FIRE EVACUATION MODELLING OF A CANADIAN WILDLAND URBAN INTERFACE COMMUNITY

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Abstract

Wildland Urban Interface (WUI) communities are situated at the interface between human development and wildland fuel. In addition to their proximity to susceptible regions, routes of evacuation in WUIs are often limited, posing great risks to these communities in the event of a natural disaster. Considering the abundance of WUI interfaces in Canada, Canadian-based research is vital in developing national wildfire regulations. However, the limited amount of Canadian research forces authorities to seek wildfire evacuation techniques from foreign sources, which may not be proven to be effective in northern, boreal forests. To begin the research herein, a Canadian WUI community in central Canada was selected as a case study to investigate assembly and evacuation patterns during a fire evacuation to illustrate the complexity of the situation and the current research needs required. First stage simulations of evacuations were performed in the traffic simulation software PTV VISSIM, which extracted useful data including evacuation times and related parameters. Results demonstrated that the addition of an extra highway access road reduces evacuation times by up to an hour and twenty minutes- time which can determine whether a resident evacuates or not. However, the predictive power of the software is limited by its ability to incorporate effects of human behaviour and the fire behaviour itself. Thus, extending these findings to include the need for evacuee behaviour and fire dynamics is a crucial second stage to the formation of a more complete strategic evacuation plans for communities at risk of wildfires. This study is vital to creating a Canadian-based approach to WUI wildfire evacuations, and largely expanding the knowledge base in the field.

Key Words: WUI; wildfires; egress; evacuation; human behaviour; traffic modelling.

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1. Introduction

In 2016, Northern Alberta experienced the Fort McMurray wildfire, leading to the largest evacuation in its history. In addition to the evacuation of 88 000 residents, the province incurred $9.9 billion in damages as a result of this event (Antunes 2016; Lewis 2019). Highlighting the significance of this matter, this was not an isolated event and is likely to recur more frequently due to climate change associated factors and increased interactions between people and the wildland (Johnston and Flannigan 2018). It is internationally recognised that modelling tools that integrate fire-associated factors to inform decision making during wildland urban interface (WUI) fires are lacking (Ronchi et al. 2019). Further exacerbating the fire problem, Canada annually experiences an average 6200 wildfire burns and over 2.7 million hectares of wildland loss (StatsCan 2018).

To combat the recurrence of Fort McMurray wildfires, Alberta implemented US-based prevention techniques such as thinning trees around the city (Antunes 2016). Despite their efficacy in other regions, these precautions have not yet been proven effective in northern, boreal forests due to differences in community structure, vegetation, climate, and culture. In addition, community needs vary geographically as demonstrated by differences in evacuation guidelines between the United States and Australia (mandatory evacuation versus permission to stay and defend) (Folk et al. 2019). In Canada, evacuation is favoured (McLennan et al. 2019), however, evacuation orders cannot be legally enforced (with the exception of Manitoba) (Christianson et al. 2019). Additionally, the behavioural patterns of residents faced with a hurricane are investigated and extrapolated to those faced with a wildfire, as similar responses are assumed to be observed in these two scenarios and research in the latter is lacking (Johnston et al. 2019). Both hurricanes and wildfires are unpredictable in nature due to their dependency on many factors, provide similar evacuation timeframes, have the capacity to displace large groups of people, and have the potential to change course without warning (possibly decreasing time available to make protective action decision making) (Folk et al. 2019). Research from hurricane and WUI fire literature was previously employed to create a first-stage conceptual model of decision-making for WUI fires which lays the groundwork for the development of the research framework discussed in this paper. Considering the phase-based nature of this study, it is important to differentiate between the earlier phase of this project which considered the behavioural component and the current phase which aims to further frame WUI research through a Canadian case study. Herein, the authors are aiming to study Canadian specific data, specifically the state of traffic modelling tools in this context. We aim to illustrate the complexity of the Canadian WUI evacuation scenario, which reinforces what strategic future research is needed to advise policies and guidelines concerning wildfire evacuations, as the annual number of wildfires in Canada continues to rise. The research findings herein, begin to fill knowledge gaps identified in the *Blueprint for Wildland Fire Science in Canada* (Sankey 2018) and keep Canada on pace with the current and emerging challenges of wildfires. These gaps follow several research themes which include (1) understanding fire in a changing world, (2) recognizing the existence of different social groups, (3) building resilient communities and infrastructure, (4) managing ecosystems, (5) delivering innovative fire management solutions, and (6) reducing the effects of wildland fire on Canadians.

2. Objectives

To assess the capabilities and limitations of the current Canadian system, a north-central Canadian-based WUI community was utilized (characterized as a boreal forest). In light of its proximity to densely forested areas, this community is susceptible to wildfires and therefore requires a suitable evacuation plan. A view of the community is shown in Figure 1. Since this is a standalone research contribution to knowledge, this figure is stripped of identifiers to preserve the community's autonomy. Also, no references are made elsewhere in the paper to the project that served as the source of information for the case study.

