fire attack:

- **Light fuels—When the fire is in light fuel and flame lengths are short, a narrow fog pattern from a nozzle delivering 6 to 24 gpm (22 to 90 l/min) may be sufficient.**
- **Heavy fuels—When compared to light fuels, for heavier fuels having greater flame lengths and thermal output, you may need a wider fog pattern at 23 to 95 gpm (87 to 360 l/min).**
- **Jackpots of fuel—When laying a wet line during indirect attack, don't waste water on jackpots of fuel—it is better to modify your line to avoid them.**

Warning—Adjustable Fog Nozzle

An adjustable fog nozzle is essential to provide a protective pattern for the nozzle operator in case of a flare-up. And know what you're getting into—make sure the gallons per minute output *exceeds* the thermal output expected on the fireline.

Narration Script: Laying down wet line isn't rocket science, but you do need to do it based on fuel types, slope, weather, and your equipment. And for goodness sake, make sure your hoseline doesn't get near the flames, and watch for jackpots of fuel. Your hose won't do much good if it's burning.

Knowledge Check 8

Multiple choice—check the box of the answer(s) you choose.

Identify THREE advantages of using Class A foam in your wet line.

- ☐ **Reduces manpower requirements**
- ☐ **Extends your water supply**
- ☐ **Contains more-intense fires**
- ☐ **Better wetting of fine fuels**
- ☐ **Controls tall flame lengths in heavy fuels**
- ☐ **Clearly shows line location**

The correct answers are better wetting of fine fuels, extends your water supply, and clearly shows line location.

Topic summary

If you want to do your job and do it well, there's a lot to know about suppression. We covered quite a bit of it in this topic, including:

- **Fire attack methods**
- **Suppression techniques**
- **Control line construction and positioning**
- **Threats to control lines**

- **Water use**
- **Wet line construction and location**

Remember—information is useful only if it's used! It's up to you to train and get the practical experience you need to translate this information into the field.

Narration Script: We have just scratched the surface of wildland fire suppression. This topic may have given you a good grounding, but there are numerous practical skills for you to acquire. Work with an instructor to drill on specific attack methods until they become second nature for you. Stay safe and have fun.

Topic 4: Heavy Equipment Operations and Airdrops

Topic introduction

Mechanized equipment can make your fire fighting duties easier and *control* **a** *wildland fire* **sooner. But the sheer size and the moving parts of the mechanized equipment used on the** *fireline* **poses risks to you and your fellow firefighters.**

In this topic, we'll look at how to tame those risks by:

- **Working safely around mechanized equipment**
- **Alerting equipment operators of your presence**
- **Using various communication signals to make the area safer**
- **Ensuring the safety of the entire** *hand crew*
- **Constructing a** *control line* **with mechanized equipment**
- **Cleaning up after a** *dozer* **has constructed the control line**
- **Preparing for the planned or unplanned** *airdrop*

So, start your engine and prepare for safety.

Narration Script: Better living through machinery? Well, maybe. Would you rather cut a fireline with a dozer or a McCleod? Obviously, machines can cut out lots of labor and save your energy for other tasks. But these machines demand respect. And if you don't keep a watchful eye on that piece of machinery you're working around, it could change from a useful tool into the "Terminator."

Mechanized fireline construction introduction

Now on to the fast and easy way to build control line—with mechanized equipment. *Topography* **permitting, there are various kinds of equipment, such as** *bulldozers***, graders (road maintainers), and** *tractor-plows***, available for constructing control lines.**

However, in areas where wildland fires occur frequently, mechanized equipment specifically designed for building control lines is a common sight.

Before discussing the use of *heavy equipment* **in fireline construction, the next section will begin by discussing safety considerations when working around this equipment.**

Narration Script: On a major wildland fire scene, nothing warms the heart of a tired firefighter leaning on a shovel like a bulldozer grinding by and building in seconds a line that would have taken him or her hours to do. If you've gone though the modules of this course in order, you should already be familiar with what types of heavy equipment there are, what they can do, and how to do it safely. Here we'll focus on some of the tactical applications of this equipment and how they are used to build fast and effective control line.

Heavy equipment operations

As a wildland firefighter, you will often be part of ground crews working around heavy equipment—equipment that can crush you in a heartbeat if something goes wrong. Understand the safety measures!

Here's what you need to know:

- **Hazards of working around heavy equipment**
- **Communication with operators**
- **Safety procedures for firefighters**

You will examine each subject in turn to do some "heavy equipment" lifting.

Narration Script: We move on from our discussion on apparatus safety, and now it's time to bring out the big guns! Even if you're not the operator, you need to be aware of the hazards and safety considerations when working around heavy equipment. So, whether it belongs to your agency or an outside contractor, get familiar with the specific safety concerns and guidelines for heavy equipment.

Heavy equipment hazards

Seeing potential hazards and being seen by equipment operators are two of your high-priority safety concerns.

Be alert at all times, especially when equipment is moving. Remember to look up, down, and around:

- **Always know where the equipment is. You've seen what happens to the things that a bulldozer runs over. You don't want to look like that!**
- **Watch for debris dislodged upslope. When a large rock or similar item becomes dislodged, it can roll down with sufficient speed to injure or kill anyone in its path.**
- **Watch for burning items dislodged upslope. Burning pinecones, logs, and other objects can roll down the hill and start fires below you and your crew.**

Keep going through this topic and we'll tell you how to avoid these hazards.

Narration Script: When working around heavy equipment, such as such as 'dozers, tractors, plows, and the vehicles that transport them, our first bit of safety advice is to look out and get out of the way! It's just common sense really.

Seeing and being seen

Because of the noise produced by running heavy equipment and by the fire, most equipment operators rely primarily on their vision to locate hazards. Never assume the operator knows where you are.

Stay visible to equipment operators at all times by:

- **Posting a** *lookout* **if your crew operates near heavy equipment**
- **Having proper** *personal protective equipment* **(PPE) to increase visibility—now you know why wildland PPE includes headlamps or chemical light sticks and reflective clothing**
- **Approaching carefully—night or day, approach mechanized equipment from the sides, only after being signaled to do so by the operator**

Narration Script: Remember the phrase, "children should be seen and not heard"? Around heavy equipment, you always want to be seen because there is no way that you will be heard at all above the noise from the equipment and fire. Post a lookout, keep your eyes open, and make sure operators can see you. Yelling and shouting will do you no good! If you can't see the operator, the operator can't see you.

Rapidly advancing fire and heavy equipment

Using heavy equipment also presents additional challenges when it comes to getting out of the way of a fire. Heavy equipment is usually slow moving and therefore vulnerable to being overrun by a rapidly advancing *fire front***. This is an obvious hazard for the operator, but it can also be a problem for you if the equipment blocks your** *escape route***. To avoid this predicament, operators and their support personnel must pay close attention to a** *fire's behavior* **and be prepared to withdraw into** *safety zones* **if the fire threatens their positions. Periodically, operators should use the equipment to develop safety zones.**

Knowledge Check 9

Multiple choice—check the box of the answer(s) you choose.

Slow-moving heavy equipment is vulnerable to being overrun by rapidly advancing fire.

Identify THREE safety precautions to prevent this occurrence.

- ☐ **Be prepared to withdraw into safety zones**
- ☐ **Pay close attention to a fire's behavior**
- ☐ **Work far in advance of equipment to provide reconnaissance**
- ☐ **Watch out for debris or burning items dislodged downslope**
- ☐ **Approach heavy equipment from the rear to warn operator**
- ☐ **Have equipment develop staging areas**
- ☐ **Keep an open path to your escape route**

The correct answers are pay close attention to a fire's behavior, be prepared to withdraw into safety zones, and keep an open path to your escape route.

Radio communication

Using heavy machinery as an overall strategy is often instrumental in successful wildland fire fighting. And communication with heavy equipment operators is a big part of that

strategy. Operators must talk to both supervisors and ground crews to integrate their equipment activities into the overall plan. Most important, operators must both give *and* receive information for the safe operation of the equipment.

This communication happens in two ways:
- **Via radios**
- **Through the equipment itself**

First let's talk about radios—because of the noise of the equipment, radio communication often requires that operators wear radios built into their hearing protection. Voice communication may be difficult or impossible except when the unit is stopped and throttled down.

Narration Script: A big part of the overall strategy is coordinating ground crews with equipment operators. And the way to do that is to communicate. Communication happens with radios between the operator and the ground crew.

Communication using engine signals

The second way that heavy equipment operators communicate is through the equipment itself—revving the motor is one way for the operator to communicate with the spotter on the ground:
- **Gunning the motor once means the operator wants the dozer helper to come to the dozer.**
- **Gunning the motor twice means the operator can't see the spotter.**

Next we'll discuss another way operators receive information about the safe operation of the equipment.

