Addressing Risk in Research and Practice: Business Earthquake Vulnerability in North Vancouver

by

AUTUMN ELAINE LOTZE
B.A., Denison University 2007

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Abstract

The catastrophic consequences of recent disasters like Hurricane Sandy and the Tohoku Earthquake highlight the necessity of adopting a proactive approach to risk management that emphasizes mitigation and preparedness in order to foster more resilient urban systems. This research focuses on one component of the urban system—the business community—and demonstrates the value of drawing deliberate linkages between risk research and practice to facilitate the development of community risk reduction strategies.

Using North Vancouver as a case study, this research takes a two-fold approach to examining business earthquake vulnerability. Using the lens of an M7.3 Georgia Earthquake scenario, this research estimates potential business disruption and economic loss to the business community through the application of an economic loss model that considers simultaneous disruption from building damage, lifeline outage and neighborhood damage. This assessment is contextualized with data from a survey of local business risk perceptions and preparedness behaviors.

Model results indicate that lifeline loss is a greater source of disruption to businesses than either building damage or neighborhood damage; a complete disruption of lifelines would leave only an estimated 28% of local businesses open and result in a loss of 73% of normal daily economic production. Survey results indicate business respondents are generally unprepared to respond to an earthquake or other hazard—only 25% report having a preparedness plan in place—and highlight a lack of knowledge as the most common barrier to increased preparedness.

Ultimately, this study identifies patterns of risk and vulnerability in the North Vancouver business community, examines associations between business risk perceptions and preparedness behavior, and offers ways that subsequent findings can be used to inform public risk management strategies. The study also suggests ways to refine future research in this area.
Preface
The primary research for this thesis is the original work of the author and was conducted under the supervision of Dr. Stephanie Chang at the University of British Columbia and in collaboration with the North Shore Emergency Management Office.

Survey research for this thesis received ethics approval from the University of British Columbia Behavioral Research Ethics Board under the project title “North Shore Business Preparedness Project” (ID: H13-01905).

Portions of Chapters 4 and 7 are included in the following publications (forthcoming):


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Chapter 1: Introduction
The past three decades have seen a significant rise in the annual number of natural disasters (Wirtz & Schuck, 2013). Events such as the Christchurch and Tohoku Earthquakes and Hurricanes Katrina and Sandy remind us of the catastrophic consequences that can result when natural hazards and urban environments collide. Increasing urbanization, aging infrastructure, growing economic interdependence and the continued impacts of climate change are likely to lead to a higher frequency of such disasters in the future (Botzen & Van Den Bergh, 2009; Global Science Forum, 2012; IPCC, 2012). As a result, preparedness and mitigation activities have become that much more important for cultivating safer, more resilient cities. Indeed, G20 leaders highlighted at the 2012 Los Cabos Summit the global importance of employing disaster risk management tools for population, infrastructure and economic protection going forward (G20, 2012).

The potential impacts of a disaster are myriad—injuries and casualties, infrastructure damage, environmental destruction, economic loss—and the ramifications of these can be widespread and long-lasting. Cities are complex interdependent systems, so an impact to one component can affect other parts of the system (Amendola, Ermolieva, Linnerooth-Bayer, & Mechler, 2013). A better understanding of these impacts and system interactions helps to inform planning strategies designed to mitigate future disaster-related loss.

The business sector is one of those critical components of an urban system. Businesses large and small play an integral role in the functioning of a community—tax revenue generator, employer, goods and service provider (Alesch, Holly, Mittler, & Nagy, 2001; Cochrane, 1990; Zhang, Lindell, & Prater, 2009). In the aftermath of a disaster, the resumption of operations by local businesses is a key component of community recovery. It is therefore imperative that a comprehensive community risk assessment include potential risks to the business sector and ways to reduce those risks as part of a broader community resiliency-building strategy.

1.1 Research Strategy
How best to facilitate the development of business-oriented community resiliency strategies then? In the author’s opinion, this necessitates drawing deliberate linkages between research and practice, ensuring that they are undertaken with the explicit intent of both supporting a defined goal (in this case, building business community disaster resiliency) and iteratively reinforcing the ability of the other to do so. One of the goals of research studies on issues such as community disaster risk should be to produce
outputs that can directly inform relevant public decision making processes. Observations and outcomes from public risk management efforts should be examined with an eye toward how they can help refine future scientific investigation of risk issues and reduction measures. This research seeks to foster such a link between scientific risk analysis and risk management efforts in the area of business disaster—specifically earthquake—risk and vulnerability in the context of one Metro Vancouver community—the District of North Vancouver (DNV).