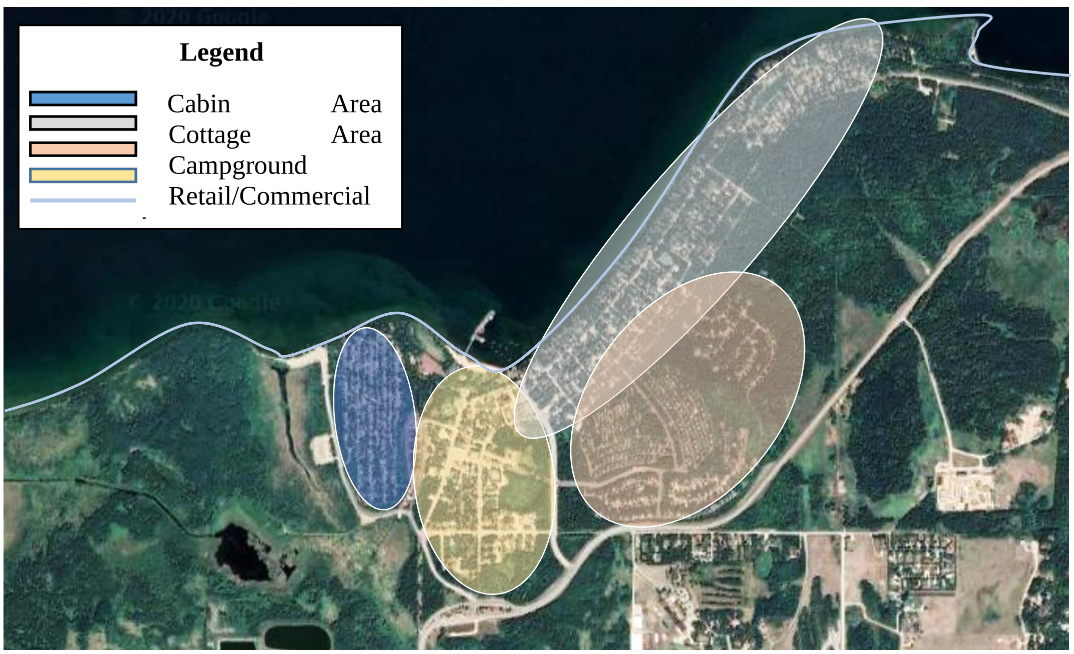

Fig. 1. The four primary areas of the case study community

The study begins by investigating the traffic evacuation component of this Canadian WUI community - a valuable contribution given the lack of Canadian WUI case studies in literature.

Early discussions with community authorities led to the hypothesis that the community's current and only egress road could be a risk for emergency associated congestion, necessitating the construction of an additional egress road which was ultimately built. Nevertheless, the hypothesis at the time of conception was unsubstantiated as it lacked quantified study. At the same time, a proper evacuation plan would consider not only traffic patterns, but also fire behaviour and decision-making procedures which are to be investigated later in this over-arching project (Folk et al. 2019; Folk and Gales 2018). Currently, these factors are typically considered independently of each other so representation of key interactions and influences that impact decision-making are lost in the analysis (Ronchi et al. 2019). The authors begin this phase of study by examining each separately in order to demonstrate the high level of uncertainty in the results when each facet is treated independently. Due to the complex nature of evacuations which often involve countless different factors (e.g. background traffic, lane reversal, fallen power lines, direction change or evolution of fire etc.), this paper begins its research framework by investigating the baseline evacuation scenario, specifically focusing on the traffic aspect in a first stage study. Future second stage research by the authors will couple the fire behaviour and human decision-making in order to develop a Canadian case study with increased awareness of these interactions and consequent decreased uncertainty in results (Folk and Gales 2018).

3. Case Study

The case study community features four main areas which were examined (see Figure 1): a cottage area (lower density with larger lots), a campground, a retail/commercial sector, and a cabin area. The cabin area was the original focus of the study due to its one egress road, which connects with the community at a 4-way stop. The cabin area consists of 530 cabins on less than 0.15 km^2 and is separated into the back-cabin area (closer to the lake) and front cabin area. The community is located in a densely forested area, which also includes abundant under-storey vegetation. The nearest fire department is volunteer based and is 12 kilometres away from the cabin area.

4. Methodology

Four main objectives were established when creating the first stage of this project. First, the project aims to create a baseline for future theoretical evacuation scenarios. Although there are many possible scenario types, collecting additional information from the community residents helped to minimize these possibilities. Secondly, distinguishing the congested areas and worst-case scenarios was critical as it provided leeway into creating a suitable evacuation plan. Thirdly, identifying the gaps and additional information required to generate a plan provides guidance for future directives. Lastly, it is mandatory to acknowledge the influence of the assumptions on the data, to understand the limitations of the results. Keeping these above objectives in mind, the community was modelled on PTV VISSIM – a microsimulation traffic modelling software platform. This software was selected as it is a commonly used toolset and is available to Canadian industries. The model is based on several mathematical sub-models relating to car following, lateral movements (lane selection, lane changing, etc.), tactical driving behaviour, pedestrian modelling, fixed routes, and dynamic routing and assignment. To transform the community set up into a model, GIS-based maps and site plans were used as provided by online information from the site. Ten scenarios were created to set a baseline for the evacuation model. These scenarios varied in four parameters (see Table 1): (1) number of car(s) per cabin, (2) departure time[1], (3) evacuation direction, and (4) number of cars from community. These parameters were specifically chosen as a result of the uncertainty in the community's demographics. The ten scenarios are described in full detail in Table 2, which illustrates specific options chosen for each. Of these, the worst-case scenarios included modelling two additional roads to mitigate the congestion – (1) an extra back cabin road, and (2) an extra highway access road.

Table 1. Parameter options for the 10 modelled scenarios

Parameter	Options
Number of car(s) per cabin	• 1 car • 2 cars
Departure time	• 0 to 1-hour • 0 to 2-hours • 0 to 4-hours
Evacuation direction	• South-West • East
Number of cars from community	• 0 cars • 1000 cars • 2000 cars

Table 2: Modelled evacuation scenario descriptions

Scenario No.	Description	
1	1 car per cabin (530) 1-hour departure window	South-West evacuation 0 cars from community
2	1 car per cabin (530) 1-hour departure window	East evacuation 0 cars from community
3	1 car per cabin (530) 1-hour departure window	South-West evacuation 1000 cars from community
4	1 car per cabin (530) 1-hour departure window	East evacuation 1000 cars from community
5	1 car per cabin (530) 2-hour departure window	South-West evacuation 1000 cars from community

[1] The authors define departure time as the time taken from the initiation of the mandatory evacuation to the time that the individual actually begins to evacuate the cabin by vehicle.