Narration Script: Communication also happens between operators and their spotters with the equipment's motor. One rev of the engine means the dozer helper should come to the dozer. Two revs mean the dozer operator cannot see the spotter.

Hand signals

When operators communicate with the ground crew, using either radio communication or hand signals, it saves time and reduces the chances of misunderstanding.

Agree upon a few simple hand signals to convey these messages in advance to aid the spotter or line supervisor in directing the activity of earth-moving equipment:
- **Stop—use a back and forth, waist high, swinging motion**
- **Come ahead—use an up and down motion from waist to arm's length above**
- **Turn—swing a flag or light on the side where the operator is to turn**
- **Reverse—use a full-circle arm motion in front of the spotter**

- **Caution—wave a flag or light in a half circle at arm's length above your head**
- **Attract operator's attention—you may also use one blast on a police whistle or suitable substitute**

Any time you need to refresh your memory on these signals, refer to the Incident Response Pocket Guide (IRPG).

Safety tips for firefighters

As a firefighter, you have a role in maintaining everyone's safety on the fireline.

When working around heavy equipment, firefighters should:
- **Assess the safety of the situation continually**
- **Never allow personnel to work on a *slope* below an operating dozer**
- **Shout "*Rock!*" if heavy equipment working upslope dislodges rocks or other materials that start rolling downhill**
- **Never try to get on or off heavy equipment while it is in motion**

Narration Script: Safety precautions are EVERYBODY'S responsibility—firefighter and operator alike. We all need to watch out for one another. For example, if you see a rock barreling down the hill, shout, "ROCK!" so you'll alert any firefighters who may be downhill. But of course, if they follow these rules, they never will be downhill from a dozer, will they?

Specific safety procedures for firefighters

Here are more specific safety precautions for firefighters when working around heavy equipment:
- **Clearance requirements**
- **Approach considerations**
- **Visibility issues**
- **Water usage guidelines**

Read the following to see your way through the specifics.

Clearance Requirements

The dozer or tractor always has the right of way. When working on a ground crew:
- **Stay at least 50 ft. (15 m) behind and at least 100 ft. (30 m) in front of operating bulldozers or tractor-plows**
- **In timber, stay back twice the height of any trees surrounding operating bulldozers or tractor-plows**
- **Be careful and maintain stable footing when working around winch cables**
- **Be alert to soft spots or bogs that could trip you up and put you in the danger zone**

Approach Considerations

- **Approach heavy equipment only when it is stopped and you have been signaled that it is okay to approach**
- **On approach, stay in full view of the heavy equipment operator at all times**
- **Do not sit or sleep when working on the fireline, near the fireline, or near heavy equipment—always find a safe area to rest**

Visibility Issues

- **Stay in full view of the heavy equipment operator at all times**
- **Wear helmet lights and reflective vests so you are more visible to equipment operators when working near heavy equipment at night**
- **Take extra precautions when visibility is poor**

Water Usage Guidelines

When heavy equipment and engines are working together:

- **Conserve water and let the equipment do as much line construction as possible**
- **Use the available water resources on hot spots and for keeping yourself and the equipment safe**

Safety precautions when working around engines

It's not just dozers and tractor plows you need to worry about—you have to be on your toes when working around engines and normal wildland fire fighting rigs.

To stay safe around engines:

- **Stay alert when an engine is moving**
- **Know the hazards of a charged hoseline**
- **Make certain nozzle operators and personnel nearby are wearing eye protection**
- **Look out for rolling materials when working uphill or downhill of equipment**
- **Be vigilant during night operations or poor visibility**
- **Keep your footing and watch out for shifting equipment (winches and jacks) when removing any stuck vehicle**

If you need a review of all the safety procedures when working around engines, be sure to look through the Transportation Safety Module.

Knowledge Check 10

Multiple choice—check the box of the answer(s) you choose.

What is the safety guideline when you're working on a ground crew in the trees with heavy equipment nearby?

- ☐ **Signal the operator to attract the operator's attention**
- ☐ **Stay back twice the height of surrounding trees**
- ☐ **Radio the operator to inform him of your location**
- ☐ **Get assigned to a different ground crew until heavy equipment is done with its tasks**

The correct answer is stay back twice the height of surrounding trees.

Mechanized line construction tactics

Dozers and other heavy equipment are powerful weapons against wildfire, but only if they're used correctly.

There are several considerations, including:

- **Coordinating with hand crews**
- **Working in pairs**
- **Using proper technique**
- **Restoration**

You will investigate each consideration in turn.

Narration Script: While these machines are expensive to operate, the speed they can construct a control line with makes them highly desirable. Of course, mechanized equipment can do more than cut control line—they can also construct temporary roads into a fire area to allow access by engines. But use them correctly!

Coordinating with hand crews

Mechanized control line construction normally takes place farther from a *fire's edge* **than hand-built lines. This prevents burning material from being buried by the equipment. Buried burning material may surface later and cause** *slopover* **or complicate** *mop-up***.**

Whether you are working on a hand crew or with an engine company, you may frequently have to follow up on control lines constructed by mechanized equipment. Your crew will improve and maintain these control lines, such as by bucking logs and felling *snags*. You will need hand tools, water, or both to *patrol* **the lines for spot fires and for doing mop-up.**

Dozer or tractor plow follow-up

When your hand crew is supporting heavy equipment during fireline construction, the equipment has done most of the work.

However, you will still have some follow-up steps to do, including:

- **Cleaning up combustible materials**
- **Breaking up machine piles and berms**
- **Fireproofing needed areas**
- **Preparing and burning out the control line**
- **Securing the control line**
- **Mopping up the interior**
- **Patrolling the control line**

Read the following to see more detail about completing the fireline.

Cleaning Up Combustible Material

You'll have to remove all combustible materials from the control line and be sure to extend the control line down to mineral soil, permafrost, or water level.

Breaking Up Machine Piles and Berms

The mounds or walls of earth outside or downhill of the side of a ditch or trench (called berms) may contain burning fuel that can smolder and eventually start up a new fire. If possible, use heavy equipment to break up these piles and berms.

Fireproofing Needed Areas

Include adjacent areas outside the control line in your fireproofing activities. These areas could be affected by radiant heat from inside the control line.

Preparing and Burning Out the Control Line

Use blacklining to secure the line. This means making sure there are no unburned fuels adjacent to the control line by burning out between the fire and the control line.

Securing the Control Line

Remove tree limbs so fire doesn't move from the ground into the canopy. Also, knock down any trees or snags threatening the control line's security. Usually, trained sawyers will be handling snags, so consult your crew boss with any questions before you attempt to move logs, limbs, or snags.

Mopping Up the Interior

It's easy to focus on the job at hand—so keep an eye out for any threats to the control line from inside the fire area.

Patrolling the Control Line

Patrol the area to locate and extinguish any hot spots after the control line has been constructed.

Working in pairs

Bulldozers and other heavy equipment are usually more efficient when operated in pairs. The operator of the lead bulldozer can rough out a control line and remove some of the *fuel***. The operator of the second machine can complete the line construction down to** *mineral soil***. This is not to mention the safety principles you should already know—by working in** *tandem* **operators can:**

- **Help each other if either machine becomes stuck or stalled**
- **Quickly build a safety zone if the operators' position is in danger of being overrun by fire**

Caption: An example of bulldozers working in tandem.

Using proper technique

The principles of mechanized control-line construction are essentially the same as those with hand crews. Operators should follow the principles for proper line locations that were covered earlier in this topic. Also, operators may need a swamper (also called a *line locator*) on foot to guide them in *heavy fuels* **or smoke. And as with hand crews, heavy equipment operators should push burning fuels well inside the line (into the** *black***) and push unburned materials to the control line.**

Restoration

Mechanized equipment can severely disturb the soil, leading to soil erosion later. Therefore, after mechanized equipment has been used, it may be necessary to restore or *rehab* **the area by removing berms and to create water channels and water bars for erosion protection. Each situation should be analyzed to determine the cost/benefit of any use of mechanized equipment.**

Knowledge Check 11

Multiple choice—check the box of the answer(s) you choose.

Identify TWO true statements about tactics associated with cutting control line with mechanized equipment.

- ☐ **Involves using the lead piece of heavy equipment to cut down to mineral soil**
- ☐ **Normally takes place farther from a fire's edge than hand-built lines**
- ☐ **Requires no follow-up by hand crews**
- ☐ **Always involves relocating flammable material inside the control line**
- ☐ **Requires effective communication between operators and ground personnel**

The correct statements are normally takes place father from a fire's edge than hand-built lines and requires effective communication between operators and ground personnel.

