info@fpinnovations.ca
www.fpinnovations.ca

EXECUTIVE SUMMARY: STATE-OF-PRACTICE OF WATER DELIVERY SYSTEMS (SPRINKLERS) USED IN THE WILDLAND-URBAN INTERFACE

Ray Ault and Chad Gardeski

April 2019

This executive summary contributes to the state-of-practice review of water delivery systems (sprinklers) in the wildland-urban interface (WUI). Funding for this review was provided by the Forest Resource Improvement Association of Alberta (FRIAA).

Sprinklers are used to protect structures from wildfire during wildland-urban interface (WUI) events across Canada. Traditionally, standard forestry equipment has been used in conjunction with impact sprinklers. FPInnovations is reviewing common practices and equipment used during sprinkler deployments, in Canada, to determine if they are the most appropriate for community structure protection, or if alternative approaches should be considered.

This executive summary presents the key messages from a state-of-practice review of the pathways to structure ignition, a summary of the results of a national survey on the use of sprinklers in Canada, a summary of the standards and codes specific to the WUI that relate to the use of sprinklers, an overview of equipment evaluations conducted, a summary of WUI case studies and observations that describe actual sprinkler deployments, and a discussion on best practices and recommendations to enhance the effectiveness of sprinkler deployments.

301012735: FRIAA SPRINKLER PROJECT

EXECUTIVE SUMMARY

ACKNOWLEDGEMENTS

FPInnovations would like to acknowledge the Forest Resource Improvement Association of Alberta (FRIAA) for funding this project, and the following individuals who participated in a steering committee that provided guidance throughout this project: Morgan Kehr and Adam Gossell (Alberta Agriculture and Forestry), Steve Otway and Keven Thomson (Alberta Office of the Fire Commissioner), Dave Cox (Alberta Fire Chief's Association), Winston Delorme (Alberta Emergency Management Agency), Andy Gesner and Cliff Henderson (FRIAA).

PRIMARY AUTHORS CONTACT INFORMATION
Ray Ault
Wilderness Fire Management Inc.
(780) 658-2282
Raymond.ault@gmail.com

CO-AUTHORS CONTACT INFORMATION
Chad Gardeski
Manager – Wildfire Operations
(780) 817-1440
Chad.Gardeski@fpinnovations.ca

Follow us:

TABLE OF CONTENTS

LIST OF FIGURES

1. INTRODUCTION

Across Canada, sprinklers are used to protect structures from wildfire during wildland-urban interface (WUI) events. This project found that Canadian Wildfire agencies deploy more sprinklers during wildfire events than any other country in the world. In Canada, sprinkler deployments have traditionally been the responsibility of wildfire agencies. Over the past few years, this responsibility has shifted in many jurisdictions to be the responsibility of the Office of the Fire Commissioner (OFC). Traditionally, standard wildfire equipment has been used in conjunction with impact sprinklers to wet fuels and structures in advance, and during the impingement, of a wildfire. Agencies are looking to determine if the standard wildfire practices and equipment used in wildfire suppression operations are the most effective for community structure protection.

FPInnovations was contracted by the Forest Resource Improvement Association of Alberta (FRIAA) to conduct a state-of-practice of water delivery systems (sprinklers) used in the WUI. The objectives of this project included:

a) conducting a literature review of the pathways to structure ignition and sprinkler use,

b) development and analyzing the results of a national survey on the use of sprinklers in Canada, and conducting interviews with known contractors and other relevant agencies,

c) reviewing standards and codes, specific to the WUI, that relate to the use of sprinklers,

d) evaluating equipment – Mercedes Textiles wildfire pumps,

e) developing WUI case studies and recording observations to document the findings from actual sprinkler deployments,

f) identifying opportunities for innovation and process improvement, and

g) identifying best practices and providing recommendations that can enhance the effectiveness of sprinkler deployments.

2. LITERATURE REVIEW

In order to evaluate the effectiveness of current sprinkler technologies, it is important to understand how wildfire spreads within a community and how structures are ignited. A comprehensive review was completed that included obtaining data from various data bases, reviewing related on-line articles, published studies and other forms of documentation regarding the current understanding of structure ignition and structure protection. The most comprehensive document we found on this subject was the *Review of Pathways for Building Fire Spread in the Wildland Urban Interface, Part 1: Exposure Conditions* (Caton, S., and Hakes, R., and Gorham, D. and Zhou, A., and Gollner, M. 2017), *and Part 2: Response of Components and*

*Systems and Mitigation Strategies in the United States (*Hakes, R., and Caton, S., and Gorham, D., and Gollner, M. 2017). This document incorporates the findings from many of the individual documents that were reviewed, and comprehensively explains the current issues related to structure protection within the WUI.

The consensus within the wildfire research community points toward windblown firebrands as the primary source of structure ignition in the WUI. The pathway of structure ignition is often described as a process where receptive fuels adjacent to a structure are ignited by firebrands. These small fires continue to consume combustible materials, grow in intensity, and eventually cause the ignition of structural materials through a combination of radiant heat transfer, or direct flame contact. This process occurs in the "Structure Ignition Zone" which is a term identified in NFPA 1144 standard (NFPA, 2018). For the purpose of this report, the Structure Ignition Zone will include the area adjacent to buildings where the management or removal of combustible materials, and the application of water through the use of sprinklers, can have a significant effect on the survival of a structure during a wildfire event.