6	2 car per cabin (1060) 2-hour departure window	South-West evacuation 1000 cars from community
7	2 car per cabin (1060) 2-hour departure window	South-West evacuation 2000 cars from community
8	1 car per cabin (530) 2-hour departure window	South-West evacuation 2000 cars from community
9	2 car per cabin (1060) 4-hour departure window	South-West evacuation 2000 cars from community
10	1 car per cabin (530) 4-hour departure window	South-West evacuation 1000 cars from community

The community land use, roadways, intersections, and traffic control devices were modelled in VISSIM. The land use represents locations of traffic origins and destinations. The network geometry was created using a series of *Links* and *Conflict Areas* which represent roadways and intersections, respectively. A satellite view image of the site was scaled within VISSIM to trace roads within the community. Road widths for use by vehicles were specified as 2.5 m within the cabin area, and 3.0 m for all remaining roads. The roads do not feature curbs, gutters, or shoulders. Additionally, lane markings are present in some but not all regions in the network.

As for traffic control, all intersections within the study area were unsignalized. Therefore, all intersection interactions were modelled using VISSIM's *Stop Signs*, *Priority Rules* and *Conflict Areas* functions. Applicable speed limits were sourced from the community. The emergency evacuation nature of actions to be taken by people required the application of the dynamic assignment which tracks movements spatially and temporally (on a split-second basis).

The *Parking Lots* feature in VISSIM was used to designate the origin and destination points for the simulated vehicles. These were assigned to different *Zones* which corresponded to those in the origin-destination matrices used for traffic generation. Each branch of the road network within the cabin area was designated as a different zone (total of 19). A zone was created to represent the rest of the community and one was created for each evacuation destination on the highway (one for evacuating South-West and one for evacuating East). *Reduced Speed Areas* were used at sharp turns in the road network to temporarily slow traffic down and *Desired Speed Decisions* were used when speed limits within the network changed. Figure 2 shows the modelled network in VISSIM. The green and red sections shown in Figure 2 represent right-of-way paths for vehicles in *Conflict Areas,* where green is the right-of-way, respectively. The yellow spots represent areas where vehicles reduce their speed to turn. The blue regions are Parking Lots which act as origin and destination points for the stimulated vehicles. Finally, the black and blue outline boxes are data collection points of Conflict Areas and Parking Lots.

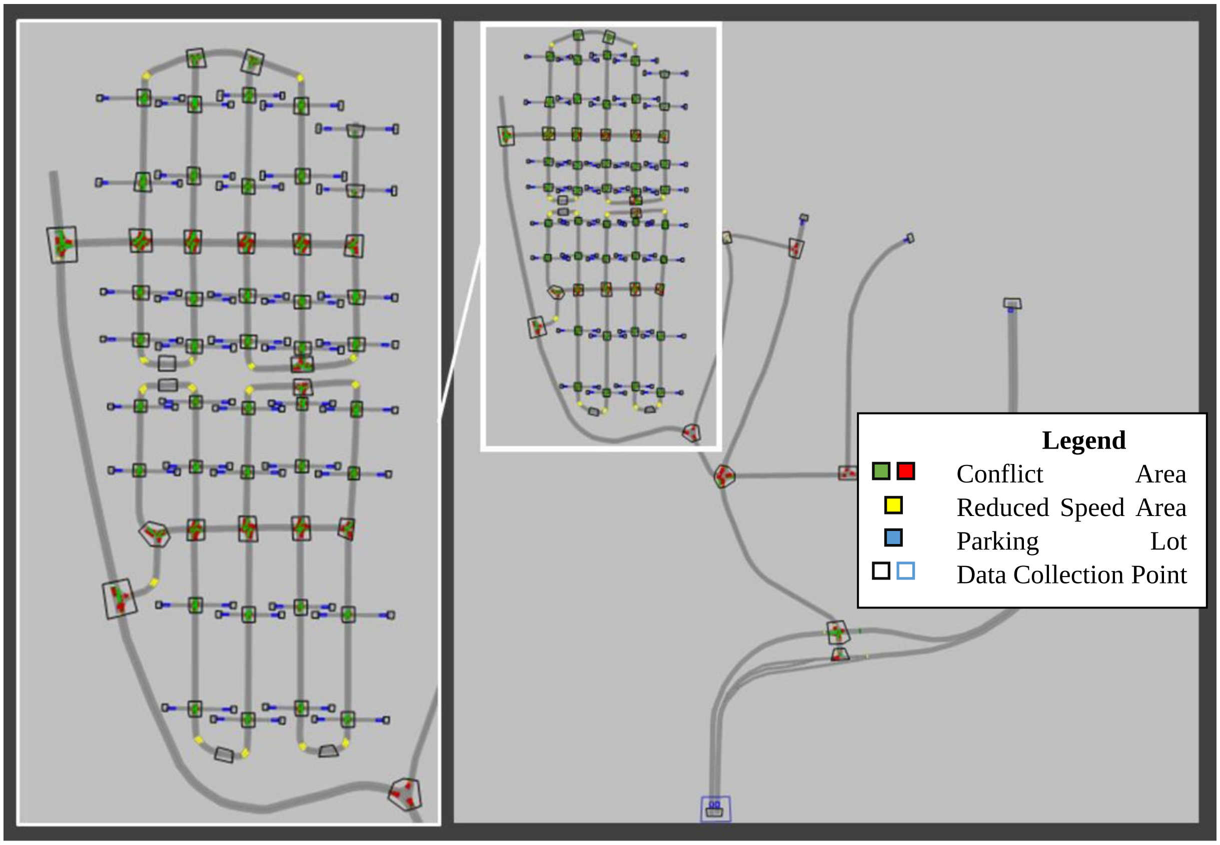

Fig. 2. Case study community road network in VISSIM

Various factors were considered when analyzing the data. To start, two evacuation times were recorded: (1) Total Evacuation Time (TET) and (2) Individual Evacuation Time (IET). The TET is the time taken for all vehicles to leave the network, while the IET is the time each individual vehicle spent travelling in the network. Additionally, queue lengths indicate the time that each vehicle waits at specific locations in the network. *Data Collection Points*, *Vehicle Travel Time Measurements*, and *Queue Counters* were used to collect information about the vehicle such as the total and individual evacuation times, queue lengths, and travel times. Data collection points and queue counters were placed at the entrance to intersections on roads of interest (focus on primary intersections and cabin area intersections) and directly before the network exit parking lots. Vehicle travel time measurements were taken along stretches of road (cabin area access road and highway access roads).