Drop-zone safety in ideal situations

Not only are engines and dozers used in the *fire suppression* **effort, but aircraft as well. When dealing with** *retardant* **and** *suppressant* **drops from aircraft, there are two** *drop zone* **safety situations to look at—one when conditions are ideal and one when they are not. In rare situations when conditions are ideal, retardants or suppressants dropped from** *air tankers* **will disperse in the air and fall to earth straight down in a fine mist. Even so, do everything you can to safely get out of the drop zone before the drop is made. Don't run unless you know you can escape. And as always, be sure to stay well away from snags.**

Narration Script: Air tankers drop water or retardants to put out the fire or to stop its forward movement. Be aware of these tankers and try to get safely out of the drop zone before the airdrop. You can be aware by practicing "look up, look down, and look around." And you should hear the sound of approaching aircraft as well. Also, your supervisor should be advised of scheduled or potential drops. And during your retreat, watch for snags! The weight of falling water or agents may cause snags to collapse on you.

Notice of an airdrop

In most cases, you'll know when an airdrop will happen in your area. When you know of an impending airdrop, you'll be able to take the right actions:

- **Indicate your presence—usually your supervisor will take care of this**
- **Move out of the area—try to be at least 200 ft. (61 m) perpendicular from the drop**

- **Stay away from large, old trees and snags—when possible, keep a distance 1.5 times the height of the nearest tree**
- **Determine when drops are completed**
- **Seize the moment once airdrops are completed and move back into the area quickly to take advantage of the retardant or water effects on the fire**
- **Keep in mind that retardant can make the area slick—and dangerous**

Drop-zone safety in less-than-ideal situations

Normally, airdrops of water or retardant hit the ground with a lot of speed and mass. You will get knocked down if an airdrop hits you while you are standing. The drop can also break tree limbs, move rocks, and launch you or your tools—posing additional hazards to anyone in the way.

If you can't get out of the drop zone in time, be aware that retardants are non-toxic. However, take these precautions:

- **Wash off as soon as you can if you are hit by retardant—otherwise your skin may become irritated**
- **Clean any retardant off of your equipment**
- **Be careful of your footing—coated surfaces are very slippery**

For these reasons, the safest thing to do is move out of the drop zone before the drop occurs.

Narration Script: In a less-than-ideal situation, the agent may hit the ground with a lot of speed and mass. If you are in the drop zone in this situation, take precautions to avoid the hazards of a direct hit and know what to do if the agent gets on you or your equipment, or in case you have to walk across terrain covered by retardant.

Getting stuck in the drop zone

If you cannot get out of the drop zone in time, your best bet is to get behind a solid object, such as a tractor, brush guard, boulder, or large, living tree. Make sure your helmet and goggles are secure.

If you get caught in the open, you've got a few other things to think about:

- **Get to where there is little loose rock and surface litter**
- **Wear your helmet and goggles**
- **Lie face down with your head *toward* the approaching aircraft**
- **Hold your helmet or something solid with one hand and your tools with the other hand to the side away from your body**
- **Spread your feet apart for stability**

After the initial drop, move out of area until you're sure no more drops are planned in that area.

Narration Script: If you get stuck in the drop zone, the good news is that you can protect yourself. If you're out in the open, find someplace that has as little loose rock and litter on the ground as possible But the best bet is to get behind a solid object, such as a boulder or large, living tree. In either case, make sure to have your helmet and goggles on securely. When caught in the open, lie face down with your head pointing towards the aircraft. Hold your helmet or chin strap in place with one hand and your hand tool with the other hand away from the side of your body. Make sure your feet are spread apart to help with stability.

Aircraft turbulence safety

Another hazard to watch out for in the drop zone is aircraft turbulence. Planes and helicopters flying at treetop level disturb the normal air patterns and create turbulence that will adversely affect fire behavior. In fixed-wing aircraft, the wingtip vortices (eddies formed at the wingtips) can create very erratic winds that can cause an increase in *intensity***. The same is true of** *rotor blast* **from low-flying helicopters. In addition, treetops and branches can be broken off by vortices from low-flying aircraft. The bottom line is to be especially vigilant on the ground when aircraft are around.**

Narration Script: Turbulence created by low-flying aircraft can cause erratic fire behavior. Keep alert and anticipate the fire's reaction. Remember Fire Order 3! Base all actions on current AND expected behavior of the fire.

Knowledge Check 12

Multiple choice—check the box of the answer(s) you choose.

A retardant drop is on its way and you've been caught in the open. You've made sure your helmet and goggles are on tight.

Identify FOUR additional steps you need to take.

- ☐ **Spread your feet apart for stability**
- ☐ **Radio the base to inform them of your situation**
- ☐ **Hold your helmet or chin strap in place**
- ☐ **Hold your hand tools to the side of your body**
- ☐ **Curl into the fetal position to minimize any retardant coating**
- ☐ **Leave any extra equipment near your feet**
- ☐ **Lie face down with your head toward the approaching aircraft**

The correct answers are spread your feet apart for stability, lie face down with your head toward the approaching aircraft, hold your helmet or chin strap in place, and hold your hand tools to the side of your body.

Topic summary

You now may have a better appreciation for the benefits and dangers of working with and around mechanized equipment. Mechanized equipment can make your fire fighting duties easier as long as you know how to work around them.

You should now have a good idea of how to:

- **Work safely around mechanized equipment**
- **Alert equipment operators of your presence**
- **Use various communication signals to make the area safer**
- **Ensure the safety of the entire hand crew**
- **Construct a control line with mechanized equipment**
- **Clean up after a dozer has constructed the control line**
- **Prepare for the planned or unplanned airdrop**

Your engine is revved for safety.

Narration Script: If you keep your wits about you and keep an eye out for your fellow firefighters—mechanized equipment can be an invaluable help to your fire fighting mission. There's nothing better than seeing a dozer work its way toward you after you've been cutting line for long hours. Machines have their place. Just make sure to keep *your* place around an operating machine.

Topic 5: Communication

Communication introduction

As a wildland *crew* **member, you will communicate any unusual situations to your supervisor—sometimes under duress or when time is a factor. Safe and efficient wildfire** *suppression* **is a direct result of effective communication. Unfortunately, no one communication method will be optimal in every situation.**

In this topic, we'll take you on a quick tour of commonly used fire ground communication techniques. Then we'll focus on the two-way portable radio and look at:

- **Means available for communication**
- **Radio frequencies**
- **Procedures and guidelines for proper use**
- **Transmission troubleshooting practices**
- **Radio care and maintenance**

If you've gone through the Preparedness, ICS, and Resources Module, you know by now that proper communication is a critical element of LCES, the Standard Fire Fighting Orders, and the "Watch-out!" situations.

Narration Script: As you'll soon find out, when you are fighting a wildland fire, you won't always be able to communicate with your team on a face-to-face basis. Fellow crew members might be out of ear shot, your supervisor might be out of sight, and the roar of the fire might overwhelm the loudest shouts.

Effective communication is essential to safe and efficient wildfire suppression. While there are many ways firefighters can communicate, the most common electronic communication tool is the portable radio. Light, durable, and able to access multiple channels, the portable radio can significantly enhance your crew's operational effectiveness. So tune in and turn up the volume. Among other things, we're going to be talking about radio frequencies, radio use, troubleshooting, and maintenance.

Means of communications

Some form of absolutely reliable communication is required between *lookouts* **and the crew and between adjacent divisions and** *Operations* **and** *Command***.**

Supervisors must verify communications at the beginning and throughout the work shift. This is most often done by radio, but radios are not always reliable in some areas. In these cases, direct voice communication is best, but some other ways to communicate, include:

- **Hand signals**
- **Signal flags**
- **Signal mirrors**
- **Whistles or air horns**

- **Runners**
- **Written messages**

Narration Script: Communication with the ICS organization and with crew members is critical at all times. And although we tend to take radios for granted, they may not work in hilly terrain or if traffic is heavy, or operational channels get messed up. Try another form of communication if radios aren't available or don't work. You might even try cell phones and pagers if you can get reception but only after all other communication methods have been attempted.

Communication plan

Communication is a two-way street. Before each work shift or assignment, get with your supervisor to make sure a communication plan is in place and that you know the details.

Learn from your supervisor:

- **What type of communication to use**
- **How often you must report**
- **What kind of information to report**
- **What types of signals to use, if necessary**
- **What backup communication plans are in place**

Handheld radios

Portable radios, often called by their brand names (such as Bendix King or EF Johnsons), are critical handheld tools allowing you to remain in contact with:

- **Other firefighters**
- *Apparatus* **operators**
- **Supervisors and other commanders**

Most portable radios have limited transmitting and receiving power, usually only 1 to 5 watts (compared to the 100 to 150 watts of a typical apparatus *mobile radio***). Therefore, portable radios also have limited range, perhaps less than 1 mi. (1.6 km) when you're communicating from portable to portable without the aid of a** *repeater***. Communications distances between portable radios and mobiles or base stations also vary depending on the** *topography* **and the capability of the mobile or** *base radio***.**

Narration Script: Prompt, dependable communication will always be vital to your fire suppression activities. When good radio reception is available, the two-way, or portable, radio will be your communication medium of choice. The two-way radio lets you communicate with crew members on or around the fireline. You can also give supervisors and support staff timely information, request reinforcements, order supplies, and ask for medical help—things that might be hard to do with mirrors or whistles.