Management or removal of combustible material from the Structure Ignition Zone is a fundamental goal of the FireSmart program in Canada and the Firewise program in the United States. The FireSmart program defines the area up to 1.5 m from the structure as Priority Zone 1a (FireSmart Canada, 2018) and recommends that this zone contain only non-combustible materials to interfere with the pathway of structure ignition.

Of all the documents and international standards and codes FPInnovations reviewed, only 4 documents and 2 standards mentioned the use of sprinklers for structure protection. Not one of these documents made direct linkages between the Structure Ignition Zone and effective sprinkler use. The most comprehensive document reviewed was a report from the Ham Lake fire in Minnesota, USA. The report provided useful information on permanent sprinkler systems that were used to protect cottages and residences in Minnesota lake country. One Australian study described a unique misting system that was attached to structures. In Canada, FPInnovations has studied the use of sprinklers for structure protection during experimental crown fires in the Northwest Territories (Walkinshaw and Ault, 2008 and 2009).

The complete literature review is published independently as; *Literature Review – Pathways and mitigation of structure ignition in the wildland-urban interface*, and is also included as "Appendix A" of the *State-of-practice of water delivery systems (sprinklers) used in the wildland-urban interface; Compendium,* located on the FPInnovations website at:
http://wildfire.fpinnovations.ca/Research/SprinklerStateOfPractice/SprinklerStateOfPractice.aspx

3. NATIONAL SURVEY – SPRINKLER USE

Determining what equipment is currently being used during sprinkler deployments is an important first step to determining how effective current equipment is and what technology

gaps need to be addressed. FPInnovations developed a survey to help identify the equipment that is currently used for structure protection in Canada. The survey was distributed to the 13 wildfire agencies (including Parks Canada and all provinces and territories except Nunavut) that are members with the Canadian Interagency Forest Fire Centre (CIFFC). All agencies indicated that they are using or have used sprinklers as a primary tool for structure protection. All provinces have sprinkler kits, and many are adopting sprinkler trailers as a way of organizing for structure protection assignments.

Not surprising, wildfire agencies favour forestry-type pumps and hose, which are the mainstay of the equipment complement. Common equipment includes Waterax Mark III and BB4 pumps, portable water tanks, 38-mm (1.5-in.) and 16-mm (5/8-in.) hose, and impact sprinklers. All survey respondents who have used sprinklers for structure protection found them to be a valuable tool.

The responsibility for structure protection varies by agency. Generally, wildfire agencies are responsible for deploying sprinklers for structure protection within and outside of the WUI. In British Columbia, Alberta, and Manitoba, the OFC has the leading role for structure protection; however, wildfire agencies continue to support sprinkler deployments.

The survey was not distributed to the OFC. Through discussions with the OFC, the Alberta Emergency Management Agency (AEMA), and the Alberta Fire Chiefs Association (AFCA), it became clear that municipal fire departments are purchasing sprinkler equipment and building structure protection trailer units similar to those used by wildfire agencies, which may not be ideally suited for structure protection efforts in the WUI.

Further discussions with the OFC revealed that British Columbia's (B.C.) OFC is expected to have six Type 1 trailers in place for the 2019 fire season, along with a Type 2 WASP urban trailer, and four FireBozz sprinkler kits. The development of B.C. inter-agency operational procedures and reimbursement rates for structure protection equipment (B.C. Interagency Working Group, 2018) has encouraged municipalities and wildfire contractors to develop structure protection trailer units, built to OFC standards. For the 2018 fire season, the B.C. OFC had standing offers with 15 contractors or municipalities for Type 2 trailers. An increase in the number of structure protection trailers in any jurisdiction increases the potential for resource sharing and interagency cooperation.

In addition, BC Wildfire is beginning to evaluate the benefits and costs of mass water delivery systems.

The details of the survey are published independently as the; *National survey on sprinkler use; a first step in determining how effective existing sprinkler equipment is and what technology gaps need to be addressed*, and is also included as "Appendix B" of the *State-of-practice of water delivery systems (sprinklers) used in the wildland-urban interface; Compendium,* located on the FPInnovations website at:
http://wildfire.fpinnovations.ca/Research/SprinklerStateOfPractice/SprinklerStateOfPractice.aspx

4. INTERVIEWS AND OBSERVATIONS

In order to better understand the extent of equipment usage and some of the challenges associated with sprinkler deployments, FPInnovations interviewed fire managers after wildfire events, during active wildfires or WUI deployments, and during deployment exercises. In addition, we reached out to various Alberta water delivery contractors to understand some of the larger equipment being used in the WUI. These interviews contributed to the conclusions and key messages in this report.

