

External Sprinkler Systems and Defensible Space: Lessons Learned from the Ham Lake Fire and the Gunflint Trail



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Executive Summary

In May 2007, the Ham Lake Fire burned approximately 76,000 acres through the Gunflint Trail in Cook County, in northeast Minnesota, an area populated with homes, cabins, and businesses, as well as into Ontario, Canada. This area had more than 100 homes and businesses equipped with wildfire sprinkler systems, due to a unique set of circumstances—the 1999 extreme wind event or “the blowdown”, a FEMA Hazard Mitigation grant, local fire department leadership, and entrepreneurial efforts. While sprinkler systems have been used extensively outside the United States, primarily in Canada and Australia, they are rarely used within the United States for structure protection.

The Ham Lake wildfire experience with the sprinkler systems as one component of wildfire preparedness demonstrated that the systems, when properly installed and maintained, can be extremely effective in protecting not only the built structure but also the trees and vegetation within the sprinkler area. Of the threatened structures on the Gunflint Trail that burned in the Seagull Lake and Saganaga Lake areas, only one had a working sprinkler. Of the threatened structures that survived, 72% had working sprinklers. All but one structure with a working sprinkler system survived the fire. This study could not systematically examine defensible space status of properties and only provides anecdotal evidence of the sprinklers, defensible space, and structure survival.

While working sprinkler systems did provide protection from wildfire, several issues emerged that rendered some sprinkler systems ineffective. One important issue was the lack of proper maintenance and testing of the systems. This resulted in sprinkler systems useless for structure protection, but also increased the danger for the firefighters who were in the path of the fire while attempting to get the systems working.

Environmental conditions influenced the fire event and created challenges for the sprinklers. The Ham Lake Fire was a fast-moving, wind-driven, early spring fire exhibiting extreme fire behavior with crowning and spotting. It was of primarily low to medium intensity, though some areas of high intensity were observed in developed areas. Fuel types were primarily jack pine and aspen/birch/spruce with some balsam fir and upland black spruce (USDA-Forest Service 2007). But with the possible exception of one structure that burned that *may* have had a sprinkler running, no structure with a functional sprinkler system was lost to the Ham Lake Fire. This was true regardless of fire behavior, intensity, surrounding fuels, or wind.

This report documents the lessons learned about sprinkler systems during the Ham Lake Fire and the reflections of those who were involved and continue to be involved with wildfire preparedness and suppression efforts along the Gunflint Trail. In fall 2007, we spoke with firefighters, homeowners, sprinkler system installers, and decision makers who all contributed to the following findings and recommendations for homeowners. In addition, we used aerial photos taken before the Ham Lake Fire to assess defensible space for the Seagull Lake homes in the burn area.

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Introduction

Wildfire sprinkler systems for structure protection have been in use for several years in Canada and Australia (Merson 2006, SA Country Fire Service 2000, Mitchell 2006), but rarely in the United States. After the 1999 extreme wind-event known as the “blowdown” in northern Minnesota increased the fuel load for potential wildfires, local awareness of the danger of catastrophic wildfire grew. As part of the Gunflint Trail community’s wildfire preparedness efforts, sprinkler systems were promoted. In 2000, Cook County received a federal Hazard Mitigation grant from the Federal Emergency Management Agency (FEMA), which enabled the widespread installation of wildfire sprinkler systems in the Gunflint Trail community. FEMA provided 75% of the cost of installation, and more than 130 sprinkler systems were installed for homes and business on the Gunflint Trail. Since then, the number of sprinkler systems on the Gunflint Trail has more than doubled.

During wildfires in 2005 and 2006, homeowners used the sprinkler systems, but they were not directly tested by wildfire. The Ham Lake Fire in May 2007 was the first direct wildfire test of the systems. It burned approximately 76,000 acres of land in northern Cook County, Minnesota (Appendix A: Figure A-1) and Ontario, Canada. The fire consumed many homes, but many more were saved. It is thought that the number of homes saved was largely due to the presence of wildfire sprinkler systems. However, another factor that may have played a part is defensible space. This report presents a summary of experiences with the wildfire sprinkler systems during the Ham Lake Fire and recommendations for informing homeowners about the use and maintenance of sprinkler systems. Findings are based on observations of burned areas, GIS analysis of defensible space as well as interviews with fire fighters and other public safety and emergency management personnel who fought the Ham Lake fire and worked

with the sprinkler systems as well as USDA-Forest Service and Minnesota DNR fire experts, hydraulics experts, and a Minnesota DNR Hydrologist.

Background

Prior to the Ham Lake Fire in May 2007, wildfire sprinkler systems were deployed during three separate fire incidents: the Alpine Fire in summer 2005, the Cavity Lake Fire in summer 2006, and the East Zone Complex Fires in September 2006. These wildfire sprinklers existed because extreme fuel loading after the 1999 blowdown led to increased awareness among residents about wildfire risk and ways they could mitigate their risk. Community and homeowner efforts included preparation and testing of Gunflint Trail evacuation plans, Firewise efforts, and the installation of wildfire sprinkler systems. In 2000, more than 130 sprinkler systems were installed with FEMA grants; the current number of systems in place is estimated to be approximately 300 (Cook County Assessor, personal communications with installers).

The summer of 2005 was the first test for the wildfire sprinkler systems with the Alpine Lake Fire that started west of Seagull Lake. During the Alpine Lake Fire, homes and other structures were threatened on the upper Gunflint Trail (primarily on Seagull Lake and Saganaga Lake). Evacuation plans were in place and ready but ultimately not ordered; the fire was contained without hitting developed areas.

In July 2006, the Cavity Lake Fire started in a location southwest of Seagull Lake. It was an intense, plume-dominated fire in an area of blowdown fuels, ultimately burning 32,000 acres. This fire burned some of the southern and western shoreline of Seagull Lake, as well as a few islands in the lake. Evacuation plans were again ready for implementation, and sprinkler systems on Seagull Lake and Saganaga Lake structures were started. Previously prescribed-burn lands in the path of the fire helped slow the blaze, weather patterns shifted,

and the fire did not touch threatened structures. Later the same year, the East Zone Complex Fires began in September. Again wildfire sprinkler systems were started in areas threatened by the fire. And again, these fires hit no threatened structures.