Fire service radio frequencies

When using fire service radios, radio frequencies *cannot* be assigned arbitrarily or assumed unilaterally by any operating unit during an *incident*. When your crew is called to a fire, check your *pre-incident plan* and the communication element of the *incident action plan* (IAP) for that particular operational period to determine which frequencies your unit should use. Also, if your agency commonly works with other agencies on *wildland fires*, it probably has written or *working agreements* for mutual frequency use and sharing. Be sure to check these agreements, as well.

There are several classes of radios:

- **Low-band**
- **Very high frequency (VHF)/high-band**
- **Ultra high frequency (UHF)**

Read the following to learn more about each radio class.

Low-Band

Low-band radios:

- **Use a low frequency range**
- **Have waves that travel greater distances than high-band radios**
- **Have waves that can bend more easily around mountains and other obstructions**
- **Were used widely in wildland fire operations from the 1960s to the 1980s**

VHF/High-Band

VHF/high-band radios:

- **Operate from the upper end of the frequency modulation (FM) range—150 to 170 kHz**
- **Have waves that travel a shorter distance than low-band radios**
- **Need repeaters to increase range**
- **Are used frequently in wildland fire operations**

UHF

UHF radios:

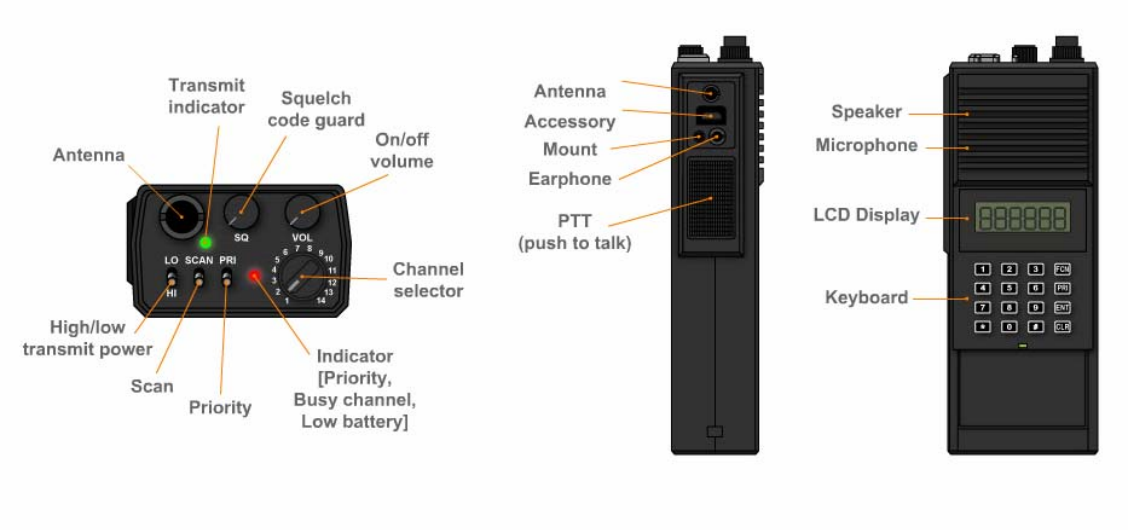
- **Use the next higher frequency band above VHF/high-band radios**
- **Have waves that travel short distances because waves are absorbed by trees and vegetative cover**
- **Are used primarily around fire base camp for the logistics section**

Narration Script: Radios work by sending out or transmitting waves of energy, called frequencies. Different radios send out and receive different frequencies. So, before you use fire service radios, get on the right frequency! Get to know how to use your radio correctly so you won't transmit on any frequency other than your assigned one. Talking over or between the radio traffic for other departments is a recipe for confusion.

Radio controls and functions

Here is what a portable, two-way radio looks like.

Narration Script: Chances are you'll encounter several kinds of radios—the portable, hand-carried, two-way radio; the mobile radio used in vehicles; and the permanent, base station radio. Here, we show you the hand-carried, two-way radio. Be sure you are familiar with your radio from top to bottom.



Caption: A top, side, and frontal view of a typical handheld radio.

Handheld radio channels

As with mobile radios on the apparatus, your portable radio may be capable of operating on multiple channels. Newer portables are capable of handling more than 200 channels. Portables may also have *scan* and *priority* functions that allow you to monitor multiple frequencies and select key frequencies for more frequent sampling. You may also have available to you portable radios that are field-programmable to the incident frequencies.

Some of these radios are capable of operating on disposable AA batteries, eliminating the need for a battery charger. However, never leave spent batteries at the scene—properly dispose of them.

Pre-planning communication procedures

Do you remember what we said about having a communication plan? The plan must also identify and address differences in communications *procedures* among agencies participating in large-scale operations. For example, don't use local or agency-specific radio codes. To eliminate confusion and ambiguity, use *clear text* when transmitting.

The essence of clear text is replacing *Ten-Codes* and any other agency-specific codes, acronyms, and abbreviations with plain English. However, there are certain standard

terms and phrases used in clear text. (For a complete list of clear-text terminology, see the *Clear Text Terminology* job aid available in the resources accompanying this course.)

While many terms are self-explanatory, others may have specific meanings but are sometimes misused because of regional differences.

Commonly confused clear text terms include:

- **A pumper is called an *engine*, not a truck.**
- **A *tanker* is an air tanker, not a mobile water supply apparatus.**
- **A mobile water supply apparatus is a *water tender*, not a tanker; some other support vehicles are also called *tenders*—dozer tenders, fuel tenders, helicopter tenders, etc.**

To avoid confusion on major ICS incidents, use *air tanker* **for aircraft and *water tender* for the wheeled tank vehicle.**

Narration Script: Basic radio etiquette calls for you to take a deep breath and organize your thoughts before you key your radio. Remember, the person you're talking to can't see what you see. You have to be calm but authoritative. This is normally described as "command presence" and can greatly facilitate communications. Also, avoid local jargon and 10-codes that may confuse firefighters from other jurisdictions.

Knowledge Check 13

Multiple choice—check the box of the answer(s) you choose.

Identify the THREE main classes of radios.

- ☐ **Ultra high frequency (UHF)**
- ☐ **Ultra low frequency (ULF)**
- ☐ **Median frequency**
- ☐ **Very high frequency (VHF)**
- ☐ **Low-band**
- ☐ **Medium low frequency**

The correct answers are very high frequency (VHF), low-band, and ultra high frequency (UHF).

Radio use guidelines

Your use of two-way fire service radios comes with a few guidelines, including:

- **Use them for official use only**
- **Give priority to all emergency radio traffic**
- **Use clear speech to relay messages**
- **Think before pushing the talk button**
- **Write down any messages you receive—have a pencil and note pad ready for messages**

Here is an especially important radio guideline—if you're reporting a serious injury or fatality, do not refer to the person by name or describe the extent of injury or condition.

Narration Script: Using fire service radios is a serious business, and you are to use them only for official use. They are NOT toys. Be professional in your radio use. Know what you are going to say before you talk, and when you do speak, relay your message clearly. Avoid saying "ah," or "um," and never use "CB" talk or other jargon. When you receive a message, write it down—and consider repeating the message back to the sender word for word. Always give emergency traffic the highest priority, and when you are reporting an injury or fatality, never refer to the person by name.

Radio use procedures

Follow these standard procedures when using your two-way radio:

- **Be courteous**
- **Do not use profanity and obscene language**
- **Answer calls promptly**
- **Be brief**
- **Declare an emergency by breaking into the radio traffic and asking that the channel be cleared for emergency traffic**
- **Talk into the microphone**
- **Use your normal tone of voice**

Here's a cautionary note for you—it might be illegal to use your local radio frequencies in another state. Make sure those frequencies are licensed by the Federal Communications Commission (FCC) for use in that state before using them.

Narration Script: Some standard procedures go along with your two-way radio use, such as being courteous, avoiding obscene language, and keeping your correspondences brief. Such procedures are just good common sense. If you need to declare an emergency, break into the radio traffic and ask that the channel be cleared for emergency traffic. And one last thing. In the course of your work, you might very well have to travel to a different state. Before you use your local, home-state radio frequencies in that new state, make sure those frequencies are licensed by the FCC. If your radio is not licensed in the state, you are breaking the law.