A comprehensive list of key messages and best practices has been published independently as; *Sprinkler deployment key messages and best practices*; *as identified through interviews and observations*, and is also included as "Appendix C" of the *State-of-practice of water delivery systems (sprinklers) used in the wildland-urban interface; Compendium,* located on the FPInnovations website at:
http://wildfire.fpinnovations.ca/Research/SprinklerStateOfPractice/SprinklerStateOfPractice.aspx

4.1 Nordegg, Alberta – Wildland-urban interface fire 2013

In May 2013, the hamlet of Nordegg was evacuated due to a wildfire that threatened the community. Alberta Agriculture and Forestry (AAF) and the Clearwater Regional Fire and Rescue Services (CRFRS) conducted several desktop emergency planning exercises in preparation for this type of event. As a result of these efforts, individual agencies were clear about their responsibilities for community protection, and resources were able to be deployed efficiently. The CRFRS used AAF sprinkler trailers and a contract water delivery service provider to deploy sprinklers to protect residential structures, community buildings, and the historic coal mine site. Effective communications between the two agencies and pre-planning significantly contributed to a successful deployment, which included the installation of 76 sprinklers that were supplied using a combination of high-volume and standard forestry equipment (20-mm to 100-mm hoses). Water sources included community hydrants, above ground community water tanks, water supplied using Mark III and BB4 forestry pumps, and water stored in portable water bladders.

Key message: The annual emergency planning exercises that were conducted in preparation for a wildfire event in Clearwater County contributed to the rapid deployment and success of this operation.

4.2 Tallcree First Nation, Alberta – deployment 2015

The structure protection specialist for the 2015 deployment at Tallcree First Nation provided notes and, in an interview, explained the assessment process used to determine which structures needed sprinklers and how water supply lines and pumps were organized during the deployment. The use of a 38-mm (1.5-in.) main line may not have been sufficient to supply adequate volume to protect all the structures in the community. The fire did not impinge the community. After the deployment, a formal community protection plan was developed based

on the learnings from the deployment and called for the use of larger 65-mm (2.5-in.) supply lines to improve the water volume supply in the event of a future deployment.

Key message: After-action reviews of community protection plans are important for identifying opportunities for improvement.

4.3 Robb, Alberta - deployment 2018

In July 2018, the community of Robb, was placed under an evacuation alert, but sprinklers were never deployed. Structure protection crews on site conducted a pre-deployment assessment. A sprinkler deployment plan was developed several years earlier, and a deployment exercise was never conducted to validate the effectiveness of the plan. During the assessment, it was determined that it would be advantageous to stage water-holding tanks around the community to supply enough volume to support the perimeter sprinklers due to the topographical differences from the main water supply (the creek) to the top of town. The assessment also revealed the advantages of using a 65-mm (2.5-in.) supply inch line rather than a 38-mm (1.5-in.) supply line to allow for more volume flow.

Key message: Plans need to be regularly updated to reflect current technologies and best practices. Plans benefit from test deployments.

4.4 Smithers Landing, British Columbia – deployment 2018

In August 2018, the lakeside unincorporated community of Smithers Landing was threatened by wildfire. Several residents used personal pumps and sprinklers to prepare their homes in the event of an evacuation. These simple private sprinkler systems relied on small pumps, garden hoses, and a variety of different sprinklers. Two of the cabins used the Bear Cat FP2126 fire pump kits. Some of these systems were in place and operational before wildfire and Structure Protection crews arrived. With an ample water supply, and the application of FireSmart guidelines, these structures were well protected.

Key message: The actions taken by residents to protect their personal property reduced the strain on limited agency resources.

4.5 Jasper National Park, Alberta – deployment plan review 2018

FPInnovations met with the Jasper Fire Department to discuss their Community Wildfire Protection Plan, which called for the use of perimeter sprinklers and structural apparatus (fire engines) within the interior of the community. A number of years ago, the town changed its source of community water from the Athabasca River to a well system located above town. Based on concerns regarding available volume and pressure from the well system, the fire department recognized that it could still tap into the old infrastructure and use water from the Athabasca River to boost the system's volume and pressure. Communities all have unique challenges that require different solutions. In this case, re-assessing the deployment plan identified a need for more volume, and a solution was developed in advance of an actual wildfire event.

Key message: Each community has different water supply challenges that require unique solutions. It is critical that those challenges are identified and addressed in sprinkler deployment plans.

4.6 Town of Canmore, Alberta – deployment exercise 2018

In September 2018, the town of Canmore conducted a sprinkler deployment exercise to validate the assumptions in the deployment plan. The exercise allowed the municipal fire department to set up planned perimeter lines to get a sense of the logistics behind the deployment and to ensure that any challenges could be addressed before an actual event. The exercise identified equipment and logistic challenges associated with using the municipal hydrants to provide enough water to supply the system, using a 38-mm (1.5-in.) supply line. Re-deployment of a 68-mm (2.5-in.) supply line provided the necessary volume for the system.

Key message: Deployment exercises give communities an opportunity to validate and improve their community protection plan.

4.7 Contractor interviews

FPInnovations was able to interview six of the ten Alberta contract companies that AAF identified as having equipment that could be used for structure protection. These companies do not necessarily work on wildfires every summer. Only two of the companies are focused on providing specific wildfire services. The availability of high-volume water pumps was the focus of the interviews. Four contractors can supply high-volume pumps with capacities exceeding 750 gallons per minute (gpm) that can accommodate 100-mm (4-in.) water supply lines. One contractor commented that Alberta oil field water supply service providers could supply 70-75 water delivery systems that are capable of delivering between 750 and 1800 gpm.