On May 5, 2007, barely one week after the ice was off the lakes, a wildfire started from what is believed to have been an escaped campfire near Ham Lake. This was early spring in the area, and vegetation green-up had not yet occurred. Northeastern Minnesota was in a state of extreme drought, and unseasonably warm weather produced temperatures above 80 degrees F, with relative humidities of less than 30%, and shifting winds gusting to 30 miles per hour. By the time the wildfire was contained on May 19, it had burned approximately 75,000 acres, more than 36,000 acres in Minnesota and almost 39,000 acres in Ontario (USDA-Forest Service, 2007). Most of the burned area was categorized as a low- to moderate-intensity burn, though some, including areas near homes and cabins covered by sprinkler systems, was categorized as high-intensity. The Ham Lake Fire behavior was described as extreme, consistent with a fast moving, wind-driven wildfire. It was primarily low to the ground, with some torching and a lot of spotting due to the wind and dry fuels. Flame lengths of more than 100 feet were observed by firefighters. The most heavily burned populated area on the United States' side of the fire was concentrated along the Seagull Lake and Saganaga Lake area at the northwest end of the Gunflint Trail. The region is surrounded on three sides by the Boundary Waters Canoe Area Wilderness and contains many permanent and recreational homes and cabins.

Defensible Space

Defensible space refers to management practice of clearing vegetation around homes to provide a firebreak. The Minnesota DNR has promoted this practice as part of their Firewise program (Minnesota DNR 2008). In general there are three zones of interest around a given home: an Intensive Zone, which is a 30-foot buffer around the house and is the area of maximum vegetation modification; an

Extensive Zone, which is an area of fuel reduction 30-100 feet from the house; and a General Management Zone, which consists of any modifications further than 100 feet from the house. Defensible space primarily refers to the Intensive Zone, and the goal in this zone is to remove as much potential fuel as possible. Possible management actions include: reducing density of surrounding forest, keeping grass short and watered, cleaning roof and gutters, pruning branches up to 6-feet long, and stacking firewood away from the home. The DNR has come up with a system of rating homes based on the level of defensible space in existence. There is a Level 1 classification, which is just a general description of the amount of defensible space determined from aerial photos, and a Level 2 classification which involves an extensive onsite assessment (Minnesota DNR 2008).

Findings: Sprinkler Systems

What did we learn about the sprinkler systems during this wildfire event? Fire threatened approximately 342 parcels with 897 structures, from Poplar Lake, half way up the Gunflint Trail, to the end of the Trail, a distance of approximately 25 miles. One hundred forty structures were lost, including 10 year-round residences, several commercial businesses, and many cabins (USDA-Forest Service 2007a). In the Seagull-Saganaga area directly hit by the fire, 56 homes, cabins and businesses had sprinkler systems (personal interviews 2007). Based on site visits and interviews in the Seagull Lake and Saganaga Lake areas of the Gunflint Trail, of the threatened structures on the Gunflint Trail that burned, only one had a working sprinkler. Of the threatened structures that survived, 72% had working sprinklers (Table 1). All properties, with one possible exception¹, that had

¹ In the discussion about this particular system, there has been speculation about why the system may have failed, including a burned or broken water pipe, or an ember blown into a dry area under a deck. With the ultimate destruction, no definitive conclusions have been reached.

working sprinkler systems survived the fire. Some local firefighters reported that a sprinkler system had been running on a home destroyed by fire; another firefighter claims the sprinkler system was not running.

Table 1. Ham Lake Fire burned area: structure survival and loss, Seagull and Saganaga Lakes, Gunflint Trail, Minnesota.*

	Sprinklers		No sprinklers	Total:
	Worked**	Failed		
Structure Survived	46	1	18	65
Structure Lost	1	8	30	39
Total	47	9	48	104

* These numbers differ from other reported numbers due to the definition of a structure. For these purposes, a structure is defined as a major, livable structure, primarily a home or cabin. Other reports include any structure, such as boathouse, shed, or outhouse.

** There is disagreement among firefighter observers over whether one structure that burned had a working sprinkler system or not. For purposes of this report, this system is included as working.

Nine properties that were lost had sprinkler systems that were not working. Some systems were not started or were started but the pumps did not work. Other problems included:

- broken water lines prior to the fire that had not been repaired
- in-take pipes did not reach the water due to very low water levels
- systems still in winter storage.

Sprinkler systems appeared to protect structures along with their surrounding vegetation regardless of fire behavior, intensity, fuels, weather/wind, or Firewise status of the property. On Seagull Lake, with some of the highest fire intensity and extreme fire behavior, all 17 structures with working sprinkler systems survived the fire. Only 10 out of 28 structures without working sprinkler systems survived. These were all homes with either nonfunctioning systems or no system present. In this area, fire destroyed 18 structures. One firefighter reported, “On Sea Island Road, that soil’s been sterilized. That was hot through there. Air Ops from the Type I Team was flying over us... They were sure we lost those houses,

based on the rolling fire behavior and 120-foot flame lengths... They thought, no way would these survive, and they did. They were just amazed.... The sprinklers worked regardless of fuel type, fire behavior, topography...”

The question remains as to what role defensible space played for structures. We did not begin this study to evaluate defensible space but do have some information about the interaction between sprinkler systems, defensible space, and survival. Anecdotal evidence suggests mixed results: based on firefighter comments some homes with defensible space survived without sprinkler systems, though there were also instances where homes without defensible space survived, and homes with defensible space were lost.

From our 2002 study, we have an extremely limited sample of homes in the burned area with a rating of their defensible space for comparison (Nelson et al. 2005). In that study, we conducted interviews and site visits with homeowners on the Gunflint Trail to develop “landscape types” that indicated the amount of vegetation removal as defensible space for a given property. Six properties from the 2002 study were in the Ham Lake burned area. Of these six properties, three had sprinkler systems and all three of these survived the fire. Of these, two properties had been categorized as having some defensible space (clearing on some but not all sides of the house), and one had been categorized as deep in the woods with no defensible space. In addition, three homes from the 2002 study that were in the Ham Lake burned area did not have sprinkler systems and were all lost in the fire. Of these three, two had been categorized as deep in the woods with no clearing or defensible space, and one was categorized as having reasonable defensible space with clearing all around the house. This is the only robust data we have on defensible space vegetation types prior to the Ham Lake fire but five years had passed between the vegetation evaluation and the fire. We did not find any systematic information on the status of a structure’s defensible space within a year of the Ham Lake fire.