Transmitting and receiving procedures

Follow these radio use guidelines:

- **Wait for the person on the other end of the conversation to finish talking before you start**
- **When initiating a call, first transmit the station name or unit number of the person you are calling, then your own name or number**
- **Hold the microphone 2 to 4 in. (5 to 10 cm) away from your mouth and in a way that prevents wind from blowing into it**
- **Wait one full second after pressing the transmit button before speaking**

- **Answer the radio with your station name or unit number**
- **If more than one station calls simultaneously, following the proper procedure for call initiation will identify who needs to answer**
- **Close the call with the proper identifier—done by the person who initiated the call**

Narration Script: By now you are probably getting the message that using a two-way radio requires more attention to detail than you imagined. That's good, because during a fire, things can happen fast. When you know how to properly use your radio, messages are immediately understood, resulting in prompt action. Here are a few procedural guidelines you need to know about transmitting and receiving a message.

Radio troubleshooting

All the user guidelines in the world won't do you any good if your radio isn't working. For that reason, check your radio daily to make sure it's in tip-top shape. If your radio *is* in good working order and you are still unable to transmit, then one of the following might be the problem:

- **Radio traffic overload**
- **Poor location**
- **Low battery**
- **Loose antenna**
- **Operating on wrong channel**

Read the following to tune into some possible solutions for each problem.

Radio Traffic Overload

If you have a radio traffic overload, the solution is to wait a bit until the traffic clears.

Poor Location

Radio waves can't go everywhere. If you can't transmit or receive or your messages are not clear, you may be in a poor location. The possible solution depends on whether you are using a repeater or not. If you're not using a repeater, get into a clear line of sight with the person you are trying to communicate with and make sure there are no obstacles between you. If you are using a repeater, just changing your location a bit or getting out of a low spot may improve your transmissions.

Low Battery

It just might be the oldest trick in the book—but make sure you have power. Check your radio to see if it indicates a low battery. Also check to see if the batteries are properly installed.

Loose Antenna

A loose antenna could be the reason for poor transmission quality. Check your antenna to see if it is properly connected.

Operating on Wrong Channel

Check to make sure you are on the proper channel. With all of the physical activity happening in your work, the channel selector knob may have been bumped and you are no longer operating on the correct frequency.

Narration Script: Following the proper radio procedures and guidelines won't do you a whole lot of good if the radio just won't transmit or receive messages. Check your radio every day to make sure it's in good working order. If it is, and it still refuses to transmit, something else is the problem. There might be traffic overload, or you might be standing in the wrong spot. Other culprits are low batteries, a loose antenna, and an improper channel.

Radio care and maintenance

An ounce of prevention goes a long way in lowering the odds of having radio problems. Here are a few care and maintenance tips for you to follow:

- **Protect your radio from dust, moisture, fire retardant, excessive vibration, dropping, and extreme heat**
- **Keep your portable radio in its protective case**
- **Do not modify or attempt to repair your radio—instead, tell your supervisor or a qualified technician about the problem**
- **Do not use the antenna when pulling the radio from its case**

Knowledge Check 14

Multiple choice—check the box of the answer(s) you choose.

Proper radio use will result in prompt action.

Identify THREE procedures to follow when transmitting and receiving a radio message.

- ☐ **Wait five seconds between pressing the transmit button and speaking**
- ☐ **Hold the radio 2 to 4 in. (5 to 10 cm) from your mouth when speaking**
- ☐ **Answer the radio with your full name**
- ☐ **When calling, first transmit the station name or unit number of the other person**
- ☐ **Close the call with the proper identifier if you initiated the call**
- ☐ **State your station name and unit number three times during every call**

The correct answers are hold the radio 2 to 4 in. (5 to 10 cm) from your mouth when speaking; close the call with the proper identifier if you initiated the call; and when calling, first transmit the station name or unit number of the other person.

Communication summary

Without effective communication methods and tools, and especially without portable radios, your suppression activities would be more dangerous and time consuming. While no single communication technique fits every bill, two-way radios allow firefighters to exchange information quickly, clearly, and at great distances.

In this topic, you've examined:

- **Means of communication**
- **Radio frequencies**
- **Procedures and guidelines for proper use**
- **Transmission troubleshooting practices**
- **Radio care and maintenance**

Narration Script: Quick, clear communication is a prerequisite for wildland fire fighting. Since you'll seldom know ahead of time what the wildland fire conditions will be at an incident, an understanding of *all* your communication options is a "must." In this topic, you investigated some of those options, and the use, troubleshooting, and care of the portable radio, your communication tool of choice.

Topic 6: Patrolling and Securing the Fireline

Topic introduction

Some of your most significant fire fighting duties will begin *after* the *fireline* is constructed and the *incident* is said to be "under *control*." This is when you will be on *patrol* and engaged in the all-important *mop-up* phase to keep the *fire* from spreading. It's also the time when you will tap some of your more crucial fire fighting skills.

Mop-up and patrol require you to tap your skills of observation and fireline protection and to keep them tapped—sometimes for days or even weeks—because a single, undetected, burning ember could rekindle the fire and wipe out all your previous fire fighting efforts.

In this topic, we're going to show you the tricks of the mop-up trade, including:

- **Patrolling**
- *Cold trailing* **and restoration**
- **Mop-up methods and strategies**

Narration Script: After nine hours of fighting a tree and brush fire in Quagmire Canyon, your fireline is constructed and the incident is under control. Now, your crew is engaged in mop-up, and finally, you think you can relax. Think again. Unbeknownst to you, another member of your crew has just walked past a log that is still hot and failed to notice it. In three days, the log will produce a small flame that will rekindle into another, larger fire, once again putting you and your crew—and the outlying areas—at risk.

As you will see in the sections that follow, some of your most important fire fighting duties begin AFTER the fireline is constructed and the incident is under control. This is the mop-up stage, and it's when you have to tap, and maintain, your skills of observation and check every possible sign of fire. In this topic, we're going to be the prod in your back, enhancing your fireline savvy, raising your hot spot awareness, and sharpening your fireline stabilization skills.

Patrol introduction

Patrol is a part of mop-up. Often, however, they are performed at the same time, with patrollers keeping an eye out for areas that need mopping-up the most. As a patrol, you will be watching for *spot fires* and preventing *hot spots* from breaking over the part of the *control line* you are assigned to. Keep your eyes especially peeled for *smoldering* materials. They will need to be extinguished or tossed into the *black* and allowed to burn.

Depending on the size and amount of *fuel* still smoldering, patrolling may last from a few minutes to a few weeks. You might have to stay on patrol until you are sure the *fire edge* is completely out.

Narration Script: An important part of your fireline duties will be patrolling the line to keep it secure. Patrol is a part of mop-up, but they are often done at the same time with patrollers

leading the way. What you'll be watching for are spot fires and hot spots. Spot fires need to be extinguished, and hot spots, such as smoldering branches and limbs, chucked into the black. Patrolling requires a sharp, disciplined eye and sometimes, a lot of patience. Depending on the incident, your patrol could last anywhere from a few minutes to a few weeks—whatever it takes to make sure the fire edge is extinguished.

Understanding the patrol assignment

As a patrol, you will travel an assigned route to prevent, detect, and *suppress* **fires. Regardless of your assignment, consider working systematically in pairs, and always know the locations of your** *escape routes* **and** *safety zone***.**

But no matter what your patrol assignment is, make sure you are clear on its:

- **Purpose**
- **Coverage**
- **Information to report**

Read the following about each consideration to improve your patrol capabilities.

Purpose

Generally, the purpose of your patrol will be to:

- **Search the constructed line for weak areas, hot spots, and slopovers**
- **Reinforce the line, when necessary**
- **Look for spot fires outside the constructed line**

Coverage

When thinking about the coverage of your patrol, consider:

- **The assignment given you by your supervisor—make sure you understand your assignment clearly**
- **The condition of your coverage area**
- **Whether the area is fairly hot or includes a long section that is cold**
- **How often the area should be inspected—once every operational period or more frequently**
- **How often reports should be made**
- **How emergencies should be reported to the supervisor**

Information to Report

Information you should report during your patrol includes:

- **Any help you need**
- **The fire's behavior**
- **The presence of machinery**
- **Any existing hazards**

Narration Script: Where and what you patrol will depend on your assignment. But no matter what your assignment is, make sure you understand its purpose, its coverage, and the kind of information you need to report.

Spot fire conditions

Now that you have your assignment, it's time to begin your patrol. Your top priority will be searching for spot fires. Spot fires are a serious threat to any control effort and should be your number one priority during patrol. A spark or an ember may ignite another full-blown blaze, obliterating your control line efforts and forcing your *crew* **to start from scratch.**

Conditions that can lead to spot fires include:

- **Extremely dry weather**
- **Steep** *topography*
- *Heavy fuels*
- *Crown fires*
- *Whirlwinds* **or dust devils**
- **Torched-out, lone trees**
- **Wind across the fireline**
- **Punky logs and tree roots hidden beneath the fireline in the soil**
- *Snags*
- *Flashy fuels*

Even wildlife, such as rabbits, has been known to cause spot fire.

Narration Script: Now that you have your assignment, you need to begin your patrol. Your mandate is to find and extinguish all spot fires and mitigate the conditions that can cause them. Spot fires are insidious. Created from even the tiniest spark or ember, a spot fire can work its way into a blaze, destroy your control line efforts, and become a full-fledged incident.