Finally, FPInnovations interviewed a duty officer with Wildfire Defence Systems in Bozeman, Montana. Wildfire Defence Systems is a contractor that supplies structure protection crews for Chubb insurance in 21 states. They have the largest private fleet of wildfire engines in the United States and a large inventory of wildfire suppression and structure protection equipment. Wildfire Defence Systems indicated that using sprinklers for structure protection in Montana is common and that deployment is often completed by private contractors. Wildfire Defence Systems uses water enhancing gel products with a gel induction system for ground based applications.

Key message: A small number of private companies are capable of providing specialized water delivery equipment. Many private companies that have the capacity to provide these services do not have the opportunity to remain current with structure protection tactics; thus they are able to reliably provide this service to the agencies.

5. STANDARDS AND CODES

FPInnovations identified and reviewed the following international standards and codes related to the Wildland-urban interface, to determine if there were any standards specific to sprinkler use that would be beneficial to Canadian agencies. The following is a list of the more relevant documents:

- International Wildland-Urban Interface Code – The objective of this code is to establish minimum regulations for safeguarding life and property from the fire intrusion due to wildland fire exposures and fire exposures from adjacent structures. The code is to be adopted and used supplemental to the adopted building and fire codes for a jurisdiction.
- California Fire Code (Chapter 49: Requirements for Wildland-Urban Interface Fire Areas (California) – This code provides minimum standards for increasing the ability of a building to resist the intrusion of flame or burning firebrands projected by a vegetation fire, and it contributes to a systematic reduction in conflagration losses through the use of performance and prescriptive requirements.
- Australia AS 5414 – 2012 Bushfire Water Spray Systems – This is a standard for the installation of permanent sprinkler systems on homes. The standard calls for a minimum reservoir of 22 000 L (4830 imperial gallons) and a 30-minute to 2-hour continuous run time for the pump.
- Canada, National Research Council – Wildland Urban Interface Fires: regulations and guidelines - A national wildland urban interface guide for Canada was under development in May 2018.

The following National Fire Protection Association (NFPA) standards guide operations in the WUI:

- NFPA 1141: Standard for Fire Protection Infrastructure for Land Development in Wildland, Rural, and Suburban Areas
- NFPA 1142: Standard on Water Supplies for Suburban and Rural Fire Fighting
- NFPA 1143: Standard for Wildland Fire Management
- NFPA 1144: Standard for Reducing Structure Ignition Hazards from Wildland Fire

Most available standards focus on mitigation practices in the WUI. No standards were identified that were applicable to sprinkler deployments from a Canadian perspective. If standards for sprinkler use in the WUI are to be developed a logical, structured approach is required that needs to be supported by science.

6. EQUIPMENT EVALUATION AND INNOVATION

The state-of-practice review indicated that there is no national approach to developing or evaluating wildfire equipment or techniques for the WUI in Canada. The United States Forest Service Technology and Development Centers in Missoula and San Dimas evaluate fire chemicals and some fireline equipment, including pumps and wildland engines.

FPInnovations believes that the lack of a process or organization to help foster and evaluate products, in Canada, limits the development and implementation of new technologies and information sharing between agencies. FPInnovations examined the feasibility of conducting these evaluations on wildfire pumps.

6.1 Equipment evaluation

There are several commercially available pumps for use in wildfire suppression and community protection operations in the WUI. The Waterax Mark-3 pump is the most widely used pump for wildfire operations in Canada. Other pumps are commercially available to wildfire and municipal firefighting agencies. Knowledge of the strengths and weaknesses of different pumps is critical to make informed investment and tactical decisions.

A standardized testing methodology was developed to evaluate five key metrics of a pump used to supply water to sprinklers: pressure, flow rate, sprinkler casting distance, fuel consumption and number of sprinklers supported without significant loss of head pressure. This testing method can be used to validate pump manufacturers' claims. Results can be used to run head-to-head comparisons between different manufacturers. Three portable fire pumps were tested using both a closed-loop and a dead-headed system: Mercedes Textiles' WICK 375 (comparable to the Mark-3), WICK 100G (comparable to the Striker), and WICK Si 300-10B (similar to the BB4). The performance was documented and will be the subject of an independent report that will be published in 2019. Figure 1 and 2 show the difference in casting distance and number of sprinklers a single WICK 375 pump can support using both a closed-loop (equal volume) and a dead-headed (declining volume) system.

In the closed-loop system, each time an additional sprinkler is opened the casting distance is affected equally throughout the system, as this system is intended to equalize volume and pressure throughout. Once all 15 sprinklers were open, the casting distance of each sprinkler in the system was 8.6 m.

Comparatively speaking, only five out of the 15 sprinklers were able to achieve a casting distance of at least 8.6 m in the dead-headed system. This system does not equalize volume or pressure, and exhibits a significant reduction in casting distance due to the lower volume and pressure available to sprinklers further away from the pump.