Reasons for sprinkler system success

Though there is some debate about the reasons for success, the wildfire sprinkler systems on the Gunflint Trail are generally believed to have worked by creating a humid microclimate and by cooling ambient air temperature.²

Firefighters reported that some sprinkler systems ran for as little as two hours before the fire arrived. Prior to that experience, it was thought that systems would need to run many hours longer to fully hydrate fuels. This was not the case with the Ham Lake Fire. Experience was that with the cooler, moister environment created by the sprinklers, embers were suppressed before they were able to ignite the fuels, whether structures or vegetation.

When the systems were successful, one outcome was a resulting “island” of standing, burnable fuel for the fire that surrounded it. In the case of the Ham Lake Fire, shifting winds over the course of more than a week meant the remaining fuels inside the burned area had to be kept cool and hydrated to prevent ignition from hotspots that surrounded the green area. Firefighters and homeowners ran sprinklers for many days following the initial fire. This presented additional challenges for the systems (discussed in a later section).

How these challenges were successfully addressed is an important condition of the management requirements. Standardized (“conforming”) systems enabled structure protection firefighters to refuel, maintain, and repair minor malfunctions in an efficient manner. Propane tanks were routinely replaced through a plan developed by the local fire department, and engine oil was checked and added as needed. Standardization meant that extra system parts were also available when needed if and when system components began to fail.

² An alternate theory is that while strong winds present during a wind-driven wildfire will quickly dissipate the humidity, these same winds will tend to pool water from the sprinklers in the same location that flying embers will be blown (Mitchell 2006).

Reasons for sprinkler systems failures

The most prevalent reasons for system failure in its broadest interpretation was that the system was not set up due to the early spring or because of a general lack of maintenance. Because the Ham Lake Fire occurred early in the spring, many sprinkler systems were still in their drained, winterized state. Most systems did not yet have the suction hose set in the water, and in some cases pumps were locked in garages or sheds with their seasonal-resident owners far away. Neighbors and/or firefighters attempted to set up the sprinkler systems, but in many cases this was not possible. Lake water levels were very low due to ongoing drought, and in several cases, rigid suction hoses did not reach the water. In other cases, PVC water pipes had broken the previous fall or winter and had not been repaired. While this can be attributed somewhat to the unusual nature of an early spring fire in this location, firefighters reported similar experiences with the Cavity Lake Fire that had burned the previous July.

For systems that were working, firefighters and managers reported many problems:

- pump/engine failures for unknown reasons
- broken flappers on sprinkler heads
- system design that left water pipe uncovered by sprinklers and exposed to burning
- propane starting problems (sticking diaphragm in regulator) on dual-fuel systems
- sprinkler heads clogged with debris

Finally, homeowners ran sprinklers in many areas that were evacuated and/or threatened, but not directly hit by the wildfire. Similar issues occurred in these areas as in areas overrun by the fire. In the evacuated areas, sprinkler systems were kept running and were maintained by local and mutual aid fire departments. When the systems were run extensively, sprinkler heads did break and get clogged with debris. One pump burned out after extensive use. Using the quasi-

experiment of sprinklers running where fire occurred and where it did not, it appears there are common challenges that need to be managed in a running system and that all malfunctions can not be attributed to fire stress.

Findings: Defensible Space Assessment

Saganaga Lake

Saganaga Lake is the northernmost of the two regions. The houses are on a peninsula bordered by Seagull River to the west and Saganaga Lake to the east. For this region, little analysis could be performed due to the lack of detailed personal knowledge of the homes in this area, and lack of high-resolution aerial photos. Of the 46 houses identified in this region, only 8 may have had defensible space. If these eight were correctly identified, then five of these had working sprinkler systems, and three did not. Only one burned, and it did not have a sprinkler system. Little else can be said about this region with any confidence.

Seagull Lake

Seagull Lake is in the southern region, and contains houses found along the eastern and northeastern shores of Seagull Lake, Cupid Lake, and Onagon Lake (see Appendix A, Figure A-2). These houses are on the following road segments: Seagull Lake Road, Seagull Access Road, Blankenburg Lane, Island Road, Gull Point Road, Onagon Road, and the Gunflint Trail itself. Based on the TIGER file (U.S. Census Bureau 2008), the sequence of house numbers could be determined (i.e., whether the numbers go up or down as you continue along the road), and from personal communication, certain landmark houses could be identified and matched with a given address. Then the rest were filled in by continuing up or down the road from these houses and matching addresses based on house locations. Some houses could not be found even with the GoogleEarth image, and so for these the location was approximated based on

neighboring house locations. Houses that could not be identified from the GoogleEarth image were likely covered by the tree canopy and thus it could be assumed had no defensible space surrounding them.

Of the 51 houses that were located in the Seagull Lake area, 16 were burned by the fire and 35 survived. The majority of these homes were classified as Level 5-High Risk houses based on the Firewise rating of defensible space. Thirty-eight houses scored a 5; seven scored a 4; five scored a 3; one house scored a 2; and there were no houses that scored a 1. None of the houses that burned had any significant defensible space (i.e., they scored a 4 or 5).

In comparison with sprinkler systems, of the houses that burned, five had sprinkler systems, but all of those failed. Of the houses that survived, only eight did not have working sprinklers, and only one of these had any significant defensible space (i.e., 2 or 3).

Table 2: Breakdown of house survival by defensible space and sprinkler presence.

		Survived	Burned
No Defensible Space (4,5)	Sprinkler	22	0
	No Sprinkler	7	16*
Defensible Space (2,3)	Sprinkler	5	0
	No Sprinkler	1	0

* Note: Of the 16 burned houses in the No Sprinkler category, 5 had sprinklers that malfunctioned. Of the seven houses that survived in that category, one had a malfunctioned sprinkler.