Searching and finding spot fires

Because spot fires are such a threat, watch for them during fireline construction when you are patrolling areas outside the control line. When you are searching for spot fires in your assigned area, here's the process to follow:

- **Select two reference points in that area, such as trees**
- **Patrol the area between the reference points in a pattern parallel to the fireline**
- **Re-patrol the area at intervals depending on how threatening the fuels are in the area**

Here is what to do when you find a spot fire:

- **Report it to your supervisor**
- **Initiate attack and suppression activities**
- **Mark the area with flagging material all the way to the main fireline, if possible**

Narration Script: To search for spot fires in your assigned area of patrol, start by selecting two reference points, such as trees. Then systematically patrol the area between the reference points in a pattern parallel to the fireline. Keep patrolling the area as long as your supervisor thinks it is necessary or as conditions warrant.

Knowledge Check 15

Multiple choice—check the box of the answer(s) you choose.

Identify THREE things your patrol should do while searching for spot fires in your assigned area.

- ☐ **Create a fireline between the spot fire and the green**
- ☐ **Patrol area at intervals determined by fuel type**
- ☐ **Alert your crew and move briskly toward the safe area**
- ☐ **Patrol the area in a pattern that is parallel to the fireline**
- ☐ **Select two reference points in your assigned area**
- ☐ **Begin patrolling from the highest vantage point**

The correct answers are patrol the area in a pattern that is parallel to the fireline, patrol area at intervals determined by fuel type, and select two reference points in your assigned area.

Cold trailing and rehabilitation

There are two wildland wrap-up tasks that, while technically not part of the patrol process, are things you may do while patrolling. They are cold trailing and *rehabilitation*.

Cold trailing is a technique for *controlling* a partly dead fire edge. It includes carefully feeling with the hand to detect any fire, digging out every live spot, and *trenching* any live edge.

Rehabilitation (or rehab for short) is an attempt to prevent or reduce any additional damage resulting from the fire or fire fighting operations. For example:

- **If you cut a fence, repair it**
- **Where it is necessary and practical to do so, restore soil to prevent erosion**
- **Cover openings in structures damaged by the fire to protect them from vandalism or the elements**

Narration Script: While you're patrolling, you may take care of a couple of other wrap-up tasks. Making sure the control line is complete and no hot spots remain is intuitively called *cold trailing*. And if you had to cut through a fence or two, the rancher would probably really appreciate a repair job so the cows don't wander off. That's part of *rehab*—not to be confused with relaxing between shifts. Rehab in the sense covered here is yet another glamorous wrap-up task you have to do before you can go back to the station.

Mop-up introduction

Now let's talk about mop-up. Patrol and mop-up may take place simultaneously, but mop-up is usually the bigger and more taxing process. During mop-up, you are securing the fire scene, and it might require snag felling, trench digging, and widening the control line.

Mop-up is the inevitable aftermath of every wildland response. While complete extinguishment of all material burning within the black may be impractical in large fires, you should extinguish all smoldering material within a specified distance from the control line as indicated by your supervisor. As with patrol, mop-up must be thorough because a small spark or flame could rekindle, starting another and perhaps larger fire. If available, an infrared device or thermal imager may help locate hidden hot spots.

Warning—Mop-Up Is Dangerous Work!

During mop-up, continue to wear full protective gear and remain alert for changes in fire behavior and weather conditions. And watch your footing!

Narration Script: Now let's cover more details about mop-up. Once an attack is over and the control line has been built, it's time to mop up. Mop-up won't be as glamorous as your initial control activities, but it's critical nonetheless. It's also usually harder than patrol work, requiring more felling, digging, scraping, and trenching. In fact, mop-up can be difficult, dirty, and tiring, but we know you didn't become a firefighter so you could take it easy.

Dry and wet mop-up

You will be involved in two kinds of mop-up, and they both involve separating burning from unburned materials, extinguishing fires, and using hand tools.

***Dry mop-up* uses no water, *wetting agent*, or *retardant*. Instead, burning materials are extinguished using soil, hand tools, or piling.**

***Wet mop-up* uses water or water and soil together to extinguish burning materials that have been separated and exposed.**

Read the following to learn more about each method.

Dry Mop-Up

Dry mop-up has several forms:

- **Boneyarding, or bone piling—placing small, unburned limbs and logs in the black**
- **Chunking and piling—allowing materials to completely burn themselves out**
- **Spreading—dispersing heavy concentrations of materials to lower fire intensity**
- **Banking—covering fuels temporarily to prevent them from igniting**
- **Turning—moving materials that could roll so they are perpendicular to the slope, and then placing a cup trench below them**

Wet Mop-Up

There are several ways to do wet mop-up:

- **Apply a fine water spray from the control line inward**
- **Use a straight stream to penetrate or reach a target**
- **Spray, stir, and spray again as necessary**
- **Use foam or another wetting agent**
- **Break apart and spread fuel concentrations to lower fire intensity**

Narration Script: Mop-up takes two forms: dry mop-up and wet mop-up. As you would imagine, dry mop-up uses no wetting agent. Instead, burning materials are extinguished using hand tools, soil, or piling. In wet mop-up, you will first separate and expose burning materials using your hand tools, and then you will douse the materials with water, agents, and soil.

Mop-up hazards

You know by now to practice looking up, down, and around for hazards. Some hazards, such as bad weather rolling in, are common to all fire fighting efforts. However, as if mop-up isn't difficult enough, mop-up strategies come with their own hazards. Check out the hazards of:

- **Dry mop-up**
- **Wet mop-up**

Read the following to see what to watch out for when using each mop-up method.

Dry Mop-Up Hazards

Hazards to look out for during dry mop-up involve looking out for things that could fall on you including:

- **Overhanging and leaning trees**
- **Snags**
- **Broken branches or tree tops**
- **Large loose pieces of bark on the ground or attached to snags**
- **Trees weakened due to roots burning away**
- **Trees ready to fall but caught in other trees**

Also, be on the lookout for material rolling down steep slopes on your position. You could even be in for a nasty experience if you happened to disturb a bee or hornet nest when using your hand tools.

Wet Mop-Up Hazards

Hazards to look out for during wet mop-up include:

- **Hot rock, dirt particles, ash, charcoal ,and mud being blown around by water streams**
- **Steam and white ash being released from fire pits and hot stump holes when hit by water**
- **Footing becoming slippery due to water and agents on the ground**
- **Firefighters tripping or falling due to extensive hose lays**
- **Coworkers being hit by water streams—avoid injuring crew members by adjusting the hose nozzle from stream to spray before applying water in their direction**

Principles of mop-up

So how do you go about mopping up after a *wildland fire***? Begin by keeping the following principles in mind:**

- **Start mop-up as soon as line construction and** *burnout* **are complete**
- **Mop up the most threatening areas first**
- **Allow fuel to burn out if it will do so quickly and safely**
- **Mop up the entire area on small fires if practical**
- **Use water in conjunction with hand tools where possible or practical**
- **Stir and mix hot embers with dirt in dry mop-up**
- **Use water sparingly, but use enough to do the job**
- **Scrape or stir fuels while applying water in deep-burning fuels, such as** *duff***, peat, or needles**
- **Use** *penetrants***, especially in deep-burning fuels**
- **Cold trail where applicable**

Caution—Testing for Heat

When using your hands during mop-up, place the back of your bare hand close to but not in contact with the fuel to test for heat.

Narration Script: Here is a quick overview of some good things to keep in mind when mopping up. Next we'll go into more details.

Systematic mop-up

On small fires where adequate *resources* **are available, mop-up involves having crews extinguish all burning materials completely. However, if you have a large fire or a lot of burning materials, complete extinguishment may be impractical. In such cases, you will need to follow partial but systematic mop-up methods instead.**

Systematic mop-up guidelines include:

- **Starting with the hottest area and progressing to the coolest**
- **Planning a beginning and ending point**

- **Sticking to the plan and working methodically**
- **Working inward from the control line**
- **Examining the entire assigned area**

You might need to implement some kind of grid or block system when you face large burns or complicated situations. If you do, set your priorities, number each block, and work each block systematically.

Narration Script: When a fire is too big, or when you are faced with too much burning material, you can enhance your safety by approaching mop-up operations systematically. When you are involved in systematic mop-up, make sure you are clear on all instructions—ask questions whenever necessary.

Using your senses

Mop-up requires you to get up close and personal with any potential trouble spots. These hot areas are not only areas to mop up, but they also pose burn and scald injuries to you if you step or reach into them.

You have to find the hot materials before you can mop them up, so you'll need to use common good sense. In fact, mop-up requires you to use *four* common senses:
- **Sight**
- **Smell**
- **Hearing**
- **Touch**

Read the following to make sense about each sense.