It is important to note that at the individual business level, decisions about risk reduction are not solely made on the basis of scientifically-analyzed risk; factors such as risk perceptions, management approach, past experience, resource availability and other competing business priorities all play significant roles in the choices businesses make (Tamuz & Lewis, 2008). A better understanding of how scientific risk analysis fits into the business decision making picture—particularly the relationship between analyzed and perceived risk and the value businesses place on hazard risk assessment information—is critical to designing public resiliency-building initiatives that will effectively promote individual-level risk reduction action.

To more comprehensively investigate this risk picture, this study takes a two-fold approach. Using the lens of a magnitude (M) 7.3 Georgia Strait earthquake scenario, this research estimates potential disruption and economic loss to DNV businesses using a model adapted from previous research by Chang and colleagues (Chang, Pasion, Tatebe, & Ahmad, 2008). To investigate business risk perception and current risk reduction activity, an online survey was also conducted among licensed North Shore businesses.

Using data from the economic loss model and business survey, this research seeks to address the following questions:

1. What potential disruption to the DNV business community (and resulting economic loss) might be produced by an M7.3 Georgia Strait earthquake event?
2. How do DNV businesses perceive the likelihood and significance of earthquake-related risks to their operations?
3. What level of interest do DNV businesses express in accessing scientific risk assessment information, and how significant a role does this information play in their risk-related decision making processes?
4. What relationships, if any, exist between businesses’ risk perceptions and preparedness activities undertaken?

5. How does the potential risk of disruption modeled by the economic loss study compare with the perceptions of risk and disruptiveness by DNV businesses?

6. What implications might findings on risk assessment, risk perception, and preparedness activity have for municipal-level risk management decisions?

Answers to these questions are intended to support an initiative by North Shore local government agencies to promote disaster mitigation and preparedness among its business community, and also to inform ongoing and future scientific research into North Shore disaster risks.

1.2 Thesis Organization

Chapter 2 provides a foundation for investigating risk by reviewing literature on its analysis, perception and management. Case study characteristics and selection rationale are outlined in Chapter 3. Chapter 4 describes the economic loss model used to estimate the potential risk of disruption to the North Vancouver business community and subsequent findings. An overview of the survey and summary of findings on risk perceptions and preparedness behavior of North Vancouver businesses are discussed in Chapter 5. North Vancouver risk analysis and business community risk perceptions are compared in Chapter 6, along with a discussion of implications of study findings for public policy and community-level preparedness planning. Chapter 7 discusses study conclusions and future research considerations.

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1 In the context of North Vancouver business behavior, “preparedness” is used broadly in this study to refer to any pre-disaster event actions and planning undertaken with the intent to reduce risk, facilitate response and/or recovery.
Chapter 2: Risk
This chapter briefly examines literature on risk—salient features of its characterization and management—specifically in the context of natural hazards. The primary emphasis of this review is on how an understanding of these risk-related issues can inform public decision making around natural hazards.

2.1 Characterizing Risk
Risk is a very prevalent topic in contemporary dialogue; what actually constitutes “risk,” however, is a subject of much discussion. Moller, in his review of risk theories, describes five main conceptions of risk: “an unwanted event which may or may not occur; the cause of an unwanted event which may or may not occur; the probability of an unwanted event which may or may not occur; the fact that a decision is made under conditions of known probabilities; [and] the statistical expectation value of unwanted events which may or may not occur” (2012, p. 58).

While it is beyond the scope of this thesis to explore in depth the varying nuances of risk definition across the body of theory, Moller’s summary highlights five aspects of risk that are significant in the discussion of hazards and disasters. The first of these is that risk refers to the experience of some unwanted event or undesired state—in this case, broadly speaking, harm (at the aggregate level, disaster; at the individual level, such outcomes as personal injury or building damage). Second is a reference to the underlying cause of the unwanted event—here, the hazard that precedes the harmful outcome. Moller’s third definition of risk raises the issue of probability—a hazard may or may not occur within a specified time period, the outcome may or may not be harmful in varying degrees. The fourth highlights the selection of a course of action in a situation where a range of outcomes are possible, and finally, in the fifth point, the idea that these possible outcomes can be statistically evaluated.

