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PLAN 528

BEST PRACTICES IN WILDFIRE MASS EVACUATION PLANNING

Findings and recommendations for
North Shore Emergency Management

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ABOUT THE
CAPSTONE REPORT

This research was conducted by Leni Vespaziani in collaboration with North Shore Emergency Management under the supervision of SCARP faculty.

This report was submitted to UBC’s School of Community and Regional Planning Capstone Course (PLAN 528 A), a requirement of the Master of Community and Regional Planning degree.

LIST OF ACRONYMS

- CNV - City of North Vancouver
- CWPP - Community Wildfire Protection Plan
- DNV - District of North Vancouver
- DRR - Disaster Response Route
- DWV - District of West Vancouver
- EOC - Emergency Operations Centre
- HRVA - Hazard, Risk and Vulnerability Analysis
- MoTI - Ministry of Transportation and Infrastructure
- NSEM - North Shore Emergency Management
- QRG - Quick Reference Guide
- RCMP - Royal Canadian Mounted Police
- SME - Subject Matter Expert
- SOLE - State of Local Emergency
- WUI - Wildland-Urban Interface

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EXECUTIVE SUMMARY

British Columbia has experienced significant economic, social, and environmental losses in recent years due to unprecedented wildfire seasons. Mass evacuations that have ensued bring attention to the challenges of the changing hazard landscape. A longer, more severe wild-fire season was ranked among the highest risks to B.C. in research of climate-related risk scenarios analysed by the Ministry of Environment and Climate Change. This analysis ranked risks by a number of consequences such as loss of life, injury, economic productivity, and cost to provincial government.

Communities must be better prepared for emergencies in order to be better positioned to respond and recover. The Province is seeking to support initiatives that increase the emergency preparedness and planning process. At the beginning of 2019, the Ministry of Public Safety approved funding for evacuation route planning to 60 local and regional governments and First Nations in B.C. Communities are now developing or updating their plans based on this funding, including the three North Shore municipalities.

North Shore Emergency Management (NSEM), a tri-municipal agency that provides emergency management services for the City of North Vancouver, the District of North Vancouver, and the District of West Vancouver, is planning to update their 2009 North Shore Evacuation Strategy. The two main intentions are to update the plan based on the changing risk profile, and to update the data and information that supports the evacuation plan.

Areas of Analysis

EVACUATION STRATEGY
Evacuation plans must adhere to legislative requirements and non-prescriptive provincial guidelines while also being adaptable to local circumstances. This area of analysis seeks to understand the strategic components of the plan, and special considerations to include.

EVACUATION ROUTING
Special consideration must be made to the way in which the evacuation route options are projected and modelled. This area of analysis seeks to explore considerations for modelling, routing, and behavioural factors of an evacuation.

Historically, the North Shore communities have not experienced frequent or large wildfires. The 2018 Whyte Lake fire in the District of West Vancouver was considered a small scale wildfire. Yet, the changing climate combined with increasing development in the wildland-urban interface have increased the North Shore’s exposure to wildfire risk. New and emerging best practices in evacuation plan-ning, lessons learned from the deadly wildfire evacuations within California, and provincial funding for evacuation routing are additional motivators for the evacuation plan updates.

The objectives of this report are to provide an updated community profile of the North Shore, an updated list of hazards which may require a mass evacuation, to identify best practices and lessons learned in mass evacuation planning, and to provide a list of recommendations to be implemented in the North Shore Evacuation Strategy updates. Research methods employed in this report include background research and information requests to update the community profile, key informant interviews and a review on best practices in academic literature and the me-dia, and independent judgment on a set of recommenda-tions most applicable to the North Shore.

The analysis conducted in this report has been categorized into four areas: evacuation strategy, response coordination, evacuation routing, and public notification. The recom-mendations of this report will provide direction for the planning ahead, and prepare the North Shore for future events.

RESPONSE COORDINATION
A number of agencies are involved in coordinating an evacuation, including local authorities, emergency responders, vendors, and neighbouring jurisdictions. This area of analysis seeks to understand how the plan should be designed and used within and between agencies.

PUBLIC NOTIFICATION
Public notification is a major component of any evacuation plan. This area of analysis seeks to understand how to notify the public, what messaging and information to include, and how different notification methods may influence evacuation.

Table 1. Summary of Report Recommendations

Evacuation Strategy	
1	Expand current strategies list to include a larger toolkit of strategies. For supply, include: contraflow, lane reconfiguration, cross elimination, special signal timings (if possible), designated bus and HOV lanes, shoulder lanes, diversion and alternate routes (see Recommendation 2). For demand strategies, include reducing shadow evacuation, phased (staged) evacuation using pre-designated zones, and muster points using pre-designated locations.
2	Priority areas identified in this report (pages 10-11) should be considered for fuel management and treatment, additional di-rectional signage, and areas of limited access should be considered for the forming of alternate evacuation routes via logging road in coordination with DNV and DWV CWPPs.
3	Create a ‘Vulnerable Populations Working Group’ which will invite local organizations to represent the vulnerable subgroups they serve. Emergency information and plan updates may be shared through this group, and key data on the vulnerable populations can be collected for NSEM. Areas of limited or water-only access should be prioritized, with representation from community associations of neighbourhood block watch groups.
Response Coordination	
4	Create an ‘Evacuation Steering Committee’ based on a list of key decision-makers and stakeholders involved in response. A series of 2-3 short, concise meetings should be held with this group for decision making and contact information updates once background information has been compiled.
5	Host a tabletop exercise with Evacuation Steering Committee and emergency responders to practice roles, responsibilities, re-sources, work through assumptions, and encourage interagency communication. This exercise should also include Tsleil-Wau-tuth and Squamish Nations, as well as neighbouring communities that are likely to host evacuees (such as Vancouver Island, Sunshine Coast, Vancouver, Burnaby, Squamish). Request plans from jurisdictions that may evacuate to the North Shore.
6	The evacuation plan should be divided into two parts: the publicly-available background information (demographic and hazard profile, zones and muster points, evacuation strategies, public notification protocols) and the operational plan. An existing four-page ‘Field Reference Guide’ should be expanded to include strategies, checklists, flowcharts, and roles to serve as the new operational plan as per updates made to the plan. The operational plan should be placed in all response vehicles.
Evacuation Routing	
7	Contact TELUS Insights Program representative to determine viability of the product in both pre-planning evacuation model-ling and during response activation.
8	Collect additional data to serve as input variables required to inform the evacuation modelling. Key contacts include MoTI, BC Wildfire Service, Statistics Canada (Neighbourhood Census Tracts).
9	Hire transportation engineering consultant to model dynamic evacuation scenarios. The models should seek to highlight areas of congestion in order to prioritize areas that will require ground traffic management (police controlled intersections), the development of alternate routes , or the supplementation by other identified modes of transportation (air, marine, rail).
Public Notification	
10	Education and engagement should include an online survey (to determine general public risk perception and preparedness), an in-person openhouse (on risk education, communication, personal preparedness, public concerns), then an information session with public (on plan updates, accessibility, and specific information for vulnerable populations).
11	Update communication strategy to include social media and web-based notifications, TV, variable message signs, and Rapid Notify. Continue inquiring on the status and anticipated launch date of Alert Ready service for evacuations in B.C.
12	Public notification protocols in the evacuation plan should be expanded to include public messaging to inform workers who may enter the area of risk, messaging for evacuation alerts at night, messaging to clarify the use of Disaster Response Routes, messaging to state zone colour at risk prior to providing further details that pertain to that zone (in order to gain better reach with targeted audiences).

INTRODUCTION

The North Shore Evacuation Planning Strategy (2009) consists of three similar plans differentiated by geographic and demographic context. The City of North Vancouver (CNV), District of North Vancouver (DNV), and District of West Vancouver (DWV) Evacuation Guidelines provide policies and procedures to safely and efficiently facilitate the evacuation and re-entry of individuals from an emergency event or disaster that puts their health and safety at risk. The plans assist first response agencies, municipal officials and staff to determine the relevant size of evacuation based on the calculated risk, and to employ the most efficient methods and resources to successfully complete the evacuation.

The Emergency Program Act (EPA) (1993) Section 12(1) provides the authority for an elected official (Council or Mayor) to mandate the declaration of a State of Local Emergency (SOLE) in order to “cause the evacuation of persons and the removal of livestock, animals and personal property that is or may be affected by an emergency or disaster and make arrangements for the adequate care and protection of those persons, livestock, animals and personal property”. The EOC Director would then prepare documents and briefings related to the SOLE. Under Local Authority Emergency Management Regulation Section 2 (3)(f), local authorities are required to “coordinate the provision of food, clothing, shelter, transportation and medical services to victims of emergencies and disasters, whether that provision is made from within or outside of the local authority”.

Evacuations may be planned (strategic), or unplanned (tactical). In a planned evacuation, some form of notice is involved. For example, the impacts of freshet flooding may be estimated in advance based on snow pack levels. The population at risk would receive advanced warning to prepare before being ordered to evacuate the risk area.

In an unplanned event, an evacuation of the population at risk would occur with little or no warning. It is often implemented on an ad-hoc basis whereby the Incident Commander initiates the evacuation process and solicits additional support from the Emergency Operations Centre. The most likely cause of an unplanned evacuation may be a hazardous materials incident or a wildfire, whereby little warning is given for the population to evacuate from the risk area, or alternatively to shelter in place. Evacuation planning commonly follows a three-step approach of alert, order, and rescind:

- 1. EVACUATION ALERT:** population at risk is warned of the potential need for evacuation. This alert highlights the nature of the hazard and to be prepared to evacuate their home and area. Some situations require immediate action with little to no notice.
- 2. EVACUATION ORDER:** population at risk is ordered to evacuate the risk area specified in a formal written order. An evacuation order is mandatory, and does not allow for any discretionary action on the part of the population at risk. All must leave the area immediately.
- 3. EVACUATION RESCIND:** population at risk may be allowed to return to the area previously evacuated once they have been advised that the danger has passed and the Rescind has been issued.