Sight

Use your eyes to look for these warning signs:
- **Smoke—look up as well as down—a treetop may be on fire**
- **Heat waves**
- **White ash—this indicates great heat and the ash may actually be covering hot embers**
- **Stump holes—be careful not to collapse the edge because hot embers or steam could lie within**
- **Steam—steam indicates great heat**
- **Gnats—gnats often hover over hot spots**

Smell

Use your nose and try to smell these tell-tale odors:
- **Smoke—see if you can learn the difference between live smoke and old smoke**
- **Burning materials—such materials emit gases containing their own smell**

Hearing

Use your ears to listen for:

- **The crack and pop of burning material**
- **The hiss of water as it touches hot materials**

Touch

Once your other senses tell you it is safe to do so, take off your glove and carefully use your bare hand to determine the heat content in burned materials. Hold it about 1 in. (2 cm) from the item, and carefully move the back of your hand closer to the item. Then if you don't feel heat that way, touch the item with the back of your hand to see if you feel any heat.

Narration Script: Another way to stay safe during mop-up is to use good sense—that is, your good sense of sight, touch, smell, and hearing.

Knowledge Check 16

Multiple choice—check the box of the answer(s) you choose.

Identify FOUR guidelines to follow when performing systematic mop-up.

- ☐ **Stay in the green during wet mop-up**
- ☐ **Start with the hottest area and progress to the coolest**
- ☐ **Fell unburned trees on steep terrain**
- ☐ **Implement a grid system when faced with complicated situations**
- ☐ **Plan a beginning and an ending point**
- ☐ **Check for cool areas by holding a gloved hand over hot areas**
- ☐ **Work inward from the control line**

The correct answers are start with the hottest area and progress to the coolest, implement a grid system when faced with complicated situations, plan a beginning and an ending point, and work inward from the control line.

Specific mop-up concerns

The goal of your mop-up activities is to strengthen the fireline. To do this, there are specific techniques to deal with specific situations:

- **Burning logs too large to move**
- **Burning material near fireline**
- **Fuels outside of (but adjacent to) fireline**
- **Burning snags**
- **Stumps and logs near fireline**
- **Burning chunks, limbs, and small logs**
- **Covered fuels**

You will examine each situation in turn to soak up some useful knowledge.

Narration Script: Now that you have an idea of general mop-up principles, take a look at some specific techniques. While some of these tips may seem repetitive, you need to be able to apply good mop-up techniques in a variety of situations.

Burning logs too large to move

When faced with a burning log that is too big to move:

- **Work from the cool end or edge of the log to avoid burning your feet**
- **Remove hot coals and *ashes* from beneath logs**
- **Cool hot logs with dirt or water**
- **Mix hot ground with cool earth**
- **Use water or dirt and scraping alternately until the fire is out**
- **Have logs cut to separate burning and unburned sections (if a chain saw and an operator are available)**

Narration Script: When you're dealing with a burning log that is too big to move, start at the cool end. Your other crewmates can scrape the log and dig under it to expose other burning material. While continuing to cool the log with water, shovels can be used to throw dirt on it and expose other hot material below it. Keep repeating this process until you are sure the log is completely cooled. Don't hesitate to call in a chain saw crew if you need to.

Burning material near fireline

When dealing with burning material near your fireline:

- **Scatter fuel well back from the line into the black and allow it to burn**
- **Cool heavy burning materials with dirt or water**
- **Mop up individual logs and stumps as soon as they are cool enough to handle**

Fuels outside of fireline

Unburned material near the fireline needs special attention:

- **Remove unburned fuel that is outside of but adjacent to the fireline by scattering it into the *green* away from the fire**
- **Remove any partially burned fuels by throwing them into the black**

Snag burning on the top

For safety, always flag snags or post a *lookout* a safe distance away to watch for and warn firefighters of falling tops or limbs. If a snag is burning above your reach, scrape away all hot materials from the base of the snag and cool the hot ground with water or by mixing with cool dirt. If the lean of a snag allows, fell it into the black with the *slope*, not across it. If the lean could cause the snag to fall into the green, scrape *combustible* fuels from the

space where the snag will fall. Once you have the snag down, scrape all burning material from its surface and extinguish with water or dirt.

Warning—Snags and Trees

Beware of snags and trees that could fall and of material that could come loose and roll downhill and hit you during mop-up. Fell snags as soon as possible when inside the mop-up zone.

Narration Script: If you encounter a tall snag that is burning or smoldering at the top, then your crew should scrape around the snag and spray it down. The ultimate goal is to get it down without spreading the fire, so anticipate where it will fall and start clearing that area, if necessary. Once you have it down, treat it like a burning log.

Snags burning at the base

If a snag is burning at its base only:

- **Make sure the snag is stable and won't fall as you are working under it**
- **Scrape away the hot coals and ashes and cool the hot ground with water or dirt**
- **Chop or scrape away burning portions of the snag with an axe or shovel**
- **Peel off loose bark as high as can be reached**
- **Extinguish burning material, including sparks or embers in cracks, with water or dirt**
- **Remove burned material from the snag and scatter it into the black**

Narration Script: If the snag you are dealing with is only burning or smoldering at the bottom, make sure the snag is stable enough for you to work around it and then scrape around the snag and spray it down. Use the proper tools to remove any burning material and peel off any loose bark as high up the tree as you can. Be sure to deal with burning material by extinguishing it and scattering it away from the snag. And make sure your job is thorough; make sure there are no embers or sparks inside cracks in the trunk.

Stumps or logs near fireline

Stumps and logs present a few common hazards that can be dealt with if you're smart and thorough:

- **Uncover and remove burning portions of any roots extending under the fireline**
- **Trench below any stumps or logs burning on steep slopes**
- **Move logs to lie with the slope so they don't roll, if possible—some logs may have to be cut in several pieces to accomplish this**

Narration Script: When you're dealing with stumps and logs during mop-up, you don't want fire burning under your fireline and popping up in the green. So, uncover and remove burning portions of any roots that extend under the fireline. To catch rolling embers, trench below any stumps or logs burning on steep slopes. And for your own safety, always work uphill of logs that are to be moved. Try to turn logs to lie with the slope, not across it. But some logs will be too big

to move or will be too dangerous if they roll out of control. If this is the case, cut them into shorter lengths until you are able to turn them inline with the slope.

Burning chunks, limbs, and small logs

To handle burning material on a steep slope, dig a trench close to but downhill from any burning materials and place the material in the trench to burn. Work the entire burned area systematically using water or dirt to cool the burning material.

Test limbs and other materials for heat with the back of your bare hand, then:

- **If you detect no heat this way, pick the material up and feel it with your hands**
- **If the material is no longer burning, spread it in an area within the black that has been cleared of all burning or hot fuels (this technique is called** *boneyarding***).**

Covered fuels

Covered fuels can smolder, re-ignite, and hide dangerous conditions. The most notable kinds of covered fuels are machine piles, *surface***, and** *subsurface ground fuels***.**

Machine piles include *dozer* **piles, pushups, and** *berms* **created when agencies use** *heavy equipment* **to build control lines or as a result of large cup trenches on steep slopes constructed by** *hand crews***. Machine pile hazards include:**

- **Trees or branches springing under tension and striking firefighters**
- **Unstable footing causing fall injuries**
- **Burn injuries from contact with pockets of hot coals**
- **Failure to recognize hazards due to reduced night vision**
- **Berms and logs falling on personnel**
- **Injuries due to crew fatigue**

Narration Script: When it comes to mop-up dangers, covered fuels are most threatening. They can be like a bear trap lying in wait. There are two kinds of covered fuels: machine piles and ground fuels. We'll look at machine piles first. They are large and sometimes high piles of fuel created when dozers, tractor plows, or even hand crews build control lines.

Break up and disperse machine piles

The next step with machine piles is to separate fuels and hot dirt with hand tools or heavy equipment. After separating the fuels, what you do next depends on whether the fuels are unburned or burning:

- **Unburned fuels—scatter and throw fuels outside the control line in the green. Do not create new piles.**
- **Burning fuels—disperse them inside the control line. You can also choose to put them in piles in the black instead. Once in piles, you can burn them completely and finish by scattering the consumed fuels to dissipate the heat of the fuels.**

After you've dealt with as much of the unburned and burning fuels in the pile as you can, cool the remaining hot materials with dirt, water, or agents. Finish by completely extinguishing any remaining burning fuels.

Narration Script: To keep machine piles from spreading the fire, your tactic is to break up or separate them all the while being aware of the hazards we covered in the previous section. But once you've separated the fuels, what do you do after that? It depends on whether the materials are unburned or burning. Read about all the details here.

Subsurface ground fuels

Another form of covered fuel is ground fuel. Such fuels might be more dangerous than machine piles because you might not see them to begin with, and they might contain hot or burning coals and embers. Take care not to step or fall into one!