How risk is evaluated and those evaluations understood are significant considerations. One of the main controversies in the study of risk is between what are frequently termed “objective” risk and “subjective” risk. Objective risk is that which is generally defined by scientific or technical experts through research studies and statistical analyses; subjective risk is the perception of risk by lay populations (Fischhoff, Watson, & Hope, 1984; Plattner, Plapp, & Hebel, 2006; Slovic & Gregory, 1999). While a common assumption is to view expert pronouncements of risk as “fact” and the public’s interpretations of those pronouncements as “fiction,” distorted by a lack of clear understanding and personal biases, it is important to note that the reasons behind these disparities are often much more
complex, and studies have demonstrated several cases in which public risk characterizations included relevant local knowledge that expert analyses lacked (Fishchoff et al., 1984).

The tension between objective and subjective risk encompasses more than just the expert and the citizen; it also evokes discussions of fact- and value-based judgments. In this sense, objective risk is determined by the statistical likelihood of an event’s occurrence and impact severity—with the implicit assumption that technical experts are the only ones equipped to make such definitions—whereas a subjective definition of risk accounts for the values and social systems of the society in which the particular risk exists, believing that risk is a product of social processes (Hansson, 2010). The challenge for local decision makers is how to reconcile technical analyses of risks to their community and the perceptions of their community on risk (noting that both have validity and value to contribute to the process) in order to develop effective risk management strategies.

2.1.1 Risk Analysis - “Objective Risk”
Disaster events are incredibly complex—a myriad of interconnected systems, structures and people are affected with consequences dispersed across geographic and temporal scales. Risk analysis is the process by which the likelihoods and expected consequences for disaster events are quantified (Plattner, 2005). An integral component of these analyses—particularly from a public decision making standpoint—is the assessment of relevant vulnerabilities. Vulnerability can be broadly conceived as the potential for loss; in other words, how and to what degree populations and assets are susceptible to the negative impacts of a hazard (see Cutter, 2006 for a discussion of vulnerability conceptualizations and definitions). The multitude of factors involved makes the process of trying to analyze disaster risks and vulnerabilities a daunting task from a research perspective.

The development of mathematical models is one way that scientists seek to manage the research complexities of disaster risk analysis and parse out certain factors from the whole for further investigation (Amendola et al., 2013; Othman & Beydoun, 2013). Models can be used for many purposes, from trying to estimate damage patterns to population behavior to economic impacts. This project is principally concerned with those models that consider economic impacts.
The insurance industry was in many ways the early driver behind the development of disaster economic loss models, seeking to better align coverage policies with loss potential. Generally referred to as a catastrophe or CAT model in the insurance context, the basic structure involves four main components (illustrated in Figure 1): characterization of the hazard (e.g., if an earthquake: epicenter location, magnitude, return period, etc.); inventory of exposed assets/properties/populations; estimation of the damage vulnerability of the assets in relation to the hazard; and evaluation of losses resulting from estimated damage (Grossi, Kunreuther, & Windeler, 2005). Given the level of uncertainty inherent in disaster events, these models employ a probabilistic approach designed to represent the range of potential outcomes (Mahdyiar & Porter, 2005).

A number of specific modeling frameworks have been developed over the years to estimate potential economic loss from hazard events, including input-output (I-O) models, computable general equilibrium (CGE) models, econometric models and social accounting matrices (SAM). The varying strengths and limitations of these frameworks are well scrutinized (see, for example, Clower 2005; Okuyama 2004; Okuyama & Chang 2011; Rose 2004a), and they are continually being refined to offer more comprehensive, nuanced estimates of economic losses.

These frameworks offer ways to understand the dynamic economic impacts of a disaster event at various geographic and temporal scales and in the context of interdependent systems. Not only can modeling be used to estimate the overall impacts of a potential disaster event, but also to help identify patterns of vulnerability according to asset characteristics. Models focused on exploring the impacts of disruption to specific systems, such as lifelines and transportation networks, have also been developed (Chang, 2003).

A better understanding of the relationships between these factors and disaster impacts can inform decision-making around resource allocation when it comes to risk reduction actions (Clower, 2005; Committee on Earthquake Engineering, 1990). The value that loss estimation modeling holds for risk management decision making is why their use in recent decades has expanded from the insurance industry into growing adoption by government agencies and private sector organizations.
Much modeling of the economic impacts of disasters has been carried out on a large scale, highly aggregated and examining regional/national loss; however, this scale of analysis can obscure differential impacts at the community level (Clower, 2005; Marshall & Schrank, 2014; Zhang et al., 2009). Disasters are in many respects local phenomena, meaning that their impacts are first experienced locally, first response happens locally, and the primary responsibility to prepare belongs to the local community. Modeling impacts at the community-scale, as Chapter 4 demonstrates, can provide more detailed insights to decision makers on local risk reduction opportunities.