Robust, well-defined plans equip responders with information and resources necessary to carry out an evacuation. Emerging best practices in evacuation planning recognize the additional considerations and efforts required for a large-scale, mass evacuation event. A mass evacuation can be understood as an evacuation event whereby thousands of people must be evacuated from a risk area to safety, potentially for an extended period of time.

Purpose

In an effort to support emergency planning on the North Shore, this report presents a set of recommendations for North Shore Emergency Management on the best practices in mass evacuation planning. Research in this report pertaining to best practice in evacuation plan design, familiarization and information sharing are not only applicable to evacuation planning but are also transferable to future emergency plans developed by NSEM.

Research Objectives and Methods

Objectives were developed around the project purpose. Research methods listed below seek to attain the objectives of the project:

OBJECTIVES	METHODS
Provide an updated profile of the North Shore community's typical transportation modes, patterns, demographics, and needs	Conduct background research and information requests in order to update demographic and transportation data for the three municipalities (Including public and private transportation agencies, schools and child care facilities, community rec facilities, housing and health care facilities, etc.)
Identify the hazards of greatest concern and problem areas that would require a mass evacuation on the North Shore	Conduct key informant interviews with municipal staff, emergency responders, and subject matter experts. Review existing documents on this subject, as outlined on the following page under Documents Consulted.
Identify best practices and lessons learned that have emerged in mass evacuation planning	Review literature on lessons learned and best practice in mass evacuation planning. Conduct key informant interviews on best practices with jurisdictions that have recently experienced mass evacuation events, or that have recently developed/updated their mass evacuation plan.
Recommend a list of best practices in evacuation planning to be implemented on the North Shore	Evaluate best practice findings with NSEM staff based on their applicability on the North Shore. Develop a set of recommendations for NSEM staff applicable to their future mass evacuation planning process.

Scope

This report discusses mass evacuation planning within the jurisdictional boundaries of the three North Shore municipalities, and does not include planning for the First Nations communities, nor the municipalities surrounding the North Shore. While mass evacuation planning requires cross-boundary collaboration, this aspect of the planning process was determined to be outside of the scope of the report.

Mass evacuation is planned using an all-hazards approach, however special attention will be paid to mass evacuation for wildfire events in this report. Wildfire hazard has been identified as a major concern for the North Shore due to the high likelihood and consequences associated with the wildland-urban interface (WUI).

Lessons learned from recent wildfire seasons in British Columbia, Alberta, and California call for fire-prone communities to adapt their emergency plans to the new reality of our hotter, drier, longer wildfire seasons, whether they have already experienced a major event or expect one in the coming years.

Research Limitations

One limitation of this report relates to the timescale of the project. The research resulted in a strong set of recommendations for mass evacuation planning on the North Shore, however additional discussions and interviews with key informants would have yielded further findings. Early outlines of the report sought to interview local emergency planners in California, however the timing of the interview-phase of this report coincided with California’s wildfire season. Thus, findings in this area are limited to media and academic literature, as well as a subject matter expert not directly involved in wildfire response.

The review of other municipal evacuation plans was dependent on the plan being publicly available, or shared by said municipality. Since the plans are internal and contain sensitive information pertaining to each municipality or district, an actual review of operational plans was left out of the analysis.



PLANNING CONTEXT



Photo Source: Twitter @metrovanmerg

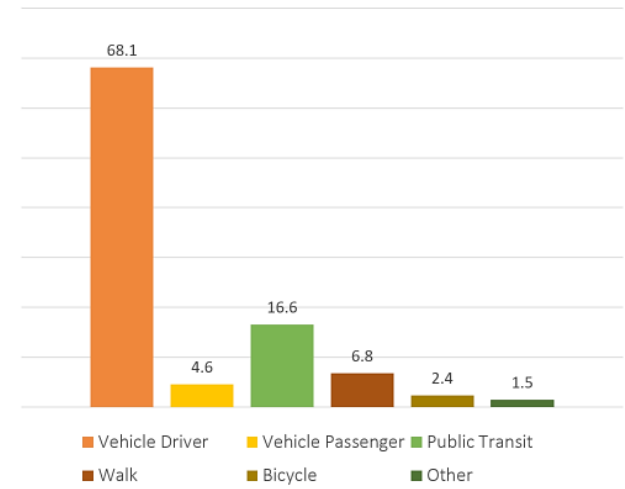
Community Profile

The North Shore is located in the Lower Mainland of British Columbia and is connected to the Sea to Sky communities to the North and Vancouver and Burnaby to the South. The North Shore landscape consists of wildland-urban interface communities nestled between the south-facing slopes of the Coast Mountains, and the coastal shores of Burrard Inlet, Howe Sound, and the Indian Arm fjord.

Five jurisdictions exist on the North Shore: District of West Vancouver, Squamish Nation, City of North Vancouver, Tsleil-Waututh Nation, and the District of North Vancouver. As outlined in the project’s scope, the planning context for the purpose of this report will focus on the three North Shore municipalities, as NSEM does not hold the jurisdictional power to enforce or enable an evacuation order for the Squamish Nation nor the Tsleil-Waututh Nation.

Based on the most recent Statistics Canada census profile data (2016), the population of the three North Shore Municipalities combined is estimated at 181,306. The total number of private dwellings on the North Shore is 77,699, with an average household size of 2.3 (Statistics Canada, 2016). English is the predominant language spoken on the North Shore, however 3,655 census respondents identified as not speaking English or French (Statistics Canada, 2016). Census results also identify the District of North Vancouver as having the highest proportion of youth (aged 0 to 14), and the District of West Vancouver has having the highest proportion of seniors (aged 65 +). Both youth and seniors are age demographics of concern during a mass evacuation event.

Figure 1. Main Modes of Commute on the North Shore



The main mode of commute on the North Shore is by privately-owned vehicles

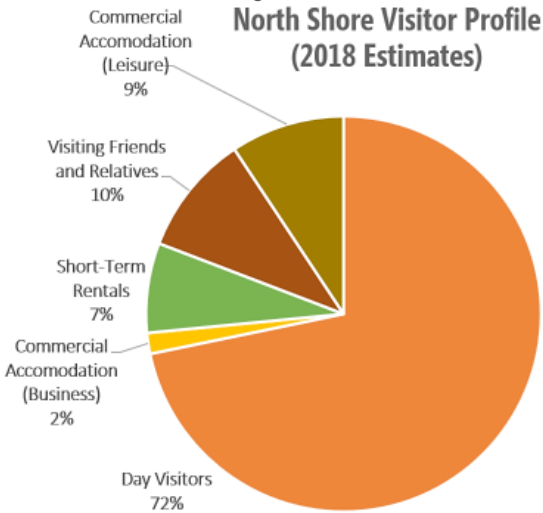
ICBC (2016) reveals a total of 106,830 passenger vehicles registered on the North Shore, including hybrid and electric (ICBC, 2016). According to Statistics Canada (2016) the City of North Vancouver has the lowest proportion of commuters by vehicle drivers (58%), the highest proportion of public transit (23%) and pedestrians (11%).

District of North Vancouver and West Vancouver yield the most similar commuter habits. However, the District of West Vancouver had the highest proportion of commuter modes by vehicle drivers (74%) and the lowest proportion of public transit users (12%). This data provides additional insight on primary modes of transportation which is valuable to evacuation routing and modelling.

Figure 1 Source: Statistics Canada (2016)

Figure 2 Source: Vancouver’s North Shore Tourism (2019)

Figure 2. North Shore Visitor Profile (2018 Estimates)



The majority of tourists to the North Shore come for day visits

The majority of visitors to the North Shore (72%) are estimated to travel for a day visit. Typical travel modes are by car, Sea-Bus, bus, or tour bus. A study of tourism on the North Shore determined that the overall volume of visitors in 2018 was 2,006,500 people (J. Belak, personal communication, 2019). Nearly half of all visitors are estimated to come from within B.C., and approximately twenty percent are from the US.

The most popular areas of gathering includes Capilano Suspension Bridge, Grouse Mountain, Quarry Rock at Deep Cove, and the Shipyards at Lonsdale Quay. With limited knowledge of the area, transportation constraints, language barriers, and lack of access to emergency notifications, tourists must be considered as a sub-group of the vulnerable population.

Hazard Profile

The North Shore is susceptible to a number of natural and technological hazards. The preliminary findings of the forthcoming Hazard, Risk and Vulnerability Analysis (HRVA) as well as discussions with NSEM have informed the list of priority hazards requiring an evacuation. In the context of mass evacuation planning, wildfire hazard was identified as the greatest risk for the North Shore. Definitions for each of the hazards are listed in Appendix A.