In looking at these results, or those of any model, it is important to keep in mind the assumptions that were made and the amount and quality of information that was known about the community. Table 3 summarizes key assumptions that were made in the modelling of this case study and the potential impacts that these assumptions had on the simulation outcomes. All assumptions ultimately had the potential to impact the congestion observed within the network (where, when, and to what degree) as well as the TET and IET. Having more information about the number of vehicles that might use the network in the community, particularly under a variety of different realistic wildland fire scenarios for example, would improve the accuracy of how many vehicles to simulate in the model and where they should originate from (cabin area vs. community, within cabin area and within community). This would also lower the uncertainty of the model.

Table 3. Key assumptions and impacts on simulation results

No.	Assumption	Impact
1	Number of vehicles evacuating from cabin area and community	-Determines number of vehicles in the network -Potential to affect the evacuation initiation time (more people, more vehicles, more time to "pack up" and leave origin) -Will affect congestion (in cabin area and where cabin/community traffic meet) -Affect total and individual evacuation times
2	Distribution of community traffic on roads leading out of the community	-Affects the amount of congestion within the network as a whole and the queue lengths (amount of congestion) at specific intersections -Affects total and individual evacuation times
3	No highway traffic	-Affects queues at highway access points which in turn impacts the queues and congestion within the cabin area and community -Affects total and individual evacuation times
4	South/West evacuation more likely	-Affects which intersections are more congested, (potentially which road community traffic would take) -Affects total and individual evacuation times
5	Normal traffic behaviour (only one turning lane onto highway, no lane reversal, right of way and priority rules at intersections)	-Affects speeds, behaviour at intersections, use of oncoming lanes -These will impact evacuation times and the distribution of traffic within the network -Affects total and individual evacuation times

6	No Counterflow	-Evacuating vehicles did not have to deal with traffic travelling in the opposite direction at intersections (impacting queues and congestion) -Affects total and individual evacuation times
7	No background traffic or evacuees making intermediate trips	-Affects the number of vehicles in the network (amount of congestion) -All traffic travelling to same destination -Affects total and individual evacuation times
8	Community evacuates in the same initiation timeframe as cabin area; community evacuees only use south exits out of community	-Affects the number of vehicles in the network (amount of congestion) -Impacts the number of vehicles that would be travelling on the highway upstream of the modelled highway access points -Affects total and individual evacuation times
9	Second car distributed evenly throughout the cabin area (one or two cars per cabin)	-Affect the routes taken by evacuees within the cabin area which impacts queues and congestion within the cabin areas and at the cabin area access intersections -Affects total and individual evacuation times
10	Sightlines and Curb Radii	-Affect how vehicles behave at intersections -Affects total and individual evacuation times

5. Results

Overall comparisons between the 10 scenarios were made by looking at the total evacuation time (TET) – when the last vehicle left the network – and the individual evacuation time (IET) of vehicles in the two sections of the cabin area. Additionally, the time that each vehicle waits at specific locations in the network (queue lengths) was considered.

5.1 Additional Roads

To begin assessing the impact of network design modifications, two alternative cabin area egress routes were also modelled for the case study community. The same assumptions and modelling approach as those detailed above were used. Figures 3a and b show the location of the two additional roads. The first road (extra back cabin area road) connects the back cabin area to a parking lot access road. This road currently exists within the community however it is not in use. As noted by the authorities having jurisdiction, there is the potential to turn this road into an emergency egress route for use in the case of an evacuation. The second road (extra cabin area highway access road) connects the main cabin area road directly to the highway. As this road does not exist, its location is arbitrary, however the southern most part of the road was made to follow an existing walking path.

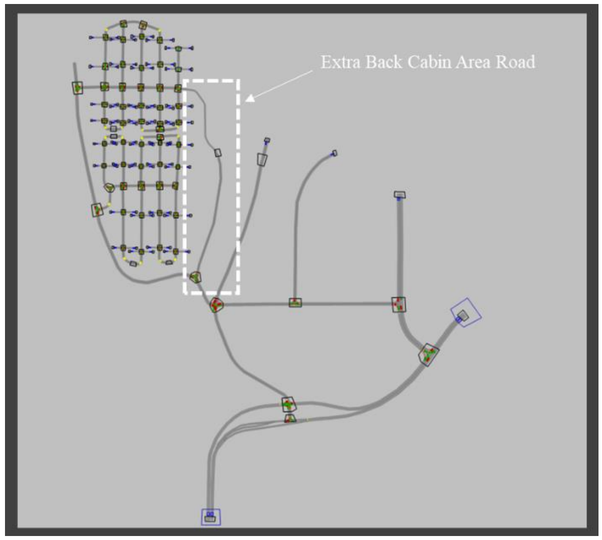

Fig. 3 (a). Location of Extra Back Cabin Area Road

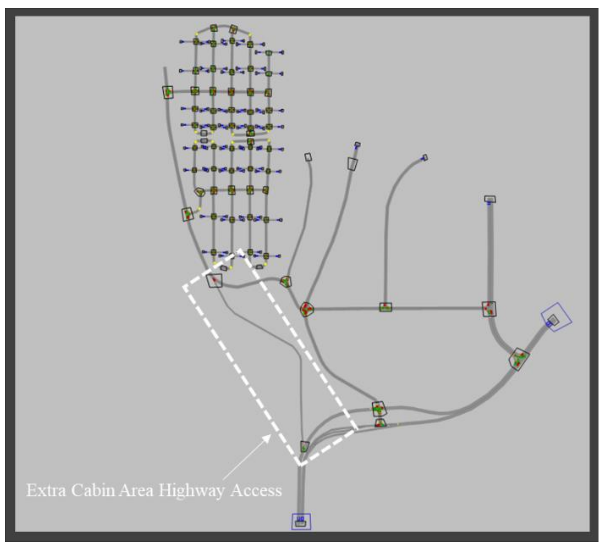

Fig. 3 (b). Location of Extra Cabin Area Highway Access Road

Scenarios 3 and 7 were modelled for each of the modified networks as these were identified as worst-case scenarios in the preliminary analysis (see Figure 5 in the next sub-section). As with this analysis, the TET and IET were compared along with the queue lengths. Each scenario was run 20 times, as this produced an error of less than 1% (i.e. an additional run would change the results by less than 1%) (Folk et al. 2019).