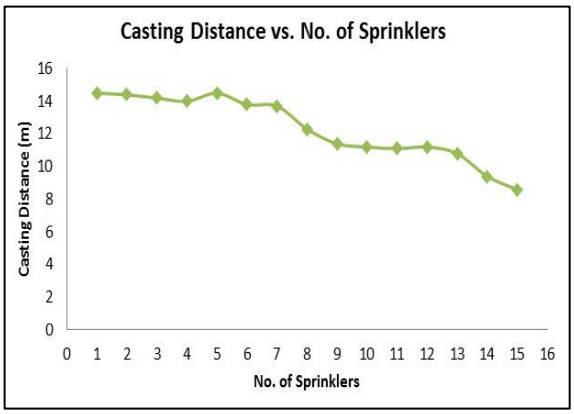

Figure 1. Casting distance vs. number of sprinklers in a closed-loop system

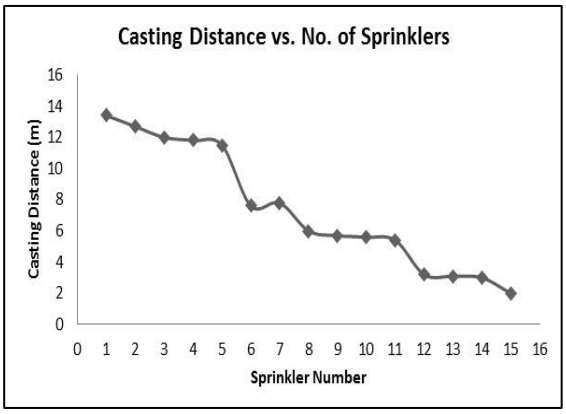

Figure 2. Casting distance vs. number of sprinklers in a dead-headed system

Evaluations of this kind provide data that practitioners can use to help make informed decisions based on defined metrics that can include but are not limited to; desired casting distances, available volume, and system pressure.

Future evaluations can be designed to examine any key metrics that are important to an agency. Equipment evaluations are not limited to pumps and can be applied to different sprinklers and other wildfire- or WUI-specific equipment.

A comprehensive report has been published independently as; *Evaluating commercially available pumps for use in the wildland-urban interface; Mercedes Textiles' pumps – WICK 375, WICK 100G, and the WICK SI 300-10B*, and is also included as "Appendix D" of the *State-of-practice of water delivery systems (sprinklers) used in the wildland-urban interface; Compendium,* located on the FPInnovations website at:
http://wildfire.fpinnovations.ca/Research/SprinklerStateOfPractice/SprinklerStateOfPractice.aspx

6.2 Innovations in technology or approach

Through the interviews with water delivery services providers, it became clear that entrepreneurs want to help solve the WUI problem. Challenges in the WUI are evolving. Science needs to support agencies in identifying emerging WUI needs and guide relevant solutions. Agencies, research organizations, and innovators can collaborate to provide equipment, technology, or service solutions.

In the case of structure protection and sprinklers, there are other industries and communities of practice such as irrigation systems manufacturers and professional engineers that could bring a different perspective to wildfire or WUI issues. A path to a broader level of engagement and collaboration is needed to solve WUI challenges.

6.3 An example of an innovative approach

FPInnovations was asked to observe the demonstration of a high-volume, high-pressure system that used up to 254-mm (10-in.) industrial hose to push water vertically to an irrigation sprinkler head approximately 15 m (50 ft.) above the ground in order to apply water over a mature forest. This innovative approach to water delivery was intended to be used in a wildfire situation. Several logistical challenges were identified that would need to be refined before this system could be used in a wildfire environment, including the deployment time, the use of heavy equipment in operations with poor access, and the environmental impact of drawing huge quantities of water that the system requires. Based on this feedback, the innovator is re-thinking the deployment logistics and size of the system, along with the intended use. This type of high-volume, high-pressure system could have applications for permanent infrastructure protection or deployment in highly accessible areas where high volumes of water or large casting distances are required. However, as the system existed at the time of observation, it would be of limited use in remote wildfire operations.

7. CASE STUDY SUMMARIES

Little documented evidence was found regarding the conditions that make sprinklers effective based on observed fire behaviour, suppression actions taken, or other strategies and tactics. This lack of information makes it difficult to improve or develop more effective tools to enhance community protection efforts. There are only a few published case studies related to structure protection in North America. Five excellent examples were identified from the United States: four written by the National Institute of Standards and Technology (NIST) and one by Minnesota's Department of Natural Resources. One of the five case studies discusses an Australian concept implemented in the US. Two of the five case studies relate to sprinklers and four of the five case studies relate to structure ignition. The differences in fuel types encountered in these case studies, limited their relevance from a Canadian fuels perspective.

Based on the limited relevant case studies available, FPInnovations examined four western Canadian WUI events and will publish four case studies that examine recent WUI incidents in Alberta and British Columbia, and document examples of successful sprinkler use. Three of the case studies relate to wildfire events, and one is an example of a permanent water delivery system used to protect industrial infrastructure. Building a case study after an event requires significant collaboration with people from the Incident's Management Team, in order to re-create and understand the events that contributed to successful sprinkler deployments or that resulted in structure loss. Gathering this information during a WUI event provides critical data collection and real-time observations that is not available after the event. Real-time data collection provides better insights and stronger conclusions to support future deployments and enhance protection efforts.

7.1 Kenow fire – Alberta, 2017

The community of Waterton experienced a major wildfire in September 2017. Structure protection initiatives involving wildfire and municipal crews protected more than 400 structures in Waterton Lakes National Park. The structure protection assignments included protecting remote back-country structures and the community itself. Strategies and tactics differed between the two assignments. Wildfire equipment was used in the back-country and along the WUI perimeter. Sprinkler lines were supported by volume pumps and 100-mm (4-in.) supply lines. Structure protection resources within the townsite included a combination of structural apparatus (fire engines) and sprinklers for specific values. Implementing the structure protection plan that was in place took eight days. Members of the Values Protection Branch said that the high-volume pumps were essential in providing an adequate water supply for the Waterton townsite structure protection efforts.