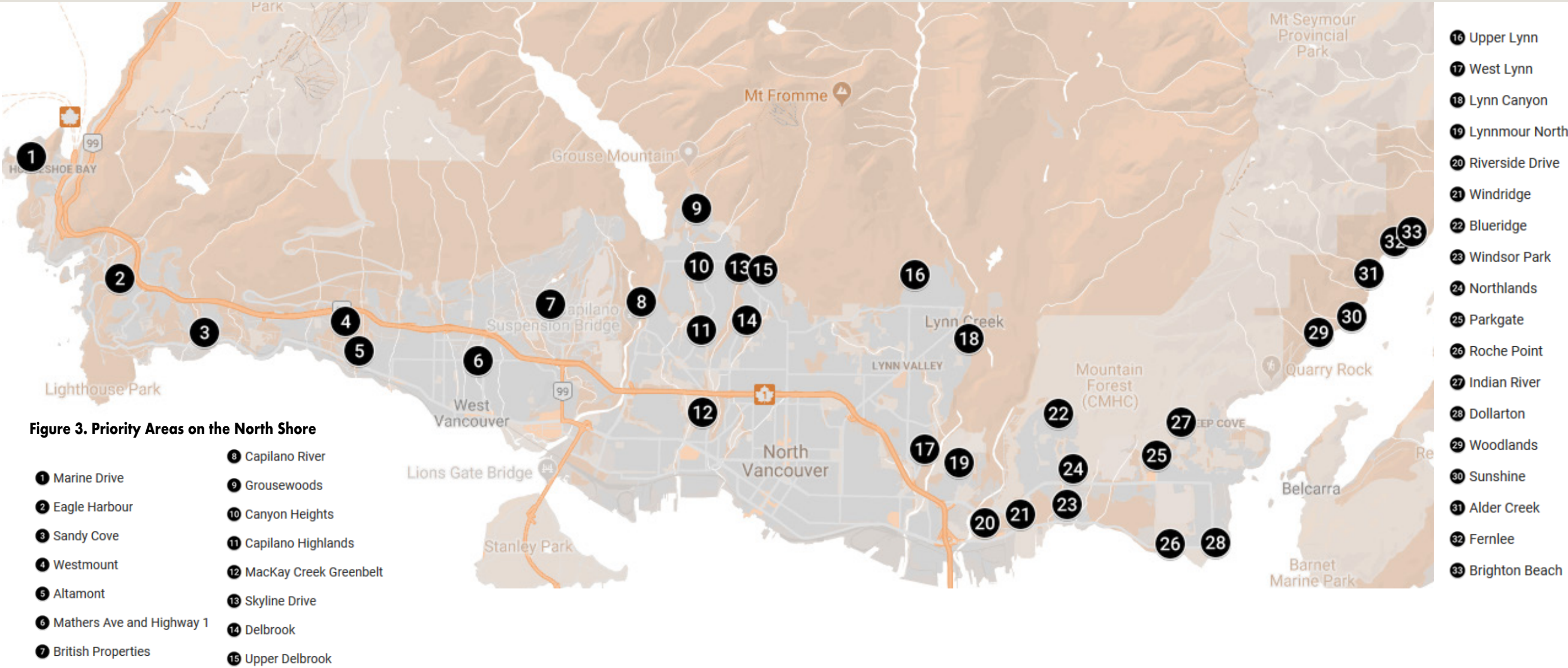
In short, the hazards include: wildfire, earthquake, landslide/debris flow, clearwater flooding (riverine and stormwater), coastal flooding, public health crisis (pandemic, epidemic), hazardous material spill (ground, air), active shooter or terrorist threat, and dam failure.



Priority Areas on the North Shore

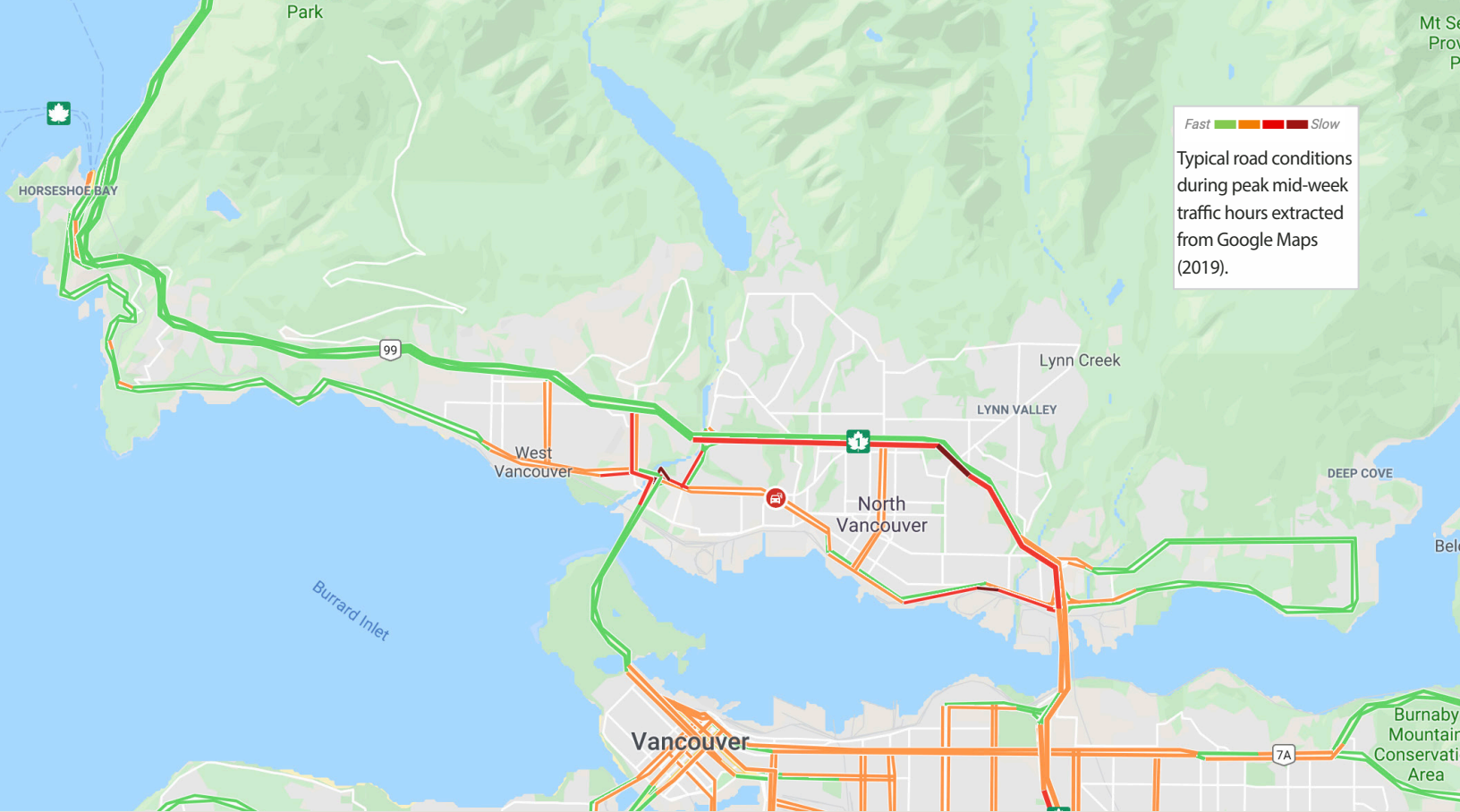
The priority areas identified in Figure 3 have been extracted from the 2019 updated District of North Vancouver Community Wildfire Protection Plan (CWPP) as well as the new District of West Vancouver Community Wildfire Protection Plan (2019). The CWPP areas are identified based on difficulty for two-way vehicle access, terrain challenges, and proximity to significant fuel loads. The terrain challenges and lack of accessibility pose a major threat to the movement of emergency responders and evacuees alike. Significant build-up of fuel loads along some of the roads included in the map pose an additional challenge. These areas are much more vulnerable to the direct spread of fire, as well as the spread of sparks and embers which may travel up to two kilometres ahead of the fire (Partners in Protection, 2003).

Areas identified in the CWPP should receive special attention during the planning and timing of wildfire evacuations. Furthermore, these areas should be considered for fire prevention measures such as fuel treatment, road widening, and additional signage that may better direct evacuees in the event that smoke overwhelms the view of evacuees driving through the areas.



Icon Image Source: Freepik and Iconixar via Flaticon.com (2019)

Map Source: Google MyMaps (2019)



Transportation Profile

The North Shore is accessible by two road bridges (Lions Gate Bridge and Second Narrows Crossing) and by SeaBus into Vancouver and the Trans-Canada Highway, and Highway 99 to communities North along the Sea to Sky Corridor. BC Ferries Horseshoe Bay (West Vancouver) Ferry Terminal connects the North Shore to both Vancouver Island and the Sunshine Coast. The primary means of transportation in an evacuation on the North Shore will be privately-owned vehicles supplemented by buses. Depending on the geographical and situational context of the evacuation event, it may be appropriate for responders to employ a strategy that includes multimodal options of air, rail, and sea transportation considered together.

The TransLink bus depot which previously housed 85 buses overnight in the North Vancouver Transit Centre has been closed since 2015, and the bus fleet has been moved off of the North Shore (Seyd, 2012). TransLink buses are still considered a viable and likely transportation option for ‘carless’ evacuees, however their use will depend on a number of logistical factors at the time of the event. If a mass evacuation is ordered outside of TransLink’s hours of operation on the North Shore, buses would need to be transported via bridge. Any regular bus routes outside of the risk area would need to be diverted and could cause significant service delay to a number of transit users. The availability of TransLink buses will depend on the geographical extent of the disaster, and the buses demanded for evacuation use will be weighed against service disruption to all other areas of the TransLink system.

A number of Charter bus companies with buses stored both on and off of the North Shore have expressed interest in assisting the North Shore with an evacuation event. Additional transportation options include TransLink SeaBus, which can accommodate 375 passengers per trip. Water taxis, private boats, and private passenger ferries may also be used. Evacuees may also be directed to Horseshoe Bay for departure to any of the BC Ferries destinations, although the use of their vessels will again depend on situational factors of the evacuation.

There is one CN rail line running through the North Shore. For passenger movement to be considered, passenger rail cars would be required. The current North Shore Evacuation Planning Strategy (2009) suggests that the use of rail would not be a desired method for the movement of evacuees, and should be avoided as it would be a time consuming process to coordinate. Interest was expressed by one seasonal Canadian rail-tour company to be explored further as a viable option for the transport of evacuees in the event of a major incident.