5.2 Evacuation Times
Total Evacuation Times

Average TET values were compared to the initiation timeframe (period of time during which vehicles left their origin zone) below and are shown in Figure 4. The data indicated that Scenarios 3 and 7 resulted in the greatest difference between the TET and departure timeframe, while scenarios 1, 2, 5, 9, and 10 resulted in the smallest differences. This is likely because Scenarios 3 and 7 featured the highest number of evacuees per departure timeframe. For example, Scenario 7 had two cars per cabin and 2000 cars from the community within a 2-hour departure time (see footnote 1). Figure 5 displays the average total evacuation times predicted for both Scenarios 3 and 7, as well as for the addition of either the extra back cabin road or the extra highway access road. It is evident that the extra back cabin area highway access road significantly reduces the TET, while the extra back cabin road does not, as mentioned previously. Tables 4 and 5 examine the expected average total evacuation times for both the base scenarios and the worst-case scenarios with additional egress roads, respectively.

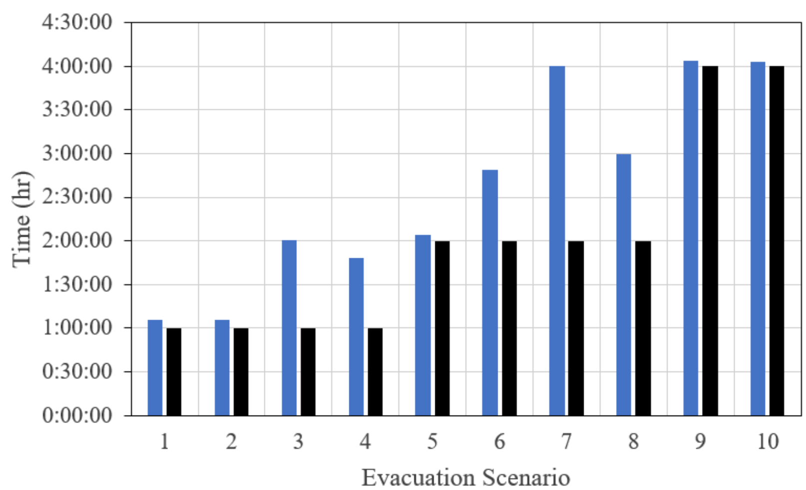

Fig. 4. Total evacuation time and departure timeframes

Table 4. Expected average total evacuation times for base scenarios

Scenario	95% Confidence Expected Total Evacuation Time Range (hr)
1	1:05:19-1:05:59
2	1:05:15-1:06:01
3	1:59:30-2:01:28
4	1:45:58-1:50:07
5	2:03:41-2:04:08
6	2:47:43-2:49:13
7	3:58:44-4:01:17
8	2:58:43-3:01:03
9	4:03:35-4:04:02
10	4:03:03-4:03:28

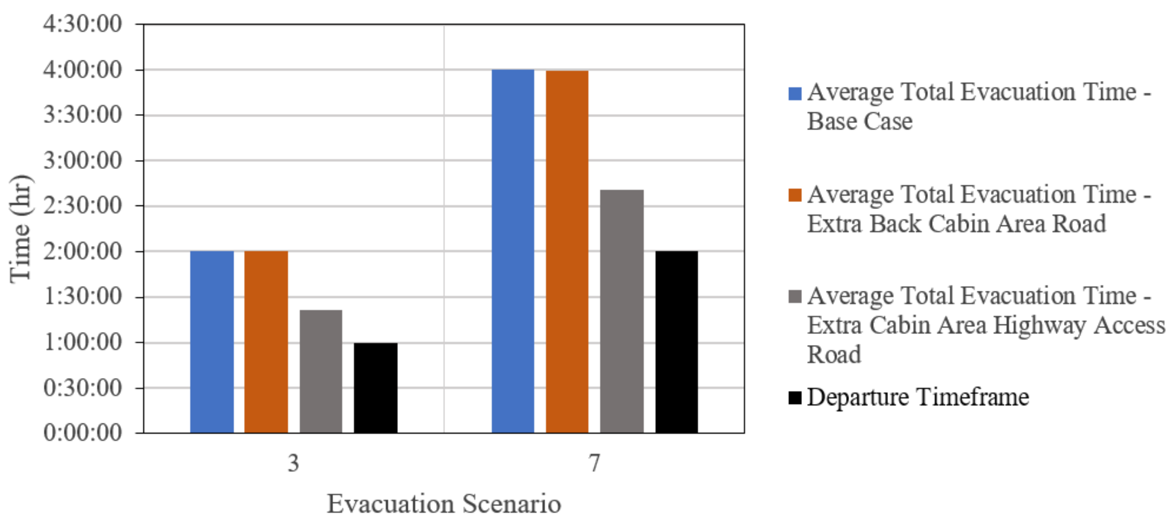

Fig. 5. Total evacuation time and departure timeframes for the worst-case scenarios with additional egress roads

Table 5. Expected average total evacuation times for the worst-case scenarios with additional egress roads

Scenario	95% Confidence Expected Total Evacuation Time Range (hr)
3- BC	1:59:30-2:01:28
3 - EBCAR	1:59:54-2:01:30
3 - ECAHAR	1:20:36-1:23:02
7 - BC	3:58:44-4:01:17
7 - EBCAR	3:57:55-4:01:15
7 - ECAHAR	2:39:34-2:42:29

Individual Evacuation Times

The aggregate IETs for the vehicles originating from the front and back cabin areas were also compared for each scenario. Figure 6 shows the aggregate average and median IETs for evacuation from each of the two cabin areas. Figure 7 shows the aggregate average and median IETs for Scenarios 3 and 7, with the addition of either an extra back cabin road or an extra highway access road.