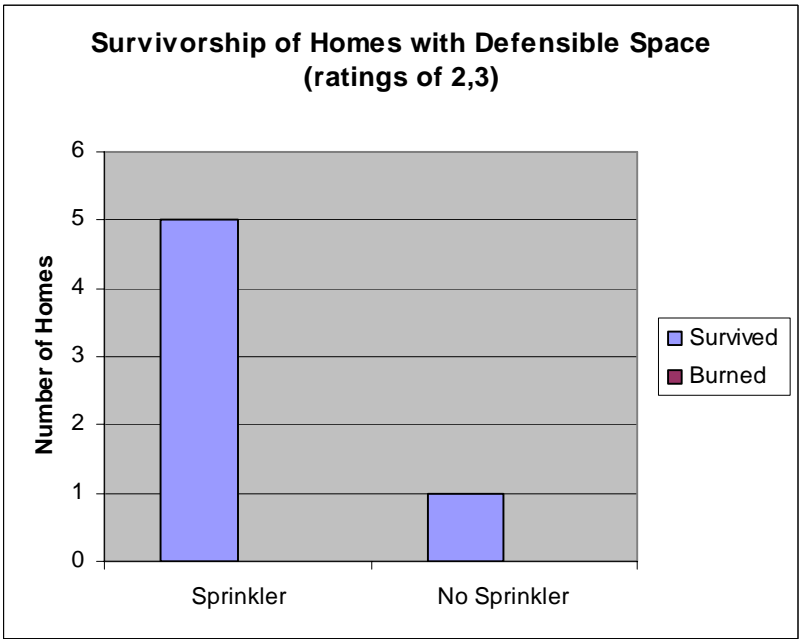
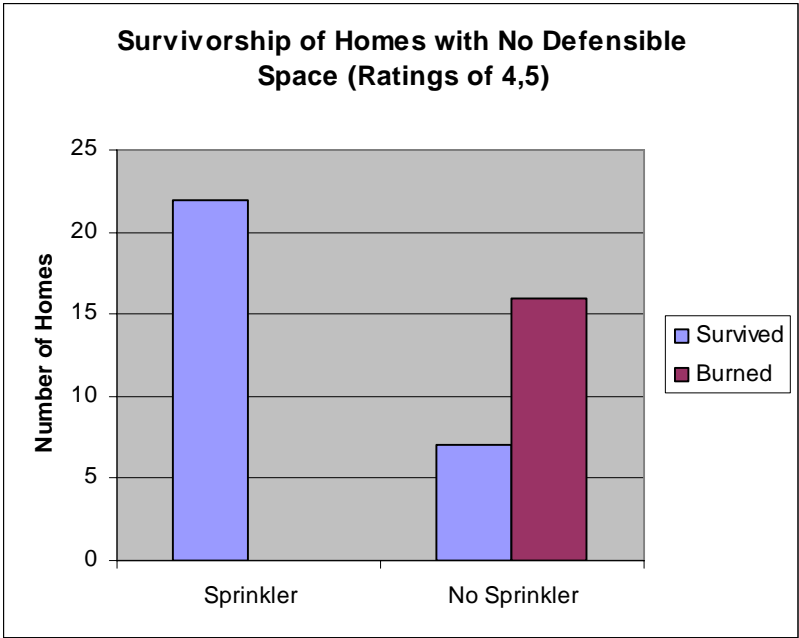


Figure 1: House survivorship by defensible space and sprinkler presence, Ham Lake Fire, along the Gunflint Trail 2007.

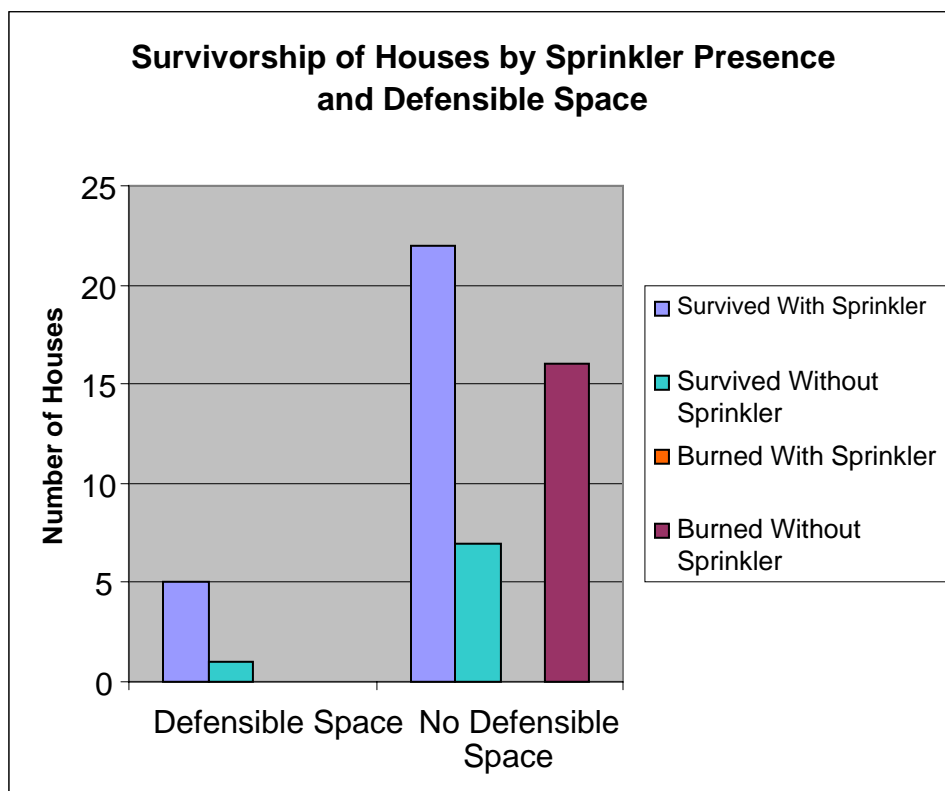


Figure 2: House survivorship by defensible space and sprinkler systems (on same axis), Ham Lake Fire, along the Gunflint Trail, 2007.

Recommendations

Sprinkler System Design Recommendations

Amount of Water: The Gunflint Trail sprinkler systems were designed to mimic two inches of rain in 24 hours when they are running. The Minnesota DNR standard for sprinkler systems mimics one inch of rain in 24 hours. Both appeared adequate for structure protection during the Ham Lake Fire. Definitive research on the amount of water needed could not be located, so the amount of water should be assumed to be at least one inch in 24 hours.

Environmental Conditions Influence Design: System requirements will vary based on coverage area desired, vertical distance from the pump to the highest

sprinkler head, and friction loss of water pressure in the pipes, heads, and other appliances on the system. There are many options for amount of water, size of sprinkler head, pipe, and size of pump/engine configuration needed to drive the system. For example, northeastern Minnesota has an abundance of water, and the focus of this report is on systems that deliver water only.

There are other considerations that are beyond the scope of this report. For example, some people suggest that running a system for a couple of hours a day to keep vegetation hydrated during dry times may be a plausible alternative to only running a system during a wildfire emergency. In addition, some practitioners have investigated using foam or gel with a sprinkler system or experimenting with using alternate water sources such as holding tanks or swimming pools.

What follows are the recommendations of the Gunflint Trail Volunteer Fire Department to residents of the Gunflint Trail, based on experiences gained with the sprinkler systems during the Ham Lake Fire (Gunflint Trail Volunteer Fire Department 2007). When designing a system for a new property, consultation with a professional sprinkler system supplier should always be done for site-specific design requirements.