Current Evacuation Practices

The following section describes the current practices in evacuation planning employed on the North Shore. Also included in this section are gaps in current practices as well as areas of research interest expressed by NSEM.

Table 2. Current Evacuation Practices

Area of Analysis	Current Practices in the 2009 North Shore Evacuation Strategy	Gaps Identified and Areas to Explore
Evacuation Strategy	<p>Strategies employed by NSEM are detailed in Appendix B. They include:</p> <ul style="list-style-type: none">• Designating Disaster Response Routes• Designating specialized Bus/HOV lanes• Traffic signal coordination and timing• Closure of highway on- and off- ramps (contra-flow operations)• Phased (staged) evacuation by areas of highest risk• Traffic control points• Shelter-in-place <p>The existing plan contains data on each community’s schools, health care facilities, subsidized housing, community facilities, livestock, and industry. The plan identifies vulnerable populations as being children, individuals with disabilities, those who speak English as a second language, institutionalized and incarcerated individuals, transient populations (tourists, business travellers and seasonal workers), and the homeless.</p>	<p>NSEM has expressed interest in exploring best practice strategies specific to the context of mass evacuation planning for areas accessible by water, and areas with limited road access and egress.</p> <p>Research findings will also seek to explore additional considerations and trends in planning for vulnerable populations during an evacuation event.</p>
Response Coordination	<p>Communication is made between each municipality’s policing units, including RCMP, fire and rescue services, and ambulance services. The Emergency Operations Centre (EOC) is the primary point of coordination between responders, and would be established in order to maintain regular communications with both the site and if activated, the District’s Emergency Call Centre.</p> <p>E-COMM, combined events channel and Surrey Dispatch are used to coordinate these groups, as able. E-COMM provides dispatch services for these departments, operating the largest multi-jurisdictional, tri-service wide-area radio network in British Columbia for response personnel throughout Metro Vancouver and parts of the Fraser Valley (E-Comm 911, n.d.).</p>	<p>NSEM has expressed interest in exploring the ways in which mass evacuation planning can be best prepared for, understood, and used by each response agency involved.</p>
Evacuation Routing	<p>Evacuation time estimates are established under the following assumptions:</p> <ul style="list-style-type: none">• Evacuation time = Population that needs to be evacuated/ Population that can be evacuated per hour• Population that needs to be evacuated requires understanding of average vehicle occupancy, population requiring transport (‘carless population’), the number of lanes available, vehicles that can be moved per hour, and the number of hours to evacuate• Approximately 2,000 vehicles per hour can move per lane under normal conditions at roughly 50 km/h, however in an evacuation scenario, this would be roughly halved to 1000-1200 vehicles/hour• The accepted estimate of roadway capacity during an evacuation order for all major arterials and highways will be 1200 vehicles/hour/lane	<p>Modelling technology as well as understanding of evacuation behaviours have arguably improved over the past ten years. Research in this area seeks to explore lessons learned and best practices that have emerged in recent years.</p>
Public Notification	<p>Methods employed by NSEM are detailed in Appendix C. They include:</p> <ul style="list-style-type: none">• Initial messaging to those in risk area• Messaging for evacuees without a mode of transportation• Messaging to include in situational updates• Messaging for individuals who refuse to evacuate• Door-to-door notifications• Mobile notifications	<p>Research in this area seeks to explore education and engagement considerations, as well as findings related to methods of communication currently excluded from the evacuation plans.</p>

DISCUSSION OF FINDINGS

The findings are based on emerging views in the literature (academic articles, a scan of news articles in the media, and publically-accessible plans). They are informed by key informant interviews with municipal and regional emergency planners that have experienced mass evacuations, hosted evacuees during mass evacuations, as well as planners that have completed or are in the process of updating their mass evacuation plans. Additional interviews were conducted with subject matter experts in wildfire consulting, post-secondary research, and the transportation industry.

The information derived from the interviews are not based on individual opinions. Rather, they are conversations on current practices in evacuation planning, lessons learned and best practices that have emerged in recent years. The breadth of these interviews is further reaching than the five jurisdictions and four subject matter experts consulted. Those interviewed have conducted their own best practice research, with their findings extending to even more communities within Western Canada and beyond.

Key Informant Interviews

Emergency Planner, Resort Municipality of Whistler
Emergency Planner, District of Squamish
Associate Director of Community Services & Public Safety, City of Prince George
Manager of Emergency Services, qathet Regional District
Fire Chief, Williams Lake
Principal, Blackwell & Associates Ltd.
Professor of Geography, University of Utah Geography
Director of Safety and Security, Rocky Mountaineer
Emergency Management & Safety (Multiple Staff), TransLink
Executive Director, Vancouver's North Shore Tourism

Literature Review and Scan of Relevant Media Sources

Key Informant Interviews with Subject Matter Experts (SMEs)

Key Informant Interviews with Emergency Planners and Managers

EVACUATION STRATEGY

Evacuation plans must adhere to legislative requirements and non-prescriptive provincial guidelines while also being adaptable to local circumstances. This area of analysis seeks to understand the strategic components of the plan, and special considerations to include.

Supply and Demand Strategies

Mandatory evacuation has been shown to more likely result in greater compliance such that enforcement policies are likely to be influential in the response (McLennan et al., 2018). The strategies employed should be compatible with the type of hazard. A slow-onset hazard may allow for planned (strategic) evacuation, while a fast-onset hazard may result in an unplanned (tactical) evacuation. Supply-side strategies seek to increase the efficiency of traffic flow and movement of evacuees out of the risk area. Supply strategies include contraflow operations, cross elimination, special signal timings, designated bus lanes, and the use of shoulder lanes. Demand-side strategies seek to manage the movement of evacuees in order to increase the efficiency of the evacuation. Demand strategies include reducing shadow evacuation, sheltering-in-place, phased evacuations, assigned destinations, transportation network companies, and muster points.

The strategies have been listed in the Table 3, with definitions and additional details of each listed in Appendix D. These strategies have been sourced from Evacuation Transportation Modeling (2012), supplemented with findings from interviews and background research.

Table 3. Current Evacuation Practices

Supply Strategies	Demand Strategies
Contraflow Lane reconfiguration Cross elimination Special signal timings Designated bus lanes Shoulder lanes Diversion Alternate routes	Reduce shadow evacuation Shelter-in-place Phased (staged) evacuations Assigned destinations Transportation network companies (TNCs) Muster points

Key Takeaway: There are many supply and demand strategies that can be employed, and they should be treated as a 'toolkit' for the response authorities to choose from based on the nature of the evacuation.

Considerations for Vulnerable Populations

The process of identifying and preparing for potential accommodations and requirements is a challenging process for emergency planners. Much of the information collected becomes outdated as populations move, needs change, and programs and services offered change. A common approach to collecting information on vulnerable populations. Whistler and Squamish, for example, use custom Statistics Canada Census Tract Profiles at the neighbourhood-scale to extract information related to age profiles, income levels, and vehicle ownership. qathet Regional District pre-educates the population on the need to self-plan within family and social support networks rather than constantly validating, updating, and expanding vulnerable population data.

One interview finding is that contact should be initiated with vulnerable subgroups during the preparedness phase. During this phase, emergency planners must also clarify the level of service and resources that the public can expect in an evacuation. Local organizations and service providers may serve as an appropriate point of contact between vulnerable individuals and emergency planners not only to gather and update information on vulnerable subgroups, but to relay emergency information to vulnerable subgroups.

A different approach is being advertised by the Colorado-based tech startup, Geospiza SWIFT™, which uses artificial intelligence to integrate population data on factors such as mobility, power dependence, limited English, and visual impairment into risk models to provide an understanding of vulnerable populations (Geospiza, n.d.). Further research will be needed to determine if this platform can be used in Canada, whereby different data sources would be required.

Key Takeaway: Contact community organizations and facilities already working with vulnerable populations to acquire population estimates and contact information, determine resources and special needs required, establish responsibilities and expectations during an evacuation.

RESPONSE COORDINATION

A number of agencies are involved in coordinating an evacuation, including local authorities, emergency responders, vendors, and neighbouring jurisdictions. This area of analysis seeks to understand how the plan should be designed and used within and between agencies.

Photo Source: CPKG Today (2019)

Plan Familiarity

All stakeholders involved in a mass evacuation event should be familiar with the evacuation plan prior to the event, including neighbourhindh jurisdictions and local First Nations. A finding across all key informants is that in developing an evacuation plan, planners must not make any assumptions on what each agency can provide or when they can expect the resources to arrive. Instead, involve all stakeholders in the development phase to work out realistic options and back-up options for redundancy.

Academics on the subject have suggested that table-top exercises may prove better than written evacuation documents. Scenario-based, to get everyone around the table talking about it using intuitive decision-making. City of Prince George is an exemplary leader in walk-through exercises of what an evacuation would look like and how it should be handled. Prince George held three tabletop exercises and meetings with key decision-makers, then held a concept drill (See Figure 4). Agencies involved learned how many resources would be required in an actual event and worked through underlying assumptions.

Whistler and Squamish emergency planners gathered all background information necessary, then developed a Steering Committee of key decision-making agencies. The planners approached the Steering Committee during the plan development phase to ask key questions and to help each agency familiarize with the content and to understand their role and responsibilities in an evacuation. The meetings were determined to be a success, however it was noted that the Steering Committee should only be consulted for decision-making in a few short, concise meetings after all background research has been collected.

In qathet Regional District, EOC staff from the three local governments are part of an an emergency planning committee. Regular monthly meetings are held by the committee, and mass evacuation planning was integrated as a standing hazard topic of their meetings. Their planners seek to build their plan together and test it to understand capacity and constraints. They understand that local government needs to try to coordinate with as many agencies as possible, while keeping in mind that the more agencies add to the table, the longer the planning process will take. Their department plans to also work alongside potential host communities in future events.