It is important to note that modeling is not without its challenges, however. Disaster events are incredibly complex, and attempts to identify and operationalize the most salient of the many processes and systems involved for modelling purposes remain a continual challenge for researchers; in addition, uncertainties in these models are compounded when linked or built on top of each other (Eguchi & Seligson, 2008; Plattner et al., 2006). As disaster events are relatively rare occurrences, and there are difficulties inherent in attempting to collect data following them, there are significant limitations in the availability of empirical data as well (Rose, 2004b; Okuyama & Chang, 2011). Given the complexities, uncertainties and data limitations involved, model results should not be viewed as exact predictions of future outcomes, but rather as tools to integrate relevant data and produce credible scenarios around which risk management planning can take place (Grossi & Windeler, 2005).

2.1.2 Risk Perception – “Subjective Risk”

Risk perception can be thought of as “the process of collecting, selecting and interpreting signals about uncertain impacts of events,” in this case, hazard events (Wachinger, Renn, Begg, & Kuhlicke, 2013, p. 1049). In essence, it is a subjective judgment about the probability of a negative event occurring and the appropriate level of concern one should have regarding that event’s consequences (Sjoberg, Moen, & Rundmo, 2004).

Numerous studies illustrate that the public’s conception of risk is multidimensional and, in addition to risk probability and consequence magnitude, influenced by attributes such as fear, uncertainty, voluntariness, catastrophic potential, and risk to future generations (Oltedal, Moen, Klempe, & Rundmo, 2004; Slovic, 1987, 1999; Slovic & Gregory, 1999:). People’s perceptions of risk are also associated with cultural, social and experiential backgrounds (Kirschenbaum, 2005). In addition, research demonstrates correlations between risk perceptions and various demographic factors such as age, gender, ethnicity, education level and socioeconomic status (Langford, Day, Georgiou, & Bateman, 2000; Oltedal et al., 2004; Slovic, 1999).
Many theories have been developed to explain the ways that people comprehend and interpret risk. Some theories focus on the influences of personality characteristics on risk perceptions, others on economic motivations, and still others with a political orientation that considers issues of power and competing interests (Wildavsky & Dake, 1990). Two of the best known and most widely used theoretical constructs for exploring risk perceptions are the psychometric paradigm and cultural theory.

The psychometric paradigm focuses on cognitive processes. Distinct risk attributes believed to influence risk attitudes are identified, and the degree to which individuals view those attributes as related to a specific risk determines their judgment of its relative riskiness and acceptability. Fischoff et al. originally proposed nine attributes as significant influencers of risk levels: voluntariness of the risk, immediacy of its effects, knowledge of the risk by people exposed to it, knowledge of the risk in science, control over the risk, relative newness of the risk, chronic-catastrophe (does the risk impact people one at a time or simultaneously in large groups), common-dread (is the risk a familiar one people have learned to cope with or rare and highly frightening), and severity of the risk’s consequences (Fischoff, Slovic, Lichtenstein, Read, & Combs, 1978). Subsequent research has explored other attributes, such as equitableness of risk and benefit distribution, ‘naturalness’ of the risk, and the degree to which it affects future generations. Attributes are then used as scales with which individuals rate specified risks. Research has demonstrated some correlation between the location of risks on the ‘cognitive maps’ produced by these attribute scales (e.g. the widely-disseminated plotting of risks along “dread” and “unknown” axes in Fischoff et al., 1978) and people’s risk attitudes (Slovic & Weber, 2002).

In contrast, cultural theory maintains that risk is a product of cultural systems, and that individuals interpret risk information in a manner that supports their existing way of life. Risk preferences are developed according to a combination of cultural biases and social relations. These combinations are broadly categorized according to a grid-group typology originally put forth by Mary Douglas. “Group” refers to an individual’s membership (or not) in a bonded social unit and the relevance of its activities in the individual’s life. “Grid” identifies

![Figure 2. Cultural Theory Grid-Group Typology](source: Manzi & Jacobs, 2008)
the degree to which an individual’s behavior is socially regulated or restricted. The intersection of these dimensions defines four types of worldviews—hierarchical, egalitarian, individualist, and fatalist (see Figure 2)—each of which identifies and focuses on risks in ways designed to preserve their ways of life; for example, views on new technologies or environmental regulations would vary to the degree that those things reinforce the culture of the individual judging them (Oltedal et al., 2004; Van der Poel & Fahlquist, 2013; Wildavsky & Dake, 1990).