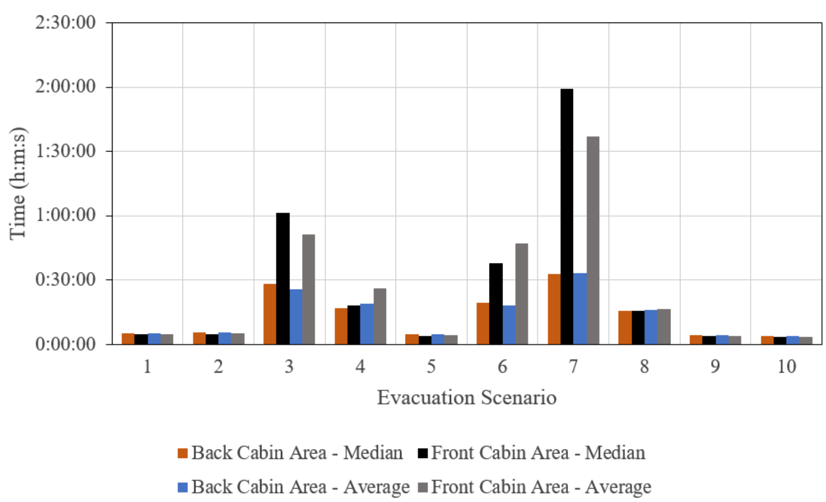

Fig. 6. Aggregate average and median individual evacuation times

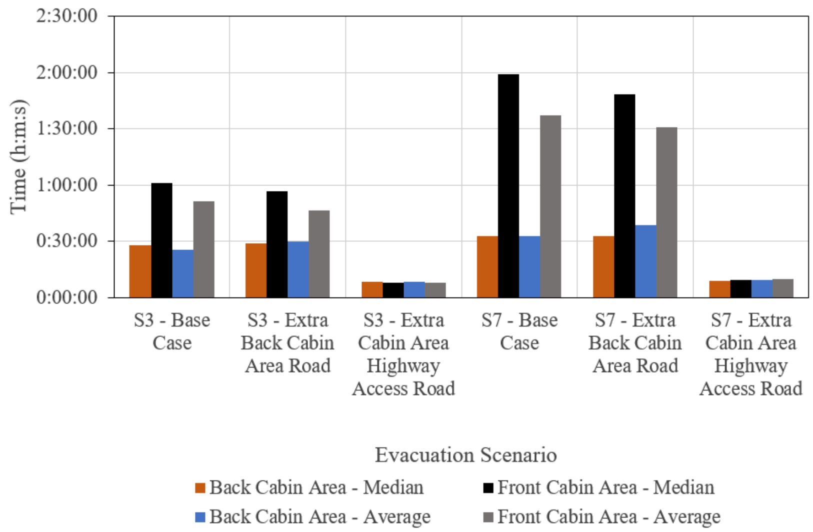

Fig. 7. Aggregate average and median individual evacuation times for the worst-case scenarios with additional egress roads

As demonstrated in Figure 7, Scenarios 3 and 7 resulted in the greatest difference between the average (and median) IET values for the front and back cabin areas. These scenarios also resulted in a larger difference between the average and the median IET values (with the median being greater than the average for the front cabin area). This is similar to the TET results, as both scenarios contained the greatest number of evacuees within their given initiation timeframe, indicating that the number of evacuees is one of the key determinants for individual evacuation time. However, since Scenario 5 and Scenario 9 which had longer initiation timeframes, involved the same number of evacuees as Scenarios 3 and Scenario 7 respectively yet resulted in short IETs, the initiation timeframe also plays an important role. Figure 7 demonstrates the significant decrease in IETs with the presence of an additional extra highway access road. It also shows that the extra back cabin road does not have an impact on the median or average evacuation times.

5.3 Queue Lengths

Congestion occurred at primary intersections in most scenarios, largely impacting the individual and total evacuation times. The greatest congestion corresponded with scenarios that had a greater number of evacuating vehicles and/or a decreased evacuation initiation timeline. Scenarios 1, 2, 5, 9 and 10 had minimal congestion (as observed within the model during the simulation and the recorded queue lengths). Figure 8 below shows the location of the measured queues. Figure 9 shows the maximum recorded queue lengths for all primary intersection within the network.