The basic system on the Gunflint Trail covers approximately one acre, with a vertical rise from the water source to the highest sprinkler head of approximately 35 to 40 feet. In this scenario, a pump pushing 60 gallons per minute is adequate to supply 10 to 12 3/4-inch sprinkler heads with 35 to 60 pounds per square inch (psi) of pressure at the pump. To accommodate 10 to 12 sprinkler heads, nozzle diameters range from 9/32 to 3/16 inch. Systems could be designed with fewer sprinkler heads with bigger nozzles pushing more water in a larger radius.

All sprinkler systems should be capable of providing at least 60 gallons per minute over an area of approximately 1 acre. For example, sprinkler heads with

1 1/64-inch diameter nozzles will spray at least 3 to 5 gallons per minute over a 30 to 45 foot radius if there is about 40 psi of pressure at the sprinkler heads. All structures, water line, and the pump itself must be covered by water spray. The pump should be capable of running unattended for 18 to 26 hours.

Pump: Pumps should be on a level base and easily accessible by well-maintained path or easy access by water if land access is unavailable. Pump intake and discharge should have a short flexible line between pump and any rigid lines. The use of 2-inch cam and groove fittings on rigid discharge and intake lines is recommended for easy release and attachment of lines. A foot valve with suspended strainer is recommended on intake. The foot valve should be suspended in the water, neither on the surface nor at the bottom of the lake to minimize debris getting into the system and clogging the sprinkler heads.

Fuel: Propane is the fuel of choice for sprinkler systems in the Gunflint Trail District, because a 50-pound propane tank will power a pump for approximately 24 hours while unattended. Remember that electric power will likely be shut off in a wildfire area. An additional 20-pound cylinder is recommended for use for testing and periodic use. The 50-pound cylinder should always be left full in case of evacuation.

Lines and Fittings: All sprinkler systems should have a flexible LP gas line hose from the pump to any tank or rigid pipelines. A valve for disconnect must be supplied near pump for any rigid gas line. Sprinkler system water supply lines and fittings must be professional quality irrigation components. They should utilize irrigation pressure fittings and not D-W-V (drain-waste-vent) plumbing fittings. PVC should be painted to protect it from UV light. Rubber hose should also be UV protected or certified (e.g., Goodyear Horizon 200).

Sprinkler heads: Sprinkler heads should be full-circle professional quality irrigation sprinkler (example brand names: Rainbird, Nelson). Sprinkler heads

must be positioned to cover the pump and delivery lines as well as primary structures and surrounding vegetation with water. Sprinkler system full-circle brass impact sprinkler heads that surround primary structure should be at least 3/4-inch in size and have 3/16-inch diameter nozzles. Approximately 12 sprinkler heads should be able to cover a one-acre area, including structure(s) to be protected, pump and supply lines.

High velocity in pipes can cause excessive friction loss and water hammer. For these reasons the pipe diameter should be selected to match the flow rate from the pump. Generally, a 3/4-inch diameter pipe can handle up to 8 gallons per minute (gpm), a 1-inch pipe can handle up to 15 gpm, and a 2-inch pipe can be used with flow rates up to 60 gpm for these types of sprinkler systems. Sprinkler systems that require more than 60 gpm should use 3-inch pipe.

Special consideration should be given to installations on water sources with fluctuating water levels. Intake lines must have a sufficient length of suction hose or pipe so that the foot valve or strainer is completely submerged at the lowest water level. Also the pump must be set on a location above the highest water level.

Installers recommend that all sprinkler systems have at least one male 1-1/2 inch NH (National Hose) threaded Fire Department standpipe hook up. Check with your local fire department for more standpipe hook up specifications. This will enable water access to fill fire department trucks or for use by property owners if needed. The standpipe hook up should be painted yellow and plainly visible. When possible, the location should be easily accessible by the fire department.

Maintenance Recommendations

Test the Equipment: Pumps with dual-fuel and/or dedicated propane should be tested monthly on propane only. Gasoline fuel tanks on pumps should be run until empty or fuel should be treated with a stabilizer.

Storage and Preparation for the Next Year: At the end of the season, the system should be run to insure that it is fully operational. It should then be completely drained and left in stand-by mode. Stand-by mode allows for immediate activation of the system by putting the intake line in the water and priming the pump. Flexible suction hose with foot valves should be connected to the pump intake and stored adjacent to the main supply line with the foot valve end facing uphill.

Rigid suction hose should be disconnected from the pump and stored adjacent to the pump and main supply line with all openings covered to keep out animals or debris. Intake and discharge openings on the pump should also be covered. Once the pump has been completely drained, the drain plug should be screwed back in place.

The pump should be covered with a weatherproof fabric cover that is easy to remove. A rigid board should be placed on the top of the pump under the cover to shed water and snow. All lines to sprinkler heads should be completely drained and reattached to the supply fittings. Any auxiliary shut-off valves should be in the open position. The 50-pound propane cylinder should be full and in the closed position.

When the sprinkler system is first activated in the spring, it should be run to test for any malfunctions. The pump should remain primed with the intake line in the water. It should stay in this state until it is ready to be drained in the fall.

Sprinklers Plus Defensible Space Firewise Principles: Sprinkler system installations should be used in conjunction with Firewise recommendations. When trimming vegetation, it is important to keep vegetation from blocking sprinkler head motion or from hiding the pump, which can make it difficult to find

or start. Dense vegetation surrounding the pump or water lines can also add to the risk that parts of the system will be vulnerable to an approaching wildfire.

Management Challenges

While the mechanics of how the sprinkler systems worked (or did not work) during the Ham Lake Fire were relatively straightforward, several issues arose related to logistics and human behavior. These present challenges that will take more research and/or experience to fully address, but should be noted here.

Firefighters and others expressed concern that with the success of sprinkler systems during the Ham Lake Fire, property owners may see an excuse or rationalization to ignore proper defensible space recommendations promoted by Firewise programs. Managers and sprinkler businesses need to emphasize that sprinkler systems can and do fail to operate, and the best chance for success is to view them as one tool among many proper defensible space recommendations.

Another issue was the influence operating sprinkler systems had on property owners under an evacuation order. During the Ham Lake Fire, some residents refused to evacuate in order to keep their system and their neighbors' systems running. These people are viewed as local heroes for saving homes, yet they caused additional work for and increased risk to local firefighters. In addition, some are concerned that with the success of the sprinkler systems, residents who are not physically and/or emotionally equipped to stay on their property will fail to follow orders to evacuate the area because of a perceived safety zone under the sprinkler system. These considerations will have to be addressed as the United States reflects about the concept of "shelter in place" used in Australia and how it does or does not fit with our wildfire protection efforts.