Many studies over the years have applied both cultural theory and the psychometric paradigm and demonstrated that their constituent factors have salience in the complex process of risk perception (a larger body of evidence in the case of the psychometric paradigm). However, a frequent observation of these models in recent empirical analysis is that they demonstrate limited explanatory power with regard to the variance of individual risk perceptions (Oltedal et al., 2004; Siegrist, Keller, & Kiers, 2005; Sjoberg, 2002; Sjoberg et al. 2004). This indicates that continued investigation is needed to identify other factors relevant to the perception process, and how they interact, in order to develop more robust explanatory models.

Recent studies have highlighted the significance of other factors and factor combinations in risk perception processes. One of these, important to mention from a public risk management standpoint, is trust. Trust (in both risk information sources and entities responsible for providing risk protection) has been identified as a significant contributor to risk perceptions (Marris, Langford, & O'Riordan, 1998; Sjoberg, 2012; Slovic, 1999; Wachinger, Renn, Begg, & Kuhlucie, 2013; Wildavsky & Dake, 1990). Past experience has also been shown to play a strong role in risk perception (Wachinger et al., 2013). People use previous, similar experiences to construct their understanding of potential future events and what constitutes an appropriate response, which can often prove problematic if past events are more dissimilar to predicted future events than individuals realize (Venette, 2008). Finally, some research has argued that attitude, risk sensitivity, and fear collectively have strong explanatory power when it comes to risk perception variance (Sjoberg, 2012).

Another dimension to risk processing that has been well studied over the years focuses on individuals’ use of heuristics—simple judgment rules—to aid in processing complex information like hazard probabilities. Three commonly applied heuristics identified by Tversky and Kahneman are: representativeness - judging the likelihood of something based on perceived similarities to an existing mental prototype; availability - judging the likelihood of something based on the ease with which related things can be brought to mind; and anchoring and adjustment - starting from a known or
suggested value and adjusting higher or lower by a degree that seems plausible to judge the likelihood of something. While these judgment tools can at times prove effective, their inherent biases and fallacies can lead to systematic and predictable errors (Tversky & Kahneman, 1974). This is especially true in low probability, high uncertainty, and high potential consequence events like natural hazards.

The affect heuristic is another commonly-employed judgment tool and refers to the way in which negative and positive emotional responses motivate risk judgments (i.e. more positive emotional response generally produces lower perception of risk and higher perception of benefit). Studies have demonstrated that changing perceptions of one attribute (e.g. risk or benefit) tends to influence perceptions of others (Axelrod, McDaniels, & Slovic, 1999; Finucane, Alhakami, Slovic, & Johnson, 2000).

While research continues to refine theoretical models in order to better explain the variances in risk perceptions, awareness of the kinds of sociocultural, cognitive and emotional processes which have been identified thus far to influence people’s judgments of risk is an important contributor to developing strategies for effective public risk management.

### 2.2 Managing Risk

From a planning and public decision-making standpoint, taking a holistic view of risk seems prudent. Scientific risk analysis provides decision makers with both an understanding of past disaster events and credible future event scenarios, but individual and organizational actions are heavily influenced by their perceptions of risk, so it is important that both kinds of knowledge inform the public decision making process (Grossi & Kunreuther, 2005).

While risk managers often possess the technical expertise to analyze risk, lack of information regarding the way that the local public perceives and evaluates risk is a common challenge. Because societal values play a significant role not only in determining how the public defines a risk but also what levels of risk are acceptable to the community, bridging this information gap is an important step in developing a responsible public risk management strategy (Figueiredo, Valente, Coelho, & Pinho, 2009; Plattner, 2005). The development of an effective risk dialogue between decision makers and the community is one way to address this gap. Understanding what motivates people to adopt risk reduction behaviors, what makes them more receptive to risk information, and how they view the role of government in public risk management is important to fostering this dialogue.
2.2.1 Protective Behavior
Stakeholder risk perceptions and the decision processes they inform are the linkages between risk analysis and risk reduction activity. It is therefore crucial to have an understanding what risk information stakeholders are accessing, how they view it, and what role that information plays in their decision about future behaviors (Grossi et al., 2005).

Psychologists, public health experts and decision theorists frequently use the term “protective” or “precautionary” behavior to describe actions undertaken by individuals in order to avoid or lessen the impact of some perceived negative outcome. In health terms, that often means the risk of disease or injury; with respect to natural hazards, this concept can be expanded from personal harm to also include damage to property and reduced ability to carry out daily activities. Protective behaviors in the natural hazards sense can be considered mitigation or preparedness measures, both of which are designed to reduce potential harm to people and/or property.