Key Takeaway: Once the background of the plan is developed, hold a few brief meetings with decision-makers and ask them to respond to questions or grey-areas that have come up in the planning process.



Figure 4. The City of Prince George carrying out a rehearsal concept drill for their evacuation plan (Photo by James Doyle, 2019)

Information Sharing

In the preparedness phase, ensure up-to-date agency and vendor information is gathered and stored so that when resources are needed in an evacuation they can be acquired with little delay. Media coverage of the 2018 Carr wildfire in Redding, California noted a lack of coordination among the various response agencies and supply vendors in response, as well as a reliance on outdated landline phone lists (Arthur, 2019).

Key informants interviewed noted that for initial contact in an evacuation event, information is delivered through a number of mechanisms such as ECOMM, email, Connect Rocket, and combined-frequency radio. Then, once the EOC is set-up, agencies can share information face-to-face and through the EOC communication mechanisms such as emails pre-assigned to specific roles. It is suggested that early activation of the EOC is essential in any event involving an interface wildfire, and once activated redundancy in the EOC is key.

Both in the EOC and on the ground, informants unanimously agreed that the most important component of the evacuation plan is the 'grab-and-go' quick reference guide (QRG) to assist in carrying out response. The QRG should be written under the assumption that some responders are not familiar with the plan, and need access to checklists, flowcharts, and simplified step-by-step information on moving people from the area at risk to areas of safety. Whistler and Squamish have separated their plan into an internal operational plan, and a master 'background' plan which is publicly accessible online. The operational plan uses simplified steps and lists for responderst to easily follow.

On the ground, responders were found to use written documents over digitized options. One informant noted that Central Caribou Search and Rescue (CCSAR) deploys iPads for their response, however this digitized option may only work for small-scale evacuations. In a mass evacuation, digitized information sharing may be limited by resource constraints such as battery and data usage, financial costs associated with acquiring sufficient devices for response, and the back-up server support that may be required for its use.

One Concern is a tech startup that has recently emerged in the field of emergency response with artificial intelligence solutions to predict and quantify disaster impacts. The company has developed a platform that enables customers to identify, quantify, and manage their risk exposure to fires, earthquakes, and floods in preparedness, response, and recovery phases. Their platform is meant to provide hyperlocal, near-real time insights on the spread of damage and the impacts of hazards to provide unprecedented situational awareness, as shown in Figure 5 (One Concern, n.d.). Yet, the company has also received criticism for exaggerating the tools' abilities and limitations with the data collected for the platform, which is potentially dangerous for emergency responders to rely too heavily on (Fink, 2019). It also remains undertain whether this type of technology would be transferable to a Canadian context which uses different data sources.

Key Takeaway: Responders will not have time to read through 100+ pages of text in order to determine their next immediate options. Plans should seek to include quick reference guides and step-by-step solutions. Digitized plans should be explored for efficiency and information sharing, but limitations may outweigh benefits of their use.

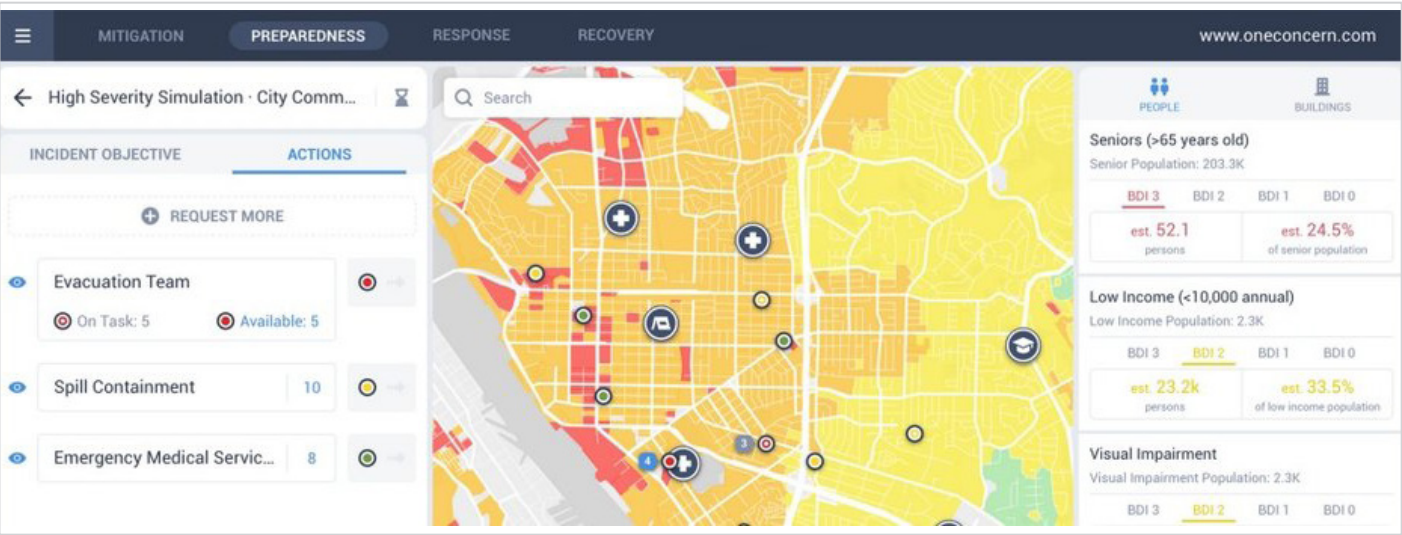
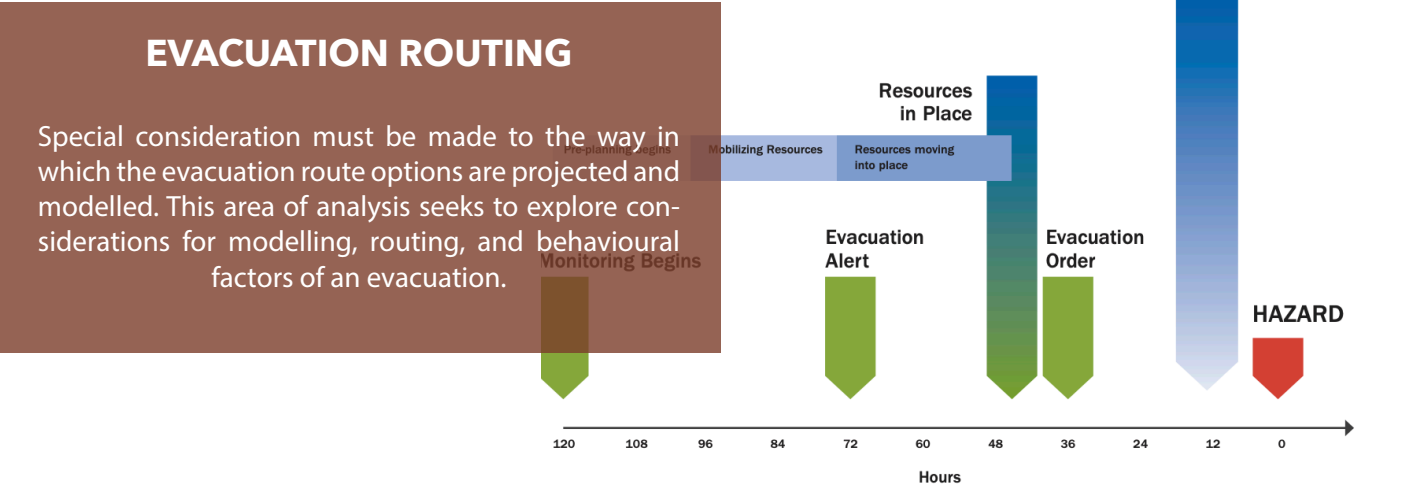


Figure 5. Sample page from One Concern platform (Via Govtech.com, 2017)



Routing and Modelling Considerations

Evacuation routing and modelling assists emergency responders in understanding how long it will take to execute an evacuation (the clearance time), and when to send out alerts and orders to the public. An extensive body of literature and models exists in the context of US hurricane events, but is less relevant to wildfires and other no-notice evacuations.

Squamish and Whistler estimate clearance time using a simplified formula similar to the one currently used on the North Shore. In their formula, vehicles and buses are calculated based on tourism occupancy rates and other available data. Both municipalities also own the rights to the evacuation models developed by their transportation engineering consultant. Thus, in the event of a large-scale evacuation emergency responders can use the models to plug in real-time data to plan out their evacuation clearance time and alerts.

Evacuation models should be developed using variables and datasets from numerous agencies. Highway vehicle capacity can be pre-determined in coordination with the Ministry of Transportation and Infrastructure (MoTI) which collects data on car counts at given points along the highway. The BC Wildfire Service prepared modelling in Prince George using scenarios to identify their zone of highest interface fire risk. Interactive, user-friendly maps of current wildfires may also be used and overlayed with municipal data to provide a common operating picture for cross-boundary areas.

One major area of exploration that resulted from the interviews was the TELUS Insights Program. Data is collected from the TELUS wireless network, de-identified to align with provincial privacy standards, then extrapolated into large aggregated data sets to reveal mass-movement patterns and trends. While the high cost of the product may be a barrier, emergency responders may benefit from the data to improve traffic flow, identify where to open new evacuation routes, and to determine where people are located in real-time.

Key Takeaway: TELUS Insights is a promising source of in-depth data analytics that should be explored, although cost is a large barrier to use.