While not openly discussed during interviews, there were several references to liability issues associated with firefighters running privately owned sprinkler systems. On the Gunflint Trail, the Volunteer Fire Department has stated that they will attempt to start wildfire sprinkler systems wherever feasible, but they provide no guarantees, and the property owner has ultimate responsibility for their system. It should be made clear to the property owner that if they want firefighters (or anyone else) to start or maintain their system, the property owner and not any firefighting agency will be responsible for system problems.

Propane as a fuel for sprinkler systems has been a big issue for the Gunflint Trail area in all of the five fires where sprinkler systems have been used. Both the cost of the propane and the location of the fill station were issues during the Ham Lake Fire. Propane is not available as part of standard firefighting resources with a state or federal Incident Management Team and must be supplied locally. Who pays for the propane in these cases has always been a big question. In addition to cost allocation, the physical location of the propane supply station presented logistical problems. On the Gunflint Trail, the only propane supply station was at the end of the Trail, in the evacuation zone. In addition to the risk from the wildfire, this sole supply station malfunctioned, temporarily halting sprinkler system refueling during the fire. On the Gunflint Trail, efforts are ongoing to address the propane issues. Propane continues to be the fuel of choice for sprinkler systems, but awareness of these issues is necessary for any future system installations.

Finally, in the style of “what if” reflection, some expressed concern that if the use of sprinkler systems expands dramatically, there may be deleterious effects on area lakes or other potentially negative ecological impacts. According to the area DNR hydrologist, this should not present a problem, as the amount of water drawn is relatively small. Furthermore, the water remains in its own watershed where surface runoff flows back to the lake from which it was drawn, and there is no danger of transporting non-native species. It is below the amount that would

require a state irrigation permit (10,000 gallons of water/day), should not impact lake levels, and will not introduce any non-native or exotic organisms. The view is that this is self-contained within a small ecological area and no negative ecological impacts should be expected.

Methodology

Data gathered for this report was obtained through interviews with Gunflint Trail volunteer firefighters, homeowners, Firewise coordinators, fire behavior and fuels specialists, and emergency management personnel from June-August 2007. Many sites with and without sprinkler systems were visited with firefighters and fire experts, in and near burned areas. Findings and recommendations were review by hydraulics and irrigation system specialists for technical accuracy.

To assess the role of defensible space in protecting homes, a Level 1 Firewise Assessment was performed on all 104 homes in the Seagull Lake and Saganaga Lake areas based on aerial photos from before the fire (Minnesota DNR 2008). Due to data limitations from the Saganana Lake region, these two areas were analyzed separately.

Level 1 Assessment

The Level 1 Assessment ranks each house on a scale of 1 to 5 based on the amount of surrounding vegetation 30 feet from the house. The Firewise rating is as follows:

- 1—No Risk: Home is in a development with no or few trees around it
- 2—Low Risk: Home is in a development with trees, but home is at least 30 feet from tree canopy edge. (30 feet is about the width of a house).
- 3—Moderate Risk: Home is within 30 feet of the tree canopy edge
- 4—High Risk: The outline of the home is obscured on at least one side by the tree canopy

5—Extreme Risk: The outline of the home is obscured on the south or west side or on more than one side by the tree canopy (Minnesota DNR 2008).

Examples of each level are provided in educational material on the Firewise website (Minnesota DNR 2008). See Appendix A for examples from this study.

Data - Aerial Photos

The most recent, high-quality aerial photos that could be found of the Gunflint Trail area were the 2003-2004 National Agriculture Imagery Program (NAIP) photos (Minnesota Dept. of Administration 2008). NAIP conducts statewide surveys each year, but unfortunately due to cloud conditions no 2005, 2006, or 2007 data is available for the study area. NAIP images have either a 1- or 2-meter ground spatial resolution. Unfortunately for the study area only 2-meter resolution data was available. This limits the confidence of the study, as 2 meters is generally too coarse to identify individual homes, unless they are out in the open. However, a higher resolution GoogleEarth image (GoogleEarth 2008) was available for the Seagull Lake area, in which homes could be easily identified. There was no metadata available for this image.

Data - Geocoding

Census Data street maps (packaged as a TIGER file) can be obtained for free online (US Census Bureau 2008), and using these street maps, addresses can be approximately located. The street maps identify the order of house numbers running along the left and right sides of each street segment. This method of locating houses is fairly accurate for larger towns or cities, but in more rural areas it has limited success for several reasons: (1) the data is often simply not available in the TIGER file; (2) streets are often windy with houses irregularly spaced; and (3) many times the address for a given house corresponds to a mailbox out on the main street and not at the actual location of the house. For these reasons, the TIGER file proved to be ineffective for the study area, except

to provide a general reference. However, based on onsite knowledge, the locations for the homes in the Seagull Lake area could be roughly identified.

Conclusion

Experience with the Ham Lake Fire in northeastern Minnesota demonstrated that external wildfire sprinkler systems can be highly effective at protecting structures and their surrounding vegetation from wildfire damage and destruction under certain conditions. Sprinkler systems are not a panacea however; they must be regularly tested and maintained, and even then, are not guaranteed to be 100% effective. When effective, there are several management challenges during wildfire events that still need to be addressed (e.g., getting property owners to evacuate when warranted and supplying propane to run the systems). Finally, Firewise principles and practices must be emphasized, with sprinkler systems as another tool on the Firewise list.