Several theories have been developed and applied to explain the adoption of protective behaviors, such as the health belief model, subjective expected utility model, protection motivation theory, and theory of reasoned action. The basic premise of these theories is that individuals are motivated to act in a precautionary manner due to the expectation that said action will reduce potential future harm. These theories attribute behavioral changes to influences by various combinations of factors, including the perceived likelihood and severity of the risk, costs and relative efficacy of the protective action [response efficacy], individuals’ beliefs in their ability to successfully implement the protective action [self-efficacy], and social pressures to undertake the action (Lindell & Prater, 2002; Van der Pligt, 1998; Weinstein, 1993).

General findings seem to support the assumption that people are more motivated to act when the perceived severity of a risk and their vulnerability to it are greater, and there are effective ways to reduce that risk which they feel capable of carrying out (Block & Keller, 1998; Figueiredo et al., 2009; Terpstra, Lindell, & Gutteling, 2009). However the findings of empirical studies based on these models can vary. For example, a study by Martin et al. found an increased adoption of risk reduction behaviors when individuals demonstrate stronger beliefs in their own vulnerability, in the severity of the risk, in the possibility that the risk can be mitigated, and in the feasibility of risk reduction options to successfully accomplish this (Martin, Bender, & Raish, 2007b). Lindell and Prater noted that seismic risk reduction behaviors are most likely to be adopted when characterized by high efficacy and low cost.
Van der Pligt found that the combination of perception of high risk and low efficacy of potential protective behaviors produces little motivation to act (1998).

As a way to investigate these variances, some researchers have reconceptualized these models in ways that allow them to delineate populations into subgroups they theorize are differentially influenced by the variables identified in health behavior models. For example, Rimal and Real developed the Risk Perception Attitude framework (RPA) categorizing populations into four attitude groups: “responsive” – high perceived risk and high efficacy beliefs, “avoidance” – high perceived risk and low efficacy beliefs, “proactive” – low perceived risk and high efficacy beliefs, and “indifference” – low perceived risk and low efficacy beliefs. Study findings provided some support for their hypothesis that those in the “responsive” group are most likely to adopt protective behaviors (Rimal & Real, 2003).

The application of the transtheoretical model (TTM), also called “stages of change” model, is another approach (for a discussion of TTM, see Prochaska & Velicer, 1997). The premise underlying the integration of TTM into the analysis is that people at different stages of the decision making process (i.e. “precontemplative” stage - unaware of or resistant to the idea of a risk requiring action, “contemplative” stage - aware of the risk and considering acting on it at some point, and “action” stage - have acknowledged the risk and are adopting some kind of protective behavioral change) are differentially influenced by the various factors identified in health behavior models (Block & Keller, 1998; Martin, Bender, & Raish, 2007b). An example of this integrated approach is a study of wildfire risk-related behavior conducted by Martin and colleagues, who found that perception of vulnerability and risk severity were more motivating for those in the pre- and contemplative stages, whereas response efficacy and self-efficacy were more influential for those at the action stage (2007a).

Some of these same influences are highlighted by studies specifically focused on the behavior of organizations with respect to natural hazard risks. Alesch et al. outline what they believe to be the four basic reasons organizations fail to take precautions against natural hazards:

- they do not perceive a risk;
- if they are aware of risks, they may believe there is nothing they can do to address it;
- they may be aware of risks and potential measures for reducing them but choose not to act at the present time due to competing business priorities;
• they may be aware of risks and potential measures for reducing them but may be prevented from acting by resource constraints, unavailable insurance coverage, lack of technical capacity, etc. (2001).

A study by Kleindorfer and Kunreuther modeling costs and benefits of earthquake and hurricane mitigation practices echoed some of this same reasoning. They surmised that a low level of investment in mitigation practices can be partly attributed to organizations’ perception that the probability of disaster damage was too low to justify investment in protective measures and budget constraints taking precedence over hazard risks (2000). Both these studies highlight the significance of perception of risk magnitude and self-efficacy (organizations having the ability and resources to successfully implement risk reduction measures).

Though more research is needed to better understand the complex relationship between risk perception and the motivation to adopt protective behaviors, a health behavior analysis of risk decision making indicates that individuals and organizations consider—and are significantly influenced by—several factors beyond the perception of risk likelihood and severity, notably the efficacy and feasibility of risk reduction options. To successfully promote behavioral change, public risk management strategies must acknowledge this. In addition, PRA and TTM approaches suggest that a better understanding of local risk reduction belief and behavioral landscapes can help inform public awareness strategies to more effectively target the types of information that will be most influential in promoting local behavioral change.