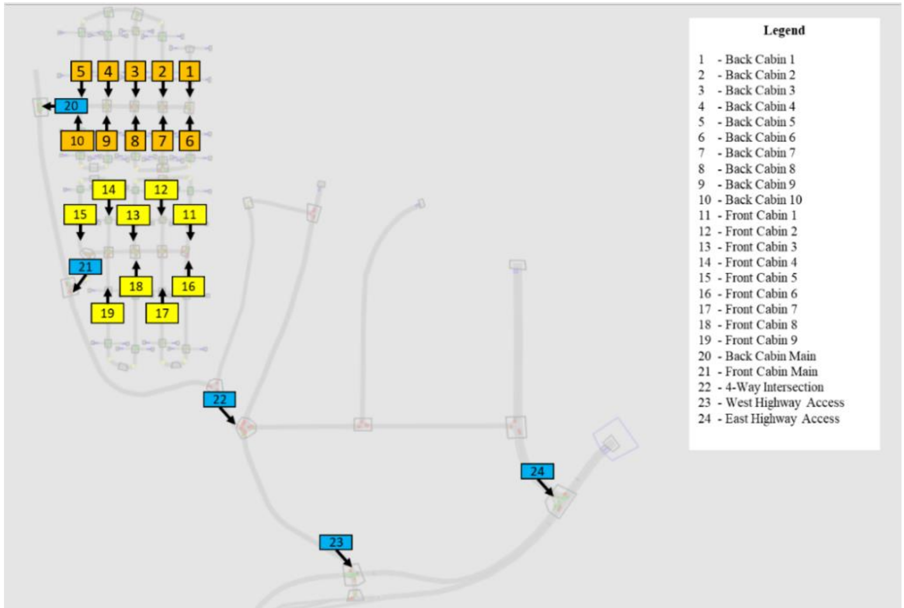

Fig. 8. Queue measurement locations

As is shown in Figure 10 below, the longest queue lengths occurred at the intersections where cabin area and community evacuees interacted (4-way stop, east and west highway access roads). The longest queues were observed during scenarios that had a greater number of evacuees and/or a shorter initiation timeframe (as was seen with the total and individual evacuation times). At the 4-way intersection, Scenarios 3 and 7 caused queues reaching all the way to the back cabin area access intersection, with Scenarios 4, 6 and 8 causing queue lengths past the front cabin area access intersection. Scenarios 3, 7 and 8 resulted in the longest queue lengths at the west highway access intersection, corresponding to increased traffic coming from the community on that road. Given that most of the evacuation scenarios had a west/south destination, fewer cars used the east highway access road. The longest queues occurred at this intersection during Scenarios 4, 7 and 8. Figure 10 displays the maximum queue lengths for the main intersections during Scenarios 3 and 7, with the addition of either an extra back cabin road or extra highway access road. It is evident that the extra highway access road significantly reduces queue lengths for all main intersections, while the extra back cabin area road has no impact on the queues.