Key message: Complex WUI events require the deployment of a variety of different systems. Pre-planning and training are critical, and deployment takes time.

A comprehensive case study has been published independently as; *Case study – Kenow fire, Alberta, 2017; structure protection in Waterton Lakes National Park*, and is also included as "Appendix E" of the *State-of-practice of water delivery systems (sprinklers) used in the wildland-urban interface; Compendium,* located on the FPInnovations website at:
http://wildfire.fpinnovations.ca/Research/SprinklerStateOfPractice/SprinklerStateOfPractice.aspx

7.2 Elephant Hill fire – British Columbia, 2017

In August 2017, the Elephant Hill fire threatened the First Nation community of Skeetchestn. At the time of deployment, structure protection resources anticipated imminent fire impingement of the 300 person community. The OFC, using 20 structural and 3 wildfire firefighters, deployed WASP low-volume, low-pressure sprinklers on approximately 105 structures in 4.5 hours. The WASP sprinklers were connected to 38-mm (1.5-in.) hose fed by community hydrants, or to the structures hose bibb. This was the first deployment where WASP technology was used as the primary sprinkler for structure protection. Ultimately, the fire did not reach the community. The deployment of low-volume (2.5-5.0 gpm) sprinklers, operating at less than 50 psi, can be important in communities that have deployment plans that call for the use of community hydrants as a primary water source, or in situations where water conservation is important.

Key message: Low-volume, low-pressure sprinklers are an effective tool that can be rapidly deployed and connected directly to a community water supply.

A comprehensive case study has been published independently as; *Case study – Elephant Hill fire, British Columbia, 2017; low-volume, low-pressure sprinkler deployment in the community of Skeetchestn*, and is also included as "Appendix F" of the *State-of-practice of water delivery systems (sprinklers) used in the wildland-urban interface; Compendium,* located on the FPInnovations website at:

http://wildfire.fpinnovations.ca/Research/SprinklerStateOfPractice/SprinklerStateOfPractice.aspx

7.3 West Babine River fire – British Columbia, 2018

In August 2018, the West Babine River fire was within 2 km of a steelhead fishing lodge located along the Babine River. The lodge manager purchased Honda pressure pumps and sprinklers to protect the main lodge, cabins, and out buildings. The OFC developed a sprinkler plan, and the BC Wildfire Service (BCWS) provided assistance to the lodge owner during sprinkler set up. The lodge manager was evacuated once the sprinkler system was operational, and the BCWS crews committed to activating the pumps if the wildfire threatened the lodge. When residents take responsibility for structure protection on their private property by implementing FireSmart guidelines and pre-position pumps, hose, and sprinklers ahead of time, it not only increases the probability that their property will survive a wildfire but reduces the pressure on the limited number of firefighters involved in an incident.

Key message: Private citizens can be empowered and responsible for deploying their own sprinkler system. This takes pressure off limited agency resources. Tools to help build citizen's capacity in advance of a WUI event can be developed.

A comprehensive case study has been published independently as; *Case study – West Babine River fire, British Columbia, 2018; private citizens supporting the protection of their own infrastructure*, and is also included as "Appendix G" of the *State-of-practice of water delivery systems (sprinklers) used in the wildland-urban interface; Compendium,* located on the FPInnovations website at:
http://wildfire.fpinnovations.ca/Research/SprinklerStateOfPractice/SprinklerStateOfPractice.aspx

7.4 Tolko mill yard – Heffley Creek, British Columbia

Tolko Forest Products has installed a permanent sprinkler system to help maintain wood quality at the Heffley Creek sawmill. The system also provides fire protection for the wood storage yard. Eighteen Big Gunn sprinklers connected to a 100-mm (4-in.) supply line are used to automatically wet the log yard based on predefined conditions. The sprinkler line is 2300 ft. long and the sprinkler radius is 120 ft. This type of system may be suitable for various industrial users or communities that require a permanent perimeter line.

Key message: This is an example of a permanent high-volume, high-pressure systems used for critical infrastructure protection.

A comprehensive case study has been published independently as; *Case study – Tolko Mill Yard, Heffley Creek, British Columbia; high-volume, high-pressure permanent sprinkler system*, and is also included as "Appendix H" of the *State-of-practice of water delivery systems (sprinklers) used in the wildland-urban interface; Compendium,* located on the FPInnovations website at:
http://wildfire.fpinnovations.ca/Research/SprinklerStateOfPractice/SprinklerStateOfPractice.aspx

8. CONCLUSIONS AND KEY MESSAGES

The literature suggests that the most common pathway to structure ignition is where receptive fuels adjacent to a structure are ignited by firebrands. These small fires continue to consume combustible materials, grow in intensity, and eventually cause the ignition of structural materials.

FPInnovations believes that the deployment of sprinklers to wet combustible fuels in the structure ignition zone, and the development of sprinklers designed specifically for use in Priority Zone 1a (0-1.5 m from a structure), can have a significant effect and improve the outcomes in the WUI.

The spectrum of WUI structure protection efforts in Canada is wide and ranges from the protection of lake-side cottages to cities imbedded in the boreal forest. We tend to use the same sprinkler deployment strategies under very different scenarios therefore; our efforts may not be as effective as they could be if the strategies were adjusted across this spectrum.