2.2.2 Risk Communication

Understanding how people interpret and choose to act on risk information is an important precursor to crafting effective risk communication strategies. Theories of risk communication focus on identifying and reducing risks as a way to avoid disasters where possible and more effectively manage them where not (Sellnow & Seeger, 2013).

For many people, even those residing in high risk areas, natural hazard risks have relatively low level of salience. Comprehensive, repetitive information is needed to convince the public that it is worth their concern (Dynes, 1995; Mileti, Fitzpatrick, & Farhar, 1992). The challenge for public risk managers tasked with raising public awareness around local risks is creating a “level of anxiety that is sufficient to motivate risk-reducing behaviors” but not so high that it overwhelms people to point of inaction with risk-induced fear (Van der Pligt, 1998, p. 9). Beyond striking a balance between motivation and fear, risk
managers must also seek to overcome the challenge of procrastination. While individuals frequently put off daily life tasks, procrastination is an even larger issue with preparedness and mitigation measures related to a non-immediate event like an earthquake; when people are not presented with a concrete and near-term deadline by which they must carry out a certain action, they are frequently unmotivated to do so and will willingly relegate it to the distant future (Lindell & Perry, 2012; Mileti et al., 1992).

What and how then can risk managers communicate in order to make hazard risks salient, overcome inertia to act, and successfully promote mitigation and preparedness actions? Numerous studies have demonstrated that risk analysis information is a necessary but not sufficient condition for successfully influencing risk reduction behavior adoption, thus it is important to understand the other factors—as identified by the behavioral models in the previous section—that promote behavioral change (e.g. Bourque, Kelley, Wood, Kano, & Mileti, 2012; Lindell & Whitney, 2000; Slovic, 1987; Van der Pligt, 1998). Indeed, research suggests that emphasizing the efficacy of preparedness and mitigations options in risk communication may be a more effective motivator than hazard likelihood and severity (Lindell & Prater, 2002). As Martin et al. note, “people must feel they have the knowledge, ability, and resources to deal with the risk at hand and that the actions they take will effectively reduce the risk, before they are ready to move into the action stage of risk reduction” (2007a, p. 898). Effective risk communication then should equip people with the kinds of information that empower them to take action.

Burns and Slovic, in a review of several recent risk perception studies, highlight key themes that have emerged as significant in risk communication strategies, including: the need to make messaging sensitive to constituent learning styles, cultural identities and relevant demographic characteristics; crafting message content to focus on clear preparedness actions; and being attentive to short memories and the tendency to procrastinate (2012). Mileti et al. emphasize that the public information stream needs to be comprehensive, consistent and reinforcing (1992). A study of preparedness behaviors in New Orleans and Los Angeles by Basolo et al. underscores both sets of recommendations, noting risk communication should clearly link preparedness actions to potential outcomes, and should be transmitted through multiple channels several times a year in order to be effective (2009).

The issues of clarity and efficacy are especially important, as research based on the Protective Action Decision Model (PADM) illustrate. PADM is another conceptualization of the way that various factors influence the adoption of protective behaviors (for a discussion of PADM, see Lindell & Perry, 2012). Like TTM, PADM incorporates temporal stages into its analysis, highlighting the process by which individuals are exposed to, comprehend, interpret and choose to act on risk-relevant information. PADM study
findings emphasize, among others, the value of clarity and consistency in risk messaging as ambiguity has been shown to inhibit individuals’ progression from information processing to action, as well as the significance of demonstrating efficacy in encouraging risk reduction adoption (Lindell & Perry, 2012).

This should be especially promoted in the case of natural hazards. Research shows that people tend to perceive natural hazard risks as unavoidable and difficult to control, which may lead to more passive planning and preparedness responses (Axelrod et al., 1999). Clearly-articulated protective measures, and validation of their efficacy, can help to overcome that passivity.

When considering the channels by which risk information is communicated, a recent study by Wood et al. suggests that the most effective communication comes from peers sharing steps they have taken to reduce risk. They recommend an emphasis on preparedness actions people can take rather than the physical impacts of a disaster and highlight the need for risk communication to be “dense.” Dense communication conveys a consistent message from several sources through various channels over a sustained period of time in order to successfully reach people through their day-to-day concerns (Wood, et al., 2012).

One of the reasons that peer communication is effective is the issue of trust. Wildavsky and Dake, in a study of cultural theory applications to risk perception, suggest that it would be profitable for risk communications to focus on factors underlying risk, specifically confidence in institutions and credibility of hazard information (Wildavsky & Dake, 1990). Marris et al. note in a study of risk perceptions that respondents prefer to rely on people with whom they have personal connections for trustworthy risk information (1998).