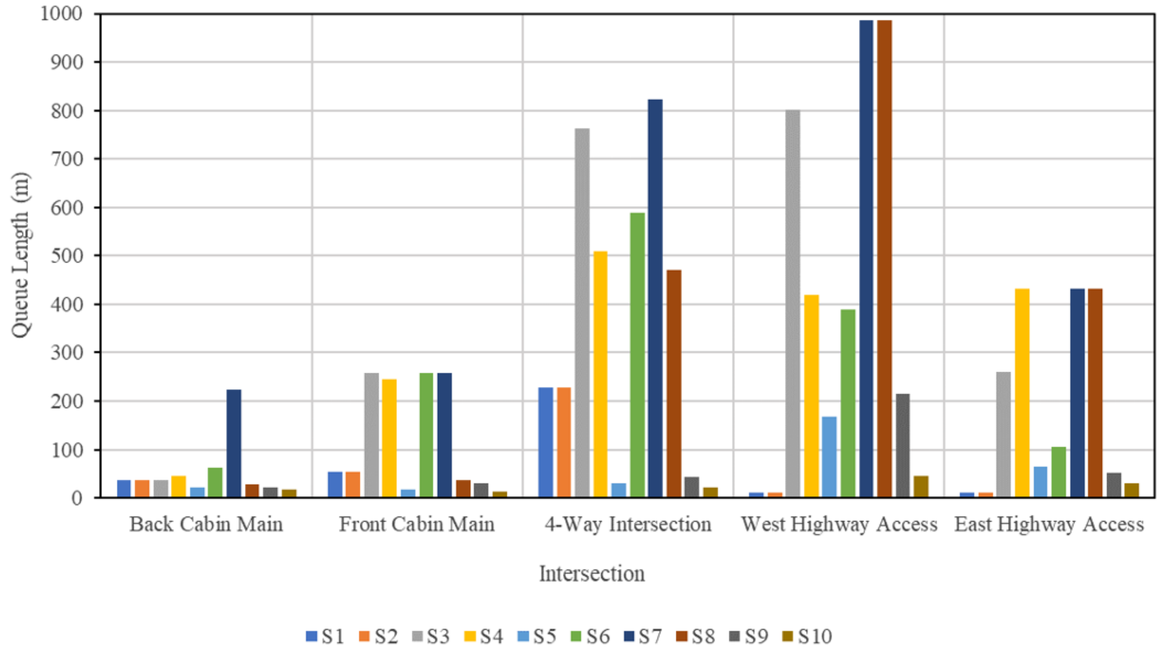

Fig. 9. Maximum queue lengths for main network intersections

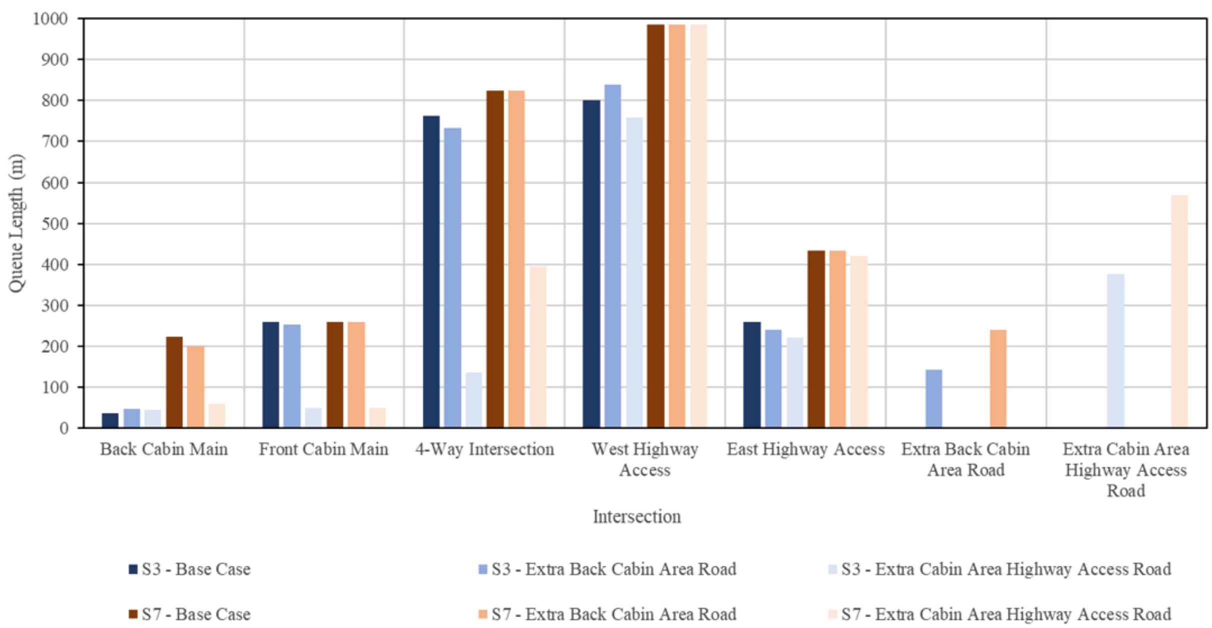

Fig. 10. Maximum queue lengths for main network intersections on the worst-case scenarios with additional egress roads

5.4 Summary

Through the conducted simulations, notable data regarding the TET, IET, and queue lengths was found for the central Canadian town under study. To begin, the addition of the extra back cabin area road had no impact on the total evacuation time whereas the addition of the extra cabin area highway access road decreased the total evacuation time by nearly 40 minutes for Scenario 3 and nearly one hour and 20 minutes for Scenario 7. The extra cabin area highway access road substantially reduced the individual evacuation times for both the front and back cabin areas in Scenario 3 and Scenario 7 (less than 25 minutes in both cases). Finally, the extra cabin area highway access road substantially reduced the queue length at the 4-way intersection. The queue length was reduced from 760 m (base case) to 130 m for Scenario 3, and from 820 m (base case) to 400 m for Scenario 7. Though preliminary, this analysis showcased that the location of additional egress routes is critical in their effectiveness and should therefore be considered carefully.

To strengthen the impact of this study, it is crucial to consider fire behaviour to better assess the likelihood of certain egress route options. In such fire evacuations, it is unlikely that all roads will be available for evacuation, due to natural roadblocks. Hence, data regarding the nature of the fire will assist in creating informed evacuation scenarios, which will incorporate the possibility of road closures. This information will also assist in better guiding the mandatory evacuation window, which will require residents to evacuate prior to the escalation of fire-related obstacles. Additionally, the fire's ability to collapse electricity lines can complicate the communication between authorities and community residents and needs to be considered in the evacuation plan. It is acknowledged that the unpredictable behaviour of fire makes it difficult to predict the progression of evacuations, thus the next phase of this study will incorporate more fire behaviour factors to build on the existing baseline.

6. Conclusions And Future Work

The analysis work presented herein for this seasonal, Canadian WUI case study community is a first stage which lays the groundwork for a more comprehensive assessment of WUI-community interfaces and how best to assist other communities under wildfire threat. It portrays the complexity of the case study and the evacuation scenario. Traffic modelling results demonstrated that congestion during evacuation stems from the cabin area rather than the community's main egress road. Hence, the addition of an egress road leading from the cabin area to the highway was found to reduce congestion and evacuation times significantly. However, the validity of this predictive model is significantly limited by omission of the effect of human behaviour in fire as well as fire dynamics which were not yet investigated in this study. A large degree of analyses is required to understand the four factors that were considered (number of car(s), departure time, evacuation direction, number of cars from community). For example, the authors have a wide distribution of departure times, that with investigation can lower the uncertainty of the model. This stresses the importance of quantifying decision-making actions within the Protective Action Decision Making framework discussed in reference (Folk et al. 2019). This data does not readily exist and is required from the community itself to understand evacuees' behaviour. To do so, surveys regarding the expected actions and behaviours of residents during a WUI fire are crucial to lower the uncertainty of the models by reducing the number of assumptions made and computational effort required. The authors' survey has been presented elsewhere in draft form (Folk and Gales 2018) and obtains information on the protective actions of community members, which will be used to formulate a second stage study.

Emergency plans are becoming the norm in urban governance and these can address the evacuation scenario in applicable WUI communities. The case study highlights the need to develop such plans using concepts, methods, and tools described in the study. Although the detailed level findings are site-specific, the high level findings are transferable to other communities. These high level findings are for the development of an emergency evacuation plan and preliminary traffic simulation for a WUI community. Additionally, the simulation tool used in this case study can be employed to simulate evacuation scenarios in other regions to aid in risk management. The scenarios to be tested should consider detailed site-specific land use and road infrastructure. Additionally, due to Canadian policies favoring but not mandating evacuation, it is important to recognize that while much can be learned from research from other regions, those findings are not simply transferable to Canada. As such, while this paper is not entirely breaking new ground, this novel Canadian case study will pave way for more Canadian-based research by laying the foundations for conducting such studies.

A stochastic traffic microsimulation tool such as VISSIM is essential for tracking the spatial and temporal states of traffic for testing scenarios. Although macroscopic methods are less demanding in terms of data, these do not have the capability to provide detailed results that are required for comparing applicable scenarios. As noted in the paper, essential models of driver decision and associated traffic flow characteristics are built into VISSIM that provide outputs that are important for developing evacuation plans. The case study provides evidence of the detailed level of results obtainable for each scenario tested.

While VISSIM has a degree of validation for traffic modelling, verifying that this software applies to higher stressed scenarios such as evacuations is essential. However ethical considerations may prohibit such a data collection exercise. Lastly, the fire risk in the community needs proper quantification to (begin to) forecast the development of the wildfire. This needs to be considered to refine the travel options that can be implemented over time. However, forecasting the fire dynamics within the community is not a light endeavour. With the rising rates of wildfires in Canada, this research is crucial for establishing a stronger knowledge base in the field. Beyond laying the groundwork to further study in this field, this project creates a first stage foundation for a Canadian-specific strategy to aid in WUI wildfire evacuations.

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