Behavioural Considerations

In 2017, Williams Lake experienced a wildfire mass evacuation which left many residents feeling unprepared. The following year, the community experienced a second wildfire mass evacuation whereby residents' senses were heightened and overall residents were much more prepared to evacuate. An evacuee's behaviour heavily depends on their risk perception, level of preparedness, their experience with prior events, and their level of confidence in the information and recommendations that emergency responders share (Hsu & Peeta, 2012).

In the Town of Paradise, California, residents had experienced approximately ten potentially damaging wildfire events over the twenty years leading up to 2018. These 'near misses' contributed to lower risk perception in the population since residents had not experienced a mass evacuation event yet in 2018, the town was ravaged by one of the deadliest wildfires in California history (T. Cova, personal communication, 2019).

Emergency responders seek to time their evacuations in a way that avoids self-evacuations and traffic congestion. Evacuation orders almost never yield full compliance from those who should leave, nor do they yield full compliance from those who should not leave. In 2018, the Municipality of Fort St. James went on alert for three weeks but never progressed to an evacuation order, yet ninety percent of the town had self-evacuated during this period. Bandwagoning or herding behaviour is common among evacuees. People tend to follow or mimic others' actions due to limited time for deliberating their own decisions (Hsu & Peeta, 2012).

A study reviewing of evacuation plans and models (Pel et al., 2011) suggests that travellers are inclined to switch routes based on the prevailing traffic information, and may reroute regardless of their typical routing behaviour. Models must reflect this reactive behaviour.

Key Takeaway: Behavioural factors add a layer of complexity to evacuation planning. Models simulating traffic should seek to sufficiently integrate reactive traveller behaviour.



Photo Source: Jgirn on Instagram (2019)

Education and Engagement

Some evacuees surveyed after the 2016 Fort McMurray wildfire noted that they were not aware of the very high wildfire risk to their community and that they had not been prepared to evacuate when they were ordered to leave (McGee, 2019). Emergency planners should not hold expectations for how the public will respond in a mass evacuation, and should focus on providing publicly-accessible plans both in-person and online. The public should also be educated on the level of service and resources that they should expect in a mass evacuation event.

qathet Regional District held nine initial public open houses to educate the public on the progress of their evacuation plan updates. These open houses informed the public on the hazards in their communities, where they should access information, and what services they would be provided. The open houses also stressed the need for individuals and households to have their own plan and network in place, should they require assistance. Residents were provided the opportunity to express their own concerns, and share ideas to contribute to the planning process.

If the public feels that there was not sufficient engagement in the planning process, they may be less prepared in an evacuation and more likely to hold unrealistic expectations about the resources and services provided by response agencies. If emergency planners choose to educate the public on their plan only after it is completed, they should ensure that special attention be placed on the role of the public in an evacuation, and additional information should be provided to vulnerable subgroups of the population.

The use of signage in educating the public emerged from the findings. The City of Prince George posts distinct orange/red coloured signs outside of schools designated as 'Community Evacuation Assembly Points'. Whistler is considering ways to integrate infographic tools into their evacuation plan, with community signage as the eventual goal. Findings also suggest that directional signage should be placed on heavily forested roads with limited access to help navigate through.

PUBLIC NOTIFICATION

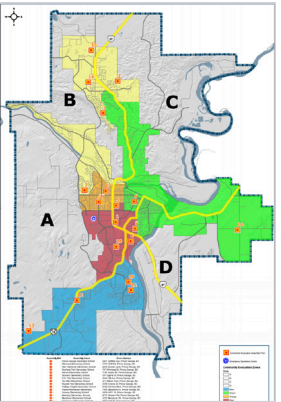
Public notification is a major component of any evacuation plan. This area of analysis seeks to understand how to notify the public, what messaging and information to include, and how different notification methods may influence evacuation.

Evacuation Zones delineate the population by area for the purpose of location-specific evacuation planning and response (Sea to Sky Multimodal Evacuation Plan, 2019). In an evacuation, zones can be prioritized for evacuation by their associated level of risk. Residents and workers must be aware of the zone that their work or home is located in. The number of zones used by emergency planners appears to depend on how strongly residents of the community identify with their assigned zone. In Whistler and Squamish, residents strongly identify with the neighbourhood they live in, so the evacuation zones have been designed based on existing neighbourhoods. This approach may not work in communities whereby residents are less familiar with their neighbourhood names and boundaries.

In Williams Lake, it was found that during one of their wildfire evacuation some residents and workers could not relate to their designated zones. The City of Prince George integrated this lesson into their own plan by basing each zone on existing garbage pickup zones, then by associating a different colour to each zone (Figure 6). Garbage schedules and zones are mailed to residents on an annual basis, and the mail-outs now include a coloured evacuation zone map. Even if residents choose not to keep their maps, they have an opportunity to look at and identify themselves with the colour on their map. Employers must educated on their zone, and share this information with their employees.

Key Takeaway: Emergency planners should educate the public on the hazards that exist in their community, the plans in place to respond to these hazards, and the role that the public is expected to play within the framework of the plan.

Figure 6. Coloured Evacuation Zone Map (City of Prince George, 2019)



Communication Methods

Options for sending out public notifications include text, call, subscriber-based alerts, TV, radio, social media, website, print, signage (variable messaging signs), and amateur radio. A combination of some or all methods may be used depending on the nature of the event. For example, in Sonoma County’s Kincade Fire of 2019, the county used the Wireless Emergency Alert System, NOAA radios, SoCoAlert, the Sonoma County alert system, Facebook and the Emergency Alert System, and the sheriff deployed its hi-lo sirens up and down the roads to further highlight danger (McKay, 2019).

Subscriber-Based Services

Findings suggest that emergency planners should use the most up-to-date warning systems. Many providers and options for alert services exist today. Due to provincial privacy laws, notifications can only be sent to a private phone or email when a citizen grants permission. For this reason, subscriber-based services are commonly used so that personal contact information can remain confidential and not used for any other purpose. Subscriber-based alerts are widely used and considered the best point of contact for citizens. Emergency communication is reciprocal, and residents must also understand their own responsibilities and participation in the process.

Many of the communities most affected by wildfires in California have relied on third-party companies to handle their messaging, in some cases with messages sent to outdated landline phone numbers. In the 2016 Shasta Lake fire of California, a city-wide evacuation order was issued yet many households were not reached. With many households moving to cellular devices and abandoning landline numbers, services that reach landline phones are being replaced by subscriber-based services that can text and/or call affected residents.

Overall findings suggest that subscriber-based services are reliable, accurate in contacting specific areas, effective in reaching individual phones, and can convey sufficient information. Yet, drawbacks include low subscription rates among communities that use it, lags in delivering notifications in areas of low bandwidth, and the limitation of only reaching the population with cellphone.

Social Media and Web-Based Methods

Social media and web-based methods include government websites supplemented by social media platforms (Twitter, Facebook, Instagram) can be used to increasingly spread notifications to individuals. The notification process is instant, simple, and easy to disseminate within social networks. Limitations include message character limits, an inability to accurately target messages to those within the risk area, and the fact that these notifications can only be accessed by individuals with accounts and computer or phone access.

Canada-Wide Alert Ready

Alert Ready is being tested as a Canada-wide public alerting system for use in a number of hazards. The system can only be issued by authorized government agencies in an event whereby an imminent threat to life exists. Once this system is completely rolled-out for use, local government can provide messaging content to Provincial authorities to notify the public. Messages will be delivered to the public over broadcast and wireless communications platforms (TV, radio, and LTE connected wireless devices). One major benefit of this method is that message reach is not limited to subscribers. Alerts can be delivered to anyone in the geographical area covered by the alert, regardless of whether they are a resident, worker, visitor, or commuter passing through the area

Signage

Highway and road signage may be effective in guiding traffic and sharing information with road users during an evacuation. This may include Dynamic Message Signs (DMS), Portable Changeable Message Signs (PCMS), digital billboards, and printed signs. Traffic cones and delineators may be used along with signage to indicate road closures, diversions, reconfigured lanes, and other hazards (Sea to Sky Multimodal Evacuation Plan, 2019). Signage may be of significant assistance in priority areas identified on the North Shore. They can provide directional support for drivers evacuating along smaller roads with high fuel loads, where visibility may be obscured by smoke.

Key Takeaway: Responders must supplement and use as many means as of consistent messaging as possible through text, call, subscriber-based alerts, TV, radio, social media, website, print, signage (variable messaging signs), amateur radio.

Messaging Considerations

Messaging can consist of descriptive content about the disaster and traffic conditions, or prescriptive recommendations which indicate when to depart, where to go, which route to take, with different levels of mandate (Hsu & Peeta, 2012). Evacuation warnings with insufficient information may lead to self-delay as individuals seek to engage in information search rather than initiating evacuation actions (McLennan et al., 2018). Abundant and well-timed information sharing has been shown to help residents cope with the stress of an evacuation (McGee, 2019), and may help the public assess their personal risk to make their own independent evacuation decisions.

Media coverage of the 2016 Fort McMurray fire was extensive yet evacuees surveyed after the event expressed that they did not receive sufficient information. Many received little to no official warning before they were ordered to leave, and social cues told them to carry on as usual. It was not until the environmental cues of the wildfire smoke made the immediacy of the wildfire threat clear to evacuees (McGee, 2019).

Phased Evacuation

During a phased evacuation, the zones outside of the risk area should be asked to remain rather than self-evacuate so that the population at risk can evacuate with minimal delay. Messaging should convince drivers outside of the risk area that they are safer where they are rather than on the road, and that they must cancel their trips to reduce background traffic (Murray-Tuite & Wolshon, 2012). The City of Prince George plans to send out notifications by first noting what evacuation zone colour the message pertains to, then shares full details about the alert or order. This allows all listeners to pay attention, then ‘tune out’ when they realize their zone is not affected. Those living in the zone at risk are prompted to pay attention to the rest of the message.