Depending on the time available for deployment, and on the fuel characteristics, fire behavior, and available water supply, different sprinkler system designs could be required for successful structure protection. Protecting structures in lake country with an ample water supply is much different from protecting structures in the WUI in a community such as Canmore or Whitecourt, with a limited water supply. The use of high-volume, high-pressure systems may be required for perimeter lines adjacent to standing timber to effectively reduce radiant heat transfer and direct flame contact with a structure. Conversely, low-volume, low-pressure systems may be effective at applying an appropriate amount of water to prevent firebrands from igniting fine fuels in the Structure Ignition Zone. However the current practice in Canada is to use the same wildfire equipment for almost every situation.

The evidence is clear: sprinklers can be effective in protecting structures from wildfire, and the current configuration of wildfire equipment has been effective, especially in areas where there is ample water supply and the number of structures to protect is limited. However, the development of equipment and technology specific to the WUI, in areas where water is limited or the number of structures is considerable could provide firefighters with an enhanced set of tools and deployment options.

8.1 Conclusions

Based on the current equipment and technology available, agencies are doing an excellent job of protecting seasonal cottages and lakeside communities. Although the reporting of results of structure protection actions tends to be anecdotal with very few published documents or after-action reviews, fire managers across the country seem to agree that sprinklers are an effective tool for structure protection.

Agencies are also doing a good job of protecting rural residential structures when adequate water is available. If limited water is available or numerous structures exist in remote settings,

the task becomes logistically more difficult. Rural residential deployments in areas with limited water supply tend to be labour-intensive and can create potential firefighter safety issues in terms of egress and available survival zones. For remote or isolated structures, the use of gels, foams, and retardants is an option that needs to be further developed to provide clear benefits to firefighters and agencies.

Smaller communities, such as Nordegg and Tallcree First Nation, on the edge of the forest or grasslands can have a heightened fire risk. These communities are more difficult to protect because potential head fire intensity resulting from wind-driven forest fires results in longer spotting distances and an increase in radiant and convective heating in close proximity to residential structures. There is potential for high intensity ignition when structures are located less than 30 m from standing timber. In these cases, communities can benefit from the use of high-volume, high-pressure systems that can move greater volumes of water than traditional forestry equipment.

Protecting a community with 200–400 structures becomes a major logistical challenge. In the case of the Kenow fire, eight days were required to prepare for the wildfire event, even when the community had an existing plan. In Alberta, existing structure protection equipment, adequate for protecting larger communities like Banff and Canmore, is likely not available on short notice. Using wildfire equipment during large-scale WUI events and outfitting every residence with a sprinkler system is not practical and it is likely not necessary if more WUI-specific equipment can be developed. The development of rapid deploy or permanent sprinkler systems capable of wetting the first 100 m from the WUI perimeter could help resolve some of these logistical challenges.

Communities that are supported by forest fuel treatments may benefit from the addition of a permanent sprinkler system, similar to the one installed by Tolko. Fuel treatments reinforced with high-volume, high-pressure sprinklers may enable a “stay and defend” strategy for structure protection crews. Permanent high-volume, high-pressure sprinkler systems are also an option for protecting industrial facilities and other critical values at risk outside the WUI. The use of permanent sprinkler lines will be especially valuable in the early spring when wind-driven fires can occur simultaneously at multiple locations, which stretches response resource availability.

As demonstrated in the Skeetchestn case study, the use of community water supplied to a rapidly deployed low-volume, low-pressure sprinkler system is an option that is currently available. The WASP sprinkler is available to residents through retailers such as Canadian Tire, and it provides a casting pattern that is similar (different distance) to that of other impact sprinklers. The benefits of the low-volume, low-pressure sprinklers need to be further explored to determine if current designs and installation practices provide adequate coverage for Priority Zone 1a.

In communities where water reservoir capacity is limited or unreliable, fire managers will be reluctant to support any external use of community water for fear of having insufficient water when it is needed for conventional structural fire containment. In all cases, structure protection becomes a water supply and water management issue. Water management technologies that control water flow and can be remotely controlled are already available. However, these technologies have not yet been well adapted for use in the WUI. These technologies can help ensure that adequate water is delivered while conserving the available supply. Ensuring that enough water is available needs to be considered during the residential planning phase and should be considered as an infrastructure upgrade for existing communities.

Finally, the case studies, observations and interviews showcase the benefits of having a wildfire structure protection and sprinkler deployment plan for forested communities. The required water supply should be determined by reverse engineering the system, starting with the number and size of sprinklers that will be deployed. An assessment of the water needed, compared to the community water available will dictate the need to leverage nearby non-community water sources such as creeks or lakes, or the need to bring in portable water or install additional permanent water storage tanks. Sprinkler deployment plans need to be validated through training and deployment exercises to ensure that they will be effective prior to a wildfire event.