Covered ground fuels include:

- **Coal seams—naturally formed layers of coal within the ground; once on fire, such fuels can burn indefinitely**
- **Peat bogs—dry peat bogs are highly combustible**
- **Heavy duff in timber and natural fuel accumulations**

To mitigate fires in these fuels, first dig out and disperse any burning materials. Then extinguish all remaining hot spots. Hand tools may not be enough. Use heavy equipment to extinguish the ground fuel fire, if necessary.

Narration Script: Ground fuels, including surface and subsurface fuels are other forms of covered fuels. The problem with ground fuels is that you might not be able to see them. Watch out! Don't step or fall into one, because ground fuel traps such as coal seams and peat bogs contain hot or burning embers.

Knowledge Check 17

Matching—select the match you choose from the pull down list.

It's been a long day of attacking fire and cutting control line. The fire is out, but your day isn't over yet.

Match each mop-up situation to the appropriate action.

All smoldering material	Turn to lie with the slope
Testing for heat	Turn to lie with the slope
Hot material on a slope	Turn to lie with the slope
Snag burning at the top	Turn to lie with the slope
Log on a slope	Turn to lie with the slope
Snag burning at base	Turn to lie with the slope

The correct matches are as follows:
All smoldering material: Extinguished within a specified distance of the control line
Testing for heat: Bare back of hand close but not touching
Hot material on a slope: Trench on downhill side
Snag burning at the top: Fell into the black
Log on a slope: Turn to lie with the slope
Snag burning at base: Peel off loose bark

Using agents for wet mop-up

When performing wet mop-up, sometimes water is not enough. You should consider using *foam* **or other wetting agents as well. When using these agents, consider these application tips:**

- **Apply directly onto burning fuel with** *adjustable fog nozzle*
- **Use sufficient volume**
- **Use repeated applications for dense fuels**
- **Use in conjunction with hand tools**

Caution—Corrosive Hazards of Agents

Remember to flush the tank and pump system after using wetting agents. Like any soap or detergent, wetting agents and Class A foam are corrosive and will cause damage to valves and proportioning devices if allowed to remain in contact.

Narration Script: You usually apply wet water directly onto burning fuel with an adjustable fog nozzle. Be sure to apply it in sufficient volume to allow it to penetrate the fuel without being vaporized by the heat of the fire. Even with the superior extinguishing characteristics of wet water, dense fuels such as logs, fence posts, cow chips, or heavily matted grass may require repeated applications coupled with the use of hand tools such as Pulaskis or McLeods to completely extinguish any deep-seated fire.

Long-term vs. short-term retardants

It is important to understand the difference between the two most common retardants you will use for wet mop-up, so look at:

- **Long-term retardants**
- **Short-term retardants**

Both long-term and short-term agents must meet strict federal environmental standards regarding corrosiveness and water pollution potential.

Read the following about each type of retardant to find out what you're dealing with.

Long-Term Retardants

Long-term retardants have an added ingredient called *thickener*. One brand uses what they call *Y-P Salt Soda*. This additive increases the viscosity to provide greater density. Density is desirable for canopy penetration when using airdrops in heavily forested zones or segments of a fire. About 1/4 in. (6.5 mm) of rainfall will totally dissipate long-term agents, even after they have dried to a crust-like finish on vegetation.

Short-Term Retardants

Short-term agents lack the thickener ingredient used in long-term agents. This makes them "wetter" and so they are better for penetrating and adhering to lighter fuels. While short-term agents are normally used as suppressants, they can still be relied on as retarding agents in grass and light brush. Short-term agents do not form as much of a crust as long-term retardants. Therefore, they can be diluted with less moisture than long-term retardants.

Foaming agents

There are two classes of foam used for fire fighting:

- *Class A foam* **is for use on** *Class A fuels***, such as grass and wood.**
- ***Class B foam*** **is for use on Class B fuels, such as** *flammable* **and combustible liquids.**

We'll only discuss Class A here because that's what you'll be using in the wildland environment.

Narration Script: Foaming agents have a wide variety of uses in wildland fire fighting. While they are simple to use, you have to keep in mind that the class and type of additive must match the fuel where it is used—for example, Class A foam is ineffective on Class B fuels and vice versa. Because Class A foam is what you'll be seeing on wildland fires, we won't get into Class B at all.

Class A foam

You generate Class A foam in two distinct steps:
1—Mechanically combine water and 0.1 to 1.0 percent foam concentrate to produce a foam solution
2—Add air to the foam solution (*aerating*) to produce foam

Foaming agents multiply the effectiveness of water as an extinguishing agent, which increases the amount of fire you can suppress with a limited amount of water.

Class A foam actually has two roles:
- **Primary role—Acts as a penetrant by decreasing the surface tension of water**
- **Secondary role—Acts as a retardant by insulating the fuel, reflecting *heat*, suppressing fuel vapors, and excluding oxygen from the combustion process**

Narration Script: Class A foam is the stuff. It can make your suppression activities so much more satisfying because it helps you put the fire out more efficiently. It's the most common penetrant you'll use, but it also has some secondary retardant properties that you should not overlook.

Class A foam characteristics

You need different types of Class A foam for different purposes on the fireground. In this context, "type" refers to the combination of:
- **Drain time**
- **Expansion ratio**

A foam with a fast drain time and a low *expansion* ratio behaves differently from a foam with a slow drain time and a high expansion ratio.

Read the following to find out more about each factor.

Drain Time

Drain time is the amount of time it takes for a given amount of foam solution to drain from the foam mass. This time is an indication of the foam's performance and durability:
- **Foam with a fast drain time is best used where quick cooling is needed such as in flame knockdown and mop-up.**
- **Foam with a slower drain time is better suited for exposure protection where a more insulating effect is needed.**

Expansion Ratio

Expansion ratio refers to the amount of finished foam you can produce from a given amount of water and foam concentrate. In other words, it is the volume of foam divided by the volume of foam solution used to produce it. Expansion ratio is determined by the characteristics of the foam solution and the means by which air is introduced. You can

introduce air with compressed air foam systems (CAFS) or air-aspirating nozzles. Depending upon the volume of air introduced and the method of its introduction, the same concentration of foam solution can produce foam with different expansion ratios.

Low-expansion foam

If you're smart, you'll adjust the type of foam you use to the specific fire situations created by various wildland fuels. In the low-expansion category—the one most used because of its versatility and excellent stream reach—there are four common types:

- **Foam solution**
- **Wet foam**
- **Fluid foam**
- **Dry foam**

Read the following to see which you should lather up with and why.

Foam Solution

Use foam solution as an extinguishing agent only during mop-up when maximum penetration and wetting is needed. The characteristics of foam solution are:

- **Clear to milky-colored liquid**
- **Lacks bubble structure**
- **Mostly water**

Wet Foam

Wet foam penetrates surface fuels rapidly and cools them well. The characteristics of wet foam are:

- **Watery**
- **Large to small bubbles**
- **Lacks body**
- **Fast drain times**

Fluid Foam

Fluid foam adheres well to foliage and drains readily, wetting the foliage in the process. The characteristics of fluid foam are:

- **Similar to watery shaving cream**
- **Medium to small bubbles**
- **Flows easily**
- **Moderate drain times**

Dry Foam

Since dry foam coats and adheres well to vertical surfaces and drains slowly, it may be well suited for pretreating exposures. The characteristics of dry foam are:

- **Similar to shaving cream**
- **Medium to small bubbles**
- **Mostly air**
- **Clings to vertical surfaces**
- **Slow drain times**

Caution When Mixing Foam

Do not mix foams or foam types from different manufacturers. Doing so may cause the solution to gel inside the tank.

Narration Script: Because of its versatility and greater stream reach, low-expansion foam is the type most often used in wildland fire fighting. There are several flavors with which you ought to be familiar.

Knowledge Check 18

Multiple choice—check the box of the answer(s) you choose.

You're involved in a mop-up operation in heavy fuels.

What characteristics are you calling for in your foam?

- ☐ **Medium expansion wet foam**
- ☐ **High expansion fluid foam**
- ☐ **Low expansion dry foam**
- ☐ **Low expansion foam solution**

The correct answer is low expansion foam solution.

Mop-up summary

Mop-up begins once the control line is built and the incident is under control. It's then you may need to be most keenly aware, when you must rely on your senses to detect any threat of rekindled fire. It's also the time when you must exercise your knowledge of crucial mop-up and patrolling tactics.

In this topic, we've examined:

- **Patrolling**
- **Cold trailing and restoration**
- **Mop-up methods and strategies**

Narration Script: Keen senses, an alert mind, and impeccable skills are your top priorities during the mop-up phase. Just because a fire is “under control” doesn’t mean a new one can’t rekindle from a single glowing ember. Take it for granted that those barely perceptible embers and sparks, and those hot spots, are there. And never let down your guard. In this topic, you’ve examined ways to keep your edge as you secure the fireline.