Evening Evacuations

In California’s 2017 Tubbs Fire, Sonoma County Officials sent out an evening evacuation alert in the evening but decided not to call for an order until approximately 1:30 am. Officials had chosen not to send out emergency orders so as not to alarm residents into self-evacuations which may have interfered with emergency efforts. The order was only received by those who had subscribed to the notification service, many of whom were asleep by the time the order was delivered. The fire resulted in 22 fatalities and 5,600 destroyed buildings (McKay, 2019). Findings suggest that if an evacuation alert is made in the evening, messaging should ask residents in areas of risk to remain awake and on alert. This lesson was integrated into the response for the Thomas Aquinas fire in Ventura, California, whereby residents were asked to remain awake and on alert. When the order came at midnight, residents were prepared to leave. No fatalities were associated with the evacuation.

Notifying Workers and Tourists

Even if public notifications reach those in the risk area, there is no guarantee that individuals commuting to the area for work or other travel will receive any messages about the evacuation. In the Getty Fire of Los Angeles (2019), many workers arrived to the evacuation zone because they were not notified by the homeowners who had employed them. This event teaches future emergency planners to include in their messaging that homeowners and business owners should notify any workers or guests to cancel their trip to the area at risk. Whistler has a high proportion of year-round tourism activity. One approach taken by their emergency planner is to have hospitality and tourism employees (i.e. conciere, tour guide staff) relay alerts and orders on to visitors who would not otherwise receive emergency notifications.

Disaster Response Route (DRR) Clarification

Disaster response routes facilitate the movement of emergency resources and responders in and out of an area affected by a major emergency. Signs have been placed along these routes for responders, but have become an area of confusion for members of the public also accessing these routes.

Interview findings suggest that some of the public have come to see these as routes to use in an evacuation. The Disaster Response Routes working group has been on hiatus however their concepts, including the removal of their signs, are under regional review. In the preparedness stage, the public should be better educated on the purpose of these routes. During an evacuation event, public messaging must clearly explain to if these routes will be closed to the public and used to move responders, vehicles, and freight with relief supplies.

Key Takeaway: Messaging content must provide sufficient information for individuals to quickly respond to evacuation alerts and orders. Maximize each notification opportunity to convey detailed yet concise messaging to the public.



RECOMMENDATIONS



Table 4. Recommendations for the North Shore Evacuation Plan Updates

Evacuation Strategy	
1	Expand current strategies list to include a larger toolkit of strategies. For supply, include: contraflow, lane reconfiguration, cross elimination, special signal timings (if possible), designated bus and HOV lanes, shoulder lanes, diversion and alternate routes (see Recommendation 2). For demand strategies, include reducing shadow evacuation, phased (staged) evacuation using pre-designated zones, and muster points using pre-designated locations.
2	Priority areas identified in this report (pages 10-11) should be considered for fuel management and treatment, additional directional signage, and areas of limited access should be considered for the forming of alternate evacuation routes via logging road in coordination with DNV and DWV CWPPs.
3	Create a 'Vulnerable Populations Working Group' which will invite local organizations to represent the vulnerable subgroups they serve. Emergency information and plan updates may be shared through this group, and key data on the vulnerable populations can be collected for NSEM. Areas of limited or water-only access should be prioritized, with representation from community associations of neighbourhood block watch groups.
Response Coordination	
4	Create an 'Evacuation Steering Committee' based on a list of key decision-makers and stakeholders involved in response. A series of 2-3 short, concise meetings should be held with this group for decision making and contact information updates once background information has been compiled.
5	Host a tabletop exercise with Evacuation Steering Committee and emergency responders to practice roles, responsibilities, resources, work through assumptions, and encourage interagency communication. This exercise should also include Tsleil-Waututh and Squamish Nations, as well as neighbouring communities that are likely to host evacuees (such as Vancouver Island, Sunshine Coast, Vancouver, Burnaby, Squamish). Request plans from jurisdictions that may evacuate to the North Shore.
6	The evacuation plan should be divided into two parts: the publicly-available background information (demographic and hazard profile, zones and muster points, evacuation strategies, public notification protocols) and the operational plan. An existing four-page 'Field Reference Guide' should be expanded to include strategies, checklists, flowcharts, and roles to serve as the new operational plan as per updates made to the plan. The operational plan should be placed in all response vehicles.
Evacuation Routing	
7	Contact TELUS Insights Program representative to determine viability of the product in both pre-planning evacuation modelling and during response activation.
8	Collect additional data to serve as input variables required to inform the evacuation modelling. Key contacts include MoTI, BC Wildfire Service, Statistics Canada (Neighbourhood Census Tracts).
9	Hire transportation engineering consultant to model dynamic evacuation scenarios. The models should seek to highlight areas of congestion in order to prioritize areas that will require ground traffic management (police controlled intersections), the development of alternate routes , or the supplementation by other identified modes of transportation (air, marine, rail).
Public Notification	
10	Education and engagement should include an online survey (to determine general public risk perception and preparedness), an in-person openhouse (on risk education, communication, personal preparedness, public concerns), then an information session with public (on plan updates, accessibility, and specific information for vulnerable populations).
11	Update communication strategy to include social media and web-based notifications, TV, variable message signs, and Rapid Notify. Continue inquiring on the status and anticipated launch date of Alert Ready service for evacuations in B.C.
12	Public notification protocols in the evacuation plan should be expanded to include public messaging to inform workers who may enter the area of risk, messaging for evacuation alerts at night, messaging to clarify the use of Disaster Response Routes, messaging to state zone colour at risk prior to providing further details that pertain to that zone (in order to gain better reach with targeted audiences).

CONCLUSION

Final Remarks

The effectiveness of an evacuation plan has important implications for the movement of populations from an area at risk to an area of safety. While the plan in itself does not provide a one-fit solution to all evacuation scenarios, it serves as a guideline for emergency planners to follow and adapt to the situational context of the event at-hand. Hazards are not static, and emergency planners must continually adapt plans to suit the changing landscape of hazards and population needs over time. North Shore Emergency Management is aware of the need to continually update the evacuation plans for each of the three North Shore municipalities. New and emerging best practices in evacuation planning, recent wildfire mass evacuations in numerous communities around the globe, and provincial funding for evacuation planning initiatives have provided motivation for the updates.

This report, and the background research provided alongside this report, serve as a background understanding to inform the updates undertaken by NSEM. The four categories of analysis in this report are evacuation strategy, response coordination, evacuation routing, and public notification. Background research and data collection, key informant interviews, and a review on best practices in academic literature and the media have provided the means from which a set of 12 recommended actions for NSEM have been formed.

Moving Forward

The flowchart on the following page (Figure 7) presents a simplified set of 21 steps for NSEM to follow in moving forward with the North Shore Evacuation Strategy updates. While this flowchart is subject to change, it assists in understanding how to integrate the recommendations in a way that is consistent with the findings of the report.

Figure 7. A Recommended Approach to Moving Forward in 21 Steps



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APPENDICES

Appendix A: Priority Hazards on the North Shore

Hazard	Description
Wildfire	Wildfires may be human-induced or naturally caused, and involve the burning of forest vegetation, grass, brush, properties, and infrastructure. Wind, temperatures, and fuel loads greatly affect the direction and spread of the fire. The North Shore is at risk of wildfire because it is located in a wildland-urban interface (WUI). Wildfires may have a significant impact on human health and safety, and can cause erosion or trigger landslides.
Earthquake	Earthquakes may be derived from slips along a fault line, sending seismic waves to the surface which shakes the ground. The North Shore is along two major faults and anticipates a large-scale earthquake event. This event may cause damage to structures, trigger landslides, liquefaction or other hazards such as fires, floods, tsunamis, hazardous material spills. A major earthquake on the North Shore would most likely also affect Metro Vancouver and other areas that North Shore residents might otherwise consider evacuating to as potential host communities which is an added concern.
Landslide/Debris Flow	Landslides are casued by the downward movement of soil, rock or other earth material. The most common type of landslide in B.C. is debris flow whereby a saturated slurry of earth, rock, and vegetation, flows in a confined channel. While not a mass-scale event, the fatal District of North Vancouver Berkley Landslide of 2005 required overnight evacuation of the risk area.
Clearwater Flooding (Riverine, Stormwater)	Riverine flooding can originate from snow melt and watershed runoff from intense and long lasting rainfall, overflowing the natural channel. Stormwater flooding in urban areas is caused by heavy rain falling on impervious surfaces, exceeding drainage infrastructure and/or watercourse capacity.
Coastal Flooding	Coastal storm flood hazards may arise as a result of storm surge in combination with tides, waves and wind effects. Sea level rise will increase coastal flood hazards in the future, affecting North Shore properties, residents and businesses along the shoreline.
Public Health Crisis (Pandemic, Epidemic)	A public health cirisis is the occurrence or threat of illness or health condition can pose a substantial risk to a significant number of people and facilities. Disease outbreaks can happen suddenly and without warning, often posing a threat to public health and safety.
Hazardous Material Spill (Ground, Air)	Hazardous material spills can happen on site or during transport by aircraft, rail, ship or truck. The North Shore has a number of industrial activities clustered at the waterfront that if released could be dangerous to human health and safety, likely requiring those affected to shelter-in-place.
Active Shooter or Terrorist Threat	Terrorism is a hostile act committed against the state and designed to exercise the use of terror, especially as a means of coercion (i.e. bomb threat, explosion, sabotage).
Dam Failure	The North Shore is home to two major dams, the Seymour Falls Dam and the Cleveland Dam. Additional smaller, earthen dams exist such as the one at Eagle Lake. A breach in the foundations, abutments, or spillways of either dam may result in the sudden, rapid, uncontrolled release of water.