8.2 Key messages

1. Sprinkler deployment plans need to be well aligned with existing FireSmart guidelines and fuel management treatments. Deployment plans should be developed using a decision tree approach. A standardized sprinkler plan template and support tools that can help practitioners design appropriate deployment plans that address the water supply challenges, should be developed.
2. Reliable water supply and delivery is essential for sprinklers to be effective. The required water supply should be determined by reverse engineering the system, starting with the number and size of sprinklers that will be deployed.
3. Wildfire equipment is commonly used in the WUI, although there is very little science to support equipment choices. In most cases, a “one size fits all” approach is being applied by structure protection specialists. New equipment that can support WUI protection efforts is emerging. This equipment should be evaluated so that agencies can make informed purchase, strategic, and tactical decisions. In addition, knowledge exchange between agencies needs to be enhanced to facilitate information sharing on what is effective and what is not. The following are some opportunities for enhancing the use of wildfire equipment within the WUI, as extracted from the case studies, observations, and interviews:
    - Classify commercially available pumps based on the number of sprinklers that they can support.
    - Improve the frequency of use of relay tanks to support sprinkler deployments.
    - Stock a variety of sprinklers (low, medium, and high-flow) in each trailer and ensure resources know how and where to effectively deploy each type.

- Stock 30 m (100 ft.) and 15 m (50 ft.) hose lengths to accommodate sprinklers with shorter casting distances.
- Evaluate the implementation of a version of the Ontario quick deploy sprinkler attachment.

Opportunities for innovation include:

a. working with manufacturers to reduce friction loss from water thieves, through enhanced equipment design
b. developing compact, lightweight, easy-to-transport relay tanks
c. designing an affordable quick-deploy sprinkler package for residents that includes a pump, sprinkler, and a portable tank. Newly designed systems should incorporate automated and remote water management technologies

4. Community hydrants and reservoirs need to be assessed to determine the extent to which they can support sprinkler deployments. In communities where the water supply is limited, the use of low-volume, low-pressure sprinklers should be considered to conserve water.

   Currently, the WASP system is the only low-volume, low-pressure system that is commercially available. Innovation opportunities to make low-volume, low-pressure systems more relevant in the WUI are thought to include:
   - development and testing a ground-based, ultra-low-volume, low-pressure, resident-installed system that can be used in conjunction with a portable pump, a well pump, or be installed on a structure's hose bibb. Design criteria for such a systems should include:
     a. sprinklers that operate at less than 25 psi and use less than 3 gpm
     b. quick deployment by the resident (less than 30 minutes per system)
     c. water management features such as automation, remote operation, and watering time control
     d. affordability

5. High-volume, high-pressure systems are becoming increasingly common. The effectiveness and efficiency of these systems is not well understood by agencies or the system manufacturers. The benefits of these systems as portable or permanent water delivery systems for protecting communities or other critical infrastructure needs to be evaluated. These systems are commonly used in the oil and gas industry to move large quantities of water. Innovation opportunities to make these systems relevant in the WUI are thought to include:
   - weight reduction to alleviate some of the remote access concerns
   - development of rapid deployment systems
   - Inclusion of water management features such as automation, remote operation, and watering time control to reduce the number of people required to operate these large-scale systems

6. Determine the feasibility of using water enhancing gels for protecting remote structures.

9. LITERATURE CITED

Caton, Sara & Hakes, Raquel & Gorham, Daniel & Zhou, Aixi & Gollner, Michael. (2017). *Review of Pathways for Building Fire Spread in the Wildland Urban Interface Part I: Exposure Conditions*. Fire Technology. 53. 10.1007/s10694-016-0589-z. Retrieved from https://www.firescience.gov/projects/15-1-04-4/project/15-1-04-4_FT-Paper_Review_of_pathways_for_building_fire_spread_in_the_WUI_Part_I_Exposure_conditions.pdf

FireSmart Canada (2018). *FireSmart Priority Zones 2017*. Resource Library. Retrieved from https://www.firesmartcanada.ca/mdocs-posts/firesmart-priority-zones-2017/

Hakes, Raquel & Caton, Sara & Gorham, Daniel & Gollner, Michael. (2017). *A Review of Pathways for Building Fire Spread in the Wildland Urban Interface Part II: Response of Components and Systems and Mitigation Strategies in the United States*. Fire Technology. 53. 10.1007/s10694-016-0601-7.

NFPA. (2018). *Standard for Reducing Structure Ignition Hazards from Wildland Fire*. Retrieved March 9, 2018 from https://www.nfpa.org/codes-and-standards/all-codes-and-standards/list-of-codes-and-standards/detail?code=1144

Walkinshaw, S., & Ault, R. (2009). *Use of sprinklers and aqueous gel for structure protection from wildfire – case study 2*. Advantage Report. Vol 11 No 3. Retrieved from http://wildfire.fpinnovations.ca/53/SprinklersAndGelForStructureProtection.pdf

Walkinshaw, S. and Ault, R. (2008). *Use of sprinkler and aqueous gel for structure protection from wildfire.* Advantage Report Vol. 9, No. 8. Vancouver, B.C.: FPInnovations-FERIC. Retrieved from http://wildfire.fpinnovations.ca/53/AdvVol9No8download.pdf

info@fpinnovations.ca
www.fpinnovations.ca

OUR OFFICES

Pointe-Claire
570 Saint-Jean Blvd.
Pointe-Claire, QC
Canada H9R 3J9
(514) 630-4100

Vancouver
2665 East Mall
Vancouver, BC
Canada V6T 1Z4
(604) 224-3221

Québec
1055 rue du P.E.P.S.
Québec, QC
Canada G1V 4C7
(418) 659-2647