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<http://theboundarycountry.blogspot.com/2007/08/ham-lake-fire-rapid-assessment-report.html>. Accessed 11/14/07

***References for Wildfire Sprinkler Installers and Supplies
(no endorsement implied or intended):***

Wildfire Sprinklers Inc. <http://www.wildfiresprinkler.com/> (Gunflint Trail, MN)

Valley Fire Protection and Services (Thunder Bay, ON)
<http://www.valleyfireprotection.com/>

Rainbird Sprinkler Heads
<http://www.rainbird.com>

Nelson Sprinkler Heads
<http://www.lrneson.com>

Pumps: Davey Hurricane
<http://www.davey.com.au>
<http://www.primopumps.com/hurricanepumps.html>

Appendix A: Maps and Aerial Photos

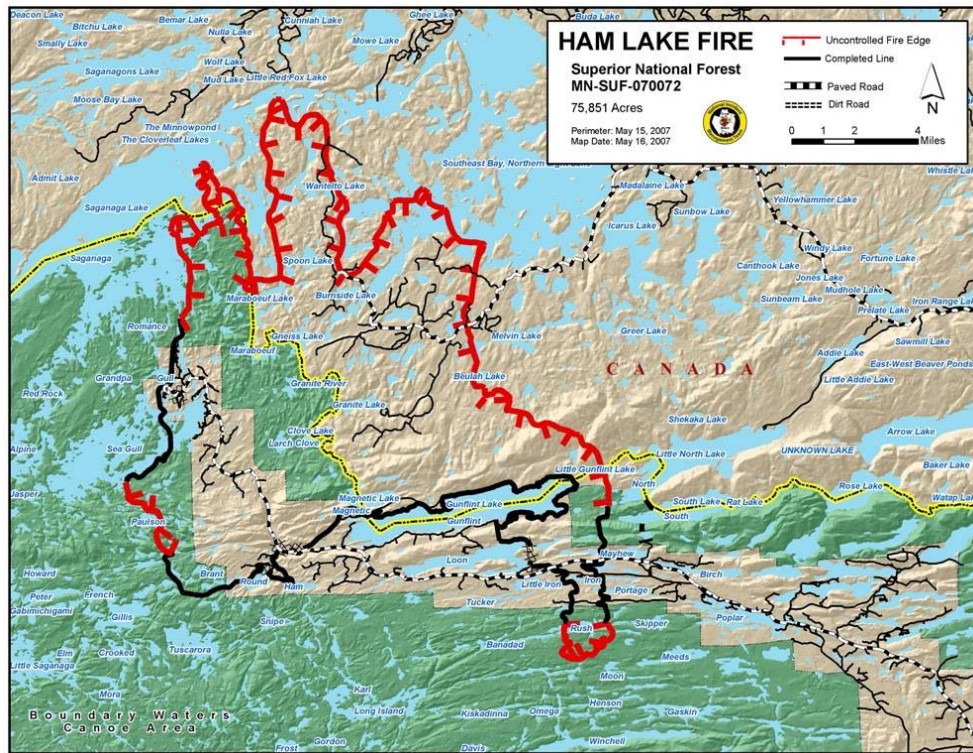


Figure A-1. Ham Lake Fire Burn Area Perimeter, Minnesota, 2007. (source: Wildland Fire and Incident Information System. Online at www.inciweb.org/incident/maps/660. Accessed 5/30/08.)

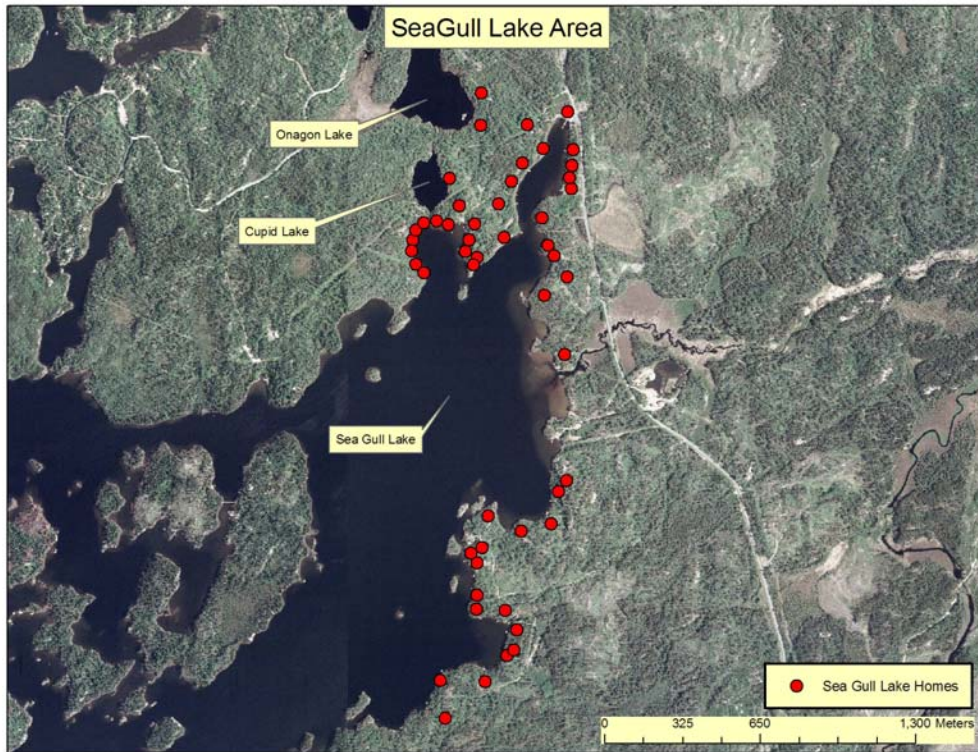


Figure A-2. Seagull Lake Study Area, Ham Lake Fire, Minnesota, 2007.
 (source: NAIP Orthophoto, Minneapolis, MN. Timothy Downing, 2008, using ArcGIS 9.2.)



Figure A-3. Example of House Rating No. 2: This building is clearly out in the open; there are trees in the general vicinity but nothing within a house length. (source: Google Earth Imagery Digital Media. Available online at <http://earth.google.com>. Accessed 5/30/08.)



Figure A-4. Example of House Rating No. 3: This building is generally in a clearing, but there are trees on the north side that are within 1 house length. (source: Google Earth Imagery Digital Media. Available online at <http://earth.google.com>. Accessed 5/30/08.)



Figure A-5. Example of House Rating No. 4: This building is obscured to the south by trees, but there is a large cleared patch to the north. (source: Google Earth Imagery Digital Media. Available online at <http://earth.google.com>. Accessed 5/30/08.)



Figure A-6. Example of House Rating No. 5: This building is completely enclosed by trees on all four sides. (source: Google Earth Imagery Digital Media. Available online at <http://earth.google.com>. Accessed 5/30/08.)

Appendix B: Sprinkler System Brochure

External Sprinkler Systems

Sprinkler systems are believed to work by creating a humid and cool environment that makes it difficult for embers blown by the wind to start a fire. External sprinkler systems also keep your home and cabin and surrounding vegetation - the fuels for the wildfire - hydrated so it is harder for a fire to start or spread.



Shoreline of Seagull Lake where intense fire burned up to vegetation. Sprinklers protected the cabin and the surrounding vegetation.

Is an external sprinkler system for you?