Appendix B: Current Evacuation Strategies on the North Shore

Strategy	Description
Designating Disaster Response Routes	To facilitate the movement of emergency resources and responders in and out of an area affected by a major emergency or disaster. Designate and sign these routes in advance, and provide key response personnel with appropriate ID. They can have secondary use as evacuation routes.
Designated Bus/HOV Lanes	To quickly move buses that most likely will be shuttling evacuees, use of HOV lanes should be maximized. This means consideration should be given to designating lanes of the evacuation routes for buses or other higher capacity/occupancy vehicles to assist with the faster movement of evacuees, and, for quicker turn-around of buses that may need to perform a number of round trips for the population lacking their own transportation. Public info and appropriate signage will be required to implement this strategy, especially in areas where no HOV lanes are currently established on designated evacuation route(s).
Traffic signal coordination and timing	Intended to maximize traffic flow in the outbound direction during an evacuation.
Closure of highway on- and off- ramps	Outbound is defined as the evacuation routes leading away from the area of risk to an area of safety. Inbound is defined as the roadways leading towards the area of risk from areas of safety (for contra-flow operations where traffic flow will be in one direction only all inbound on-ramps must be barricaded and staffed)
Phased (staged) Evacuation	Reduce congestion and demand for transportation resources during an event/threat that requires a large or mass evacuation (often used with contra-flow operations). Those in the area of highest risk would be moved first and this is done through enforced traffic management. Those in the first phase can still leave if they want to but on other streets and secondary roadways not designated as evacuation routes. Requires advance planning, communication and coordination.
Traffic Control (Traffic Control Points)	Two-way traffic should generally be maintained on all evacuation routes to allow for continued access by emergency responders. Points are established around evacuation zones along evacuation routes as required for the purpose of directing vehicles. It may be necessary to control traffic on other routes to minimize impact on evacuation routes
Shelter-in-place	To take immediate shelter where you are – at home, work, school or in between - usually for short durations in response to specific hazards. Depending on the threat and risk, sheltering in place may be a viable option to evacuate.

Appendix C: Current Public Notification Protocols on the North Shore

Type of Notification	Description
Initial messaging content to those in area at risk	<ul style="list-style-type: none">Declaration of State of Local EmergencyWhether to evacuate or shelter-in-placeWhether an evacuation alert or order is in placeAreas that need to be evacuated with reference to perimeters (street names and addresses)Why and when to evacuateTime remaining until evacuation or time available to evacuateDesignated evacuation routes, including road closuresRequest families to only utilize one vehicle, if possibleProvide rides for friends without transportationDesignated Reception Centre or Evacuation Point locationsWhat items residents should/can take with themEstimation of the evacuation periodHow pets will be accommodatedSecurity plans that will be in place to protect propertyWhen/how info updates will be made available (i.e. radio station to carry updates)Contact # for those requiring assistanceWhat to do if one’s vehicle breaks downOther info deemed appropriate and important to situation at hand
Additional messaging content	<ul style="list-style-type: none">What transportation services will be made availableThe designated assembly points for those without transportationThe frequency of pick-ups from those assembly points
Situational Updates	<ul style="list-style-type: none">Current state of emergency situationEvacuation routesRoad and area closuresLocation of assembly pointsLocation of reception centre and group lodging facilities (evacuation points, if applicable)Hotel availability, availability of food, gas, medical and other essential servicesTraffic conditions
Door-to-Door Notifications	<ul style="list-style-type: none">Police, North Shore Search and Rescue, municipal staff and volunteers to advise occupants within the area at risk. Recommended for large building, a few small building, or neighbourhood evacuationGoing door-to-door allows responders to ensure thorough notifications have been made to all residences and businesses, and the personal contact may result in more immediate attention and responseFlagging system: blue (not home/no answer, must be canvassed again), pink (notified of order to evacuate), yellow (verified as evacuated), orange (notified but refusing to evacuate), and red (‘notified and requires assistance’)
Refusal to Evacuate	<ul style="list-style-type: none">Numerous measures exist for people who refuse to evacuate. Normal police powers can be employed under: obstruction, child safety, trespass, or where they can enforce other statutes related to forest fighting and security zones
Mobile Notifications	<ul style="list-style-type: none">Utilize first responder vehicles to drive through an area of risk using the vehicle’s lights, sirens, and/or public address system to get public’s attentionMay alert those people who are not monitoring radio or television broadcasts.Spectacle of vehicle’s lights and PA system can command attention of those who may miss a door-to-door (including hearing impaired)This scale may be best for small to medium evacuations, and should not be the only means of communicating with the public who may misunderstand or not hear the messageOnly recommended for use in areas of risk not exceeding 10 blocks in size

Appendix D: Supply and Demand Evacuation Strategies

Strategy	Description	Additional Insight
Contraflow, Lane Reconfiguration (S)**	A form of reversible traffic operation in which one or more lanes of a divided highway are used for the movement of traffic in opposing direction. <ul style="list-style-type: none">Highly effective in immediately and significantly increase the directional capacity of a roadwayViewed by public as a logical use of the unused lane capacity, and to restrict inbound traffic to emergency services	<ul style="list-style-type: none">Williams Lake noted issues with inflow into an evacuation zone, and the need for a permit process to regulate and track movement of personnel re-entering the risk areaWhistler and Squamish found this to be unfeasible due to their highway lane capacityIn Hurricane Katrina, flow rate of these lanes was approximately 75% of the adjacent normally-flowing lanes
Cross Elimination (S)**	The elimination of certain turning and crossing maneuvers at intersections to remove conflicting traffic stream interruptions in favour of continuous flow in the primary inbound direction. <ul style="list-style-type: none">Accomplished using police control or by placing barricades in intersections and using flashing signals	<ul style="list-style-type: none">This has not yet been widely developed as modelling for evacuation routing. However, analysis conducted did show up to 40% reduction in travel time depending on road configuration and hazard scenario
Special Signal Timings (S)**	Disruption to regular traffic signaling operations in order to dynamically control the flow of traffic under evacuation conditions. <ul style="list-style-type: none">Highly effective in significantly impacting progression of evacuation traffic, and considered an effective method in major arterials and corridors	<ul style="list-style-type: none">Considered a less viable option in current strategy since municipal staff responsible for traffic signal coordination and timing must be notified prior to the evacuation to perform the override functionCurrent plans note that planning should ensure at least 10 major arterials are configured to electronically turn green during evacuation
Designated Bus Lane (S)**	Designate a bus lane to expedite the evacuation of those with special needs and/or without a mode of transportation. <ul style="list-style-type: none">Ensures maximum use of available buses and drivers, quick trip turnaround time, and decreases time required to evacuate a given population and to alleviate congestion	<ul style="list-style-type: none">Recommended in the current strategy as lessons learned from the Hurricane Katrina evacuation, but may also consider also including high occupancy vehiclesSquamish and Whistler excluded this option due to limited highway infrastructure
Shoulder Lanes (S)	Using the outside shoulder lanes of a highway as ‘evacu-lanes’ in order to increase traffic flow and utilize as much of the sides of a highway as possible.	<ul style="list-style-type: none">This strategy was found to complement other supply measures such as contraflow and improved signal timing
Diversion and Alternate Routes (S)	Detour and redirect drivers to use an alternate or preferred route in order to decrease traffic congestion and redirect traffic away from hazard area. <ul style="list-style-type: none">Development of alternate routes and road networks prior to an evacuation event may lead to more evacuation route options.	<ul style="list-style-type: none">City of Vernon, Pender Island, District of Harrison, and Squamish are among some of the communities exploring alternate evacuation routes either by forest logging roads or parksAlternate routes should be pre-tested with vehicles
Reduce Shadow Evacuation (D)	Clear communication and education may assist in reducing the number of people who do not need to be on the road to cancel their trips, yet some background traffic is still likely.	<ul style="list-style-type: none">The decision to evacuate is largely governed by feeling unsafe, so people must be convinced that it is safer to remain than to self-evacuate
Shelter-in-Place (D)*	To take immediate shelter where those at risk are. <ul style="list-style-type: none">This is considered to be a safer course of action for some hazards and should be clearly communicated to the public.	<ul style="list-style-type: none">Delayed, last-minute evacuations can in some cases be fatalAustralia has an approach of ‘leave early or prepare, stay and defend’ (Cova et al., 2009)
Phased (Staged) Evacuation (D)**	Find an optimal sequence of evacuation assignments (by zone) to minimize evacuation time and risk for those in areas of highest risk to reach safety.	<ul style="list-style-type: none">Number of zones can be few or many, and success of zones has been found to depend on a resident’s relatability to their zone
Assigned Destinations (D)	Assign evacuees to specific routes and destinations to decrease traffic congestion (ask, direct, or implement road blocks).	<ul style="list-style-type: none">This option may be less feasible for the North Shore whereby a number of routes and potential destinations exist
Transportation Network Companies (D)	The sharing economy (private companies and/or citizens) for transportation and sheltering resources.	<ul style="list-style-type: none">Many reservations still persist about this concept, and it would likely need to be a pre-established TNC that is already accepted and widely used by the communityWhistler and Squamish have involved Poparide to ride-share
Muster Points (D)	Designated pick-up locations for carless evacuees to access transportation during an evacuation. <ul style="list-style-type: none">Pre-arranged muster points will allow for easier information dissemination to carless population and reduce confusion during an event	<ul style="list-style-type: none">Whistler and Squamish muster points are determined by the EOC once the evacuation is confirmed, although each have pre-identified sites based on existing bus routes and no more than 2 kilometers from any residence and those who cannot travel to the muster point are directed to call and arrange transportation if possible

(*) Mentioned in current strategy to some extent
(**) Mentioned in current strategy and should be better integrated
(S) Supply strategy (D) Demand strategy

Best Practices in Wildfire Mass Evacuation Planning

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