- Do you live in an area susceptible to wildfire?
- Do you have access to a nearby water source, such as a lake or river?
- Do you have the ability to start the system when a fire is coming?
- Do you have the ability to keep the system maintained and tested?
- Can you accept how the system looks (aesthetics)?
- Can you afford it (cost)?

If you can answer yes to these questions, an external sprinkler system may be appropriate for your home or cabin.



Fire on the Gunflint Trail during evacuation.

In May 2007, a fast wind-driven wildfire overtook homes and cabins in northeastern Minnesota. Many properties were destroyed by the fire. Of 104 homes, cabins, or major structures that were hit by the fire, 39 were destroyed. Of the 65 that survived, 46 had working external sprinkler systems. Some homes without sprinklers survived because they had good defensible space. One home with a working sprinkler system was lost.



This cabin on Seagull Lake was protected by its working sprinkler system during the May 2007 wildfire. The cabins on both sides of this cabin did not have sprinkler systems and were destroyed in the fire.

Remember there is no system that is guaranteed to provide 100% protection for your home or cabin.

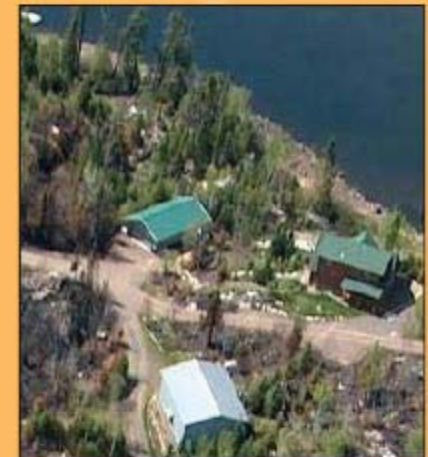
External sprinkler systems, along with other Firewise recommendations such as clearing flammable debris, thinning vegetation, and driveways wide enough for a fire engine to access your property, increase the chances that your home will survive a wildfire.

For more information on Firewise or sprinkler systems, visit www.dnr.state.mn.us/firewise

For more information and links related to sprinkler systems on the Gunflint Trail, please visit the Cook County Firewise website at www.boreal.org/fireinfo

External Wildfire Sprinkler System

Is it right for you?



This publication is available in alternative formats upon request. Call (612) 624-XXXX for details. The University of Minnesota is an equal opportunity educator and employer.

All photos courtesy of Jayne Fingarman Johnson (2007), except for the photo of the fire on the Gunflint Trail which is courtesy of Rick Johnson, Gunflint Trail Volunteer Fire Department (2007) and the cover photo which is used with permission from the USFS, Superior Nat'l Forest. Bookcover and illustrations created by Sarah Finley.

♻️ Printed on recycled and recyclable paper with at least 10 percent postconsumer material.



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Considerations for an External Sprinkler System

Access to a water source is necessary to provide enough water for a system to be effective. A well does not generally provide enough water for a sprinkler system when a wildfire is coming. A well usually requires electricity for the pump, and electricity will likely be cut off in the event of a wildfire.

Starting the system when a wildfire is approaching is another critical factor. If you have a recreational cabin and are not present, who will start your system? A neighbor who lives nearby full time may be a good option. Your local fire department may be able to start your system, but this is not always possible. In the event an evacuation is ordered, it is likely you will not be allowed to go to your cabin to start your system or to retrieve valuables. Remember: The homeowner is ultimately responsible for starting the system.

The aesthetics of the system - how it looks - is a consideration for some people.

- The pump at the water source should be easy to locate and start by someone who may not be familiar with your property. The pump should not be hidden from view.
- Water line or hose may be buried or laying on top of the ground. Buried water lines will increase installation cost and may cause increased maintenance effort to find broken pipes or leaks. Exposed water lines are susceptible to burning from the wildfire, and need to be protected by water coverage from the sprinkler system itself. Vegetation should also be cleared from exposed water line to help prevent fire near the line.
- Vegetation needs to be cleared around sprinkler heads far enough to ensure that the heads completely rotate and the water spray reaches the full radius.

Sprinkler system costs can vary greatly depending on location and site characteristics. A range of \$4,000 - \$6,000 can be used as a starting estimate.



An illustration of an external wildfire sprinkler system.

As seen in these photos, sprinkler heads and hoses can be relatively hidden in existing vegetation, and pumps should be kept covered when not in use. Many homeowners have made the decision that the extra protection offered by sprinkler systems is worth it.

An external sprinkler system is comprised of a pump and engine, water line or hose to draw in water to the pump and distribute it to the sprinkler heads on the roof of the structure(s) to be protected and in vegetation surrounding the structure. The basic system covers approximately one acre. A 60-gallon per minute pump is sufficient to provide water to 10-12 sprinkler heads, depending on the vertical distance from the water to the highest sprinkler head. High elevations (greater than 40-50 feet) will require more powerful pumps or multiple pumps to provide sufficient water pressure.

A sprinkler system or irrigation professional should be consulted when designing a system for your site. Someone with a proficient knowledge of plumbing and

hydraulics can install a sprinkler system on an existing property.

External sprinkler systems should not rely on electricity. Electric power will likely be cut off in the event of an approaching wildfire. A 50-pound propane cylinder will run a pump with a 6.5 h.p. engine for approximately 24 hours without refueling. Many systems have been set up to be switched between gasoline and propane fuels: Gasoline is used for testing or short-term (1-2 hours) running of the system, while the propane cylinder is left full in the event of evacuation and approaching wildfire.

Some recommend that systems run for 4 to 24 hours prior to the arrival of a wildfire, though this is not always possible. Experience with the 2007 Ham Lake fire with shifting winds gusting to 30 mph showed that sprinkler systems can work if run for as little as two hours before the fire arrives; however, the equivalent of a 1 inch rainfall in 24 hours is recommended.

Sprinkler Maintenance

It is the homeowners responsibility to ensure that the external sprinkler system is maintained and regularly tested. When a wildfire is headed your way and an evacuation has been ordered, it is NOT the time to be repairing broken pipes or climbing on the roof to unclog plugged sprinkler heads.

The sprinkler system should be primed and ready to go as soon as the ice is off the lake in the spring and the danger of freezing is minimal.

Run the system to be sure the pump is working and there are no leaks or clogs.

During fire season, test the system monthly to ensure it is working properly. If a dual fuel (gasoline and propane) system is installed, be sure to test the system on both fuel systems.



(Top) Example of a covered pump. (Bottom) Example of an uncovered pump.