Finally, to maximize the impact of the types of messaging described above, knowing who will be receiving them is important. As the various models of perception and behavior demonstrate, people are influenced to interpret and act on risk in different ways, and understanding what different groups of people will be more receptive to is an important component of effective risk communication strategy. Audience analysis helps risk communicators to appropriately target messaging (McDaniels, 1998; Venette, 2008).

As Venette notes in his study of Hurricane Katrina communications:

*Risk communicators want individuals to understand why taking a particular course of action is reasonable and prudent...the goal is to provide information and assistance so that people decide*
that the preferred course of action is what they want to do, and thus what they will do. Risk communicators must move beyond conviction to achieve persuasion (2008, p. 206).

To be persuasive to the point of achieving public action, the research reviewed here suggests that risk communicators must first know their audience in order to craft messaging sensitive to the cognitive processes, cultural characteristics, learning styles, and decision stages of the targets. Messaging should be clear and action-oriented, designed to convince of both the need for risk reduction efforts and the efficacy of suggested measures, and distributed regularly in coordinated fashion from sources the public trusts.

2.2.3 Risk Governance

Risk decisions are not only made at the individual or organizational level; they are also made at the community (and higher) level. Acting on behalf of the public, rather than as an individual, brings additional complexity and responsibility for those entities entrusted with the public welfare. The concept of risk governance—an approach for dealing with public risks that shares responsibility between government and civil society—aims to account for the “complex web of actors, rules, conventions, processes, and mechanisms concerned with how relevant risk information is collected, analyzed, and communicated, and how management decisions are made” (Hermans, Fox, & Van Asselt, 2012, p. 1094).

In recent years, there has been a stronger call for public participation in risk assessment and decision making processes in order to better account for public concerns and increase the legitimacy of risk management decisions (Hermans et al., 2012; IPCC, 2012; Slovic, 1999). Newer reconceptualizations of risk identify responsibility and acceptability as integral attributes, highlighting the increased awareness of risk decision making (and subsequent consequences) in the public consciousness (Van der Poel & Fahlquist, 2013).

Forward-looking risk responsibilities (as opposed to backward-looking focused largely on assigning blame and liability) can be generally divided into four categories: responsibility for risk assessment, responsibility for risk communication, responsibility for risk management, and responsibility for risk reduction. When risks are thought to be an individual matter, general expectation is that governments (and other welfare-oriented organizations) are responsible for communicating information about the risk and recommendations on how individuals can best avoid it; individuals then make their own assessment and management decisions. The burden of assessment and management shifts when risk is
viewed as a collective matter. At the local level, this means principally to the local government (Van der Poel & Fahlquist, 2013).

When risk communication is designed to inform and motivate adoption of a selected set of protective behaviors (i.e. with individual risks), it is often one-way. To support acceptable risk determinations and management decision making on collective risks, that communication will ideally be dialogic (Slovic, 1987). Two-way communication helps to inform both the public and risk managers of current conceptions of risk, values and priorities; this information both contributes to decisions about risk on the public’s behalf and also allows risk managers to refine their messaging based on audience feedback in order to improve effectiveness (Ropeik, 2012). Public dialogue can also aid decision makers in dealing with the challenge of balancing immediate concerns and future risks that may or may not materialize by soliciting public input and providing greater clarity to the public on prospective trade-offs (Tamuz & Lewis, 2008).

Perceived risk responsibility is also a significant factor in behavioral motivation; those who ascribe major responsibility for coping with disaster impacts to external entities like government are less likely to engage in protective behaviors themselves. Government—particularly local government—is commonly perceived as having a significant share of responsibility for facilitating disaster recovery (Nigg & Hans, 1994), though recent research has indicated a potential shift in public sentiment toward more self-responsibility (Lindell & Whitney, 2000). Even if public views on responsibility are evolving, it remains important that government risk communication seek to bring public perceptions of their disaster recovery responsibilities into alignment with existing public assistance program capabilities.

Maximizing budget efficiency and demonstrating accountability to stakeholders for decisions made are prominent aims for democratic public agencies, thus optimizing the use of resources in risk management efforts is critical. Local decision makers are under pressure to identify and implement the most efficient and effective risk reduction measures for their communities, meaning that they need to consider scientific analyses of risk and other factors salient to public risk perception outlined in this chapter. A key barrier to this is the lack of information about societal risks views and values prior to a disaster event (Plattner, 2005). Responsible risk governance then calls for efforts to gain these insights in order to inform decision making. In the following chapters, this research attempts to address this challenge in the District of North Vancouver, thus providing useful analysis and perception data to support local government’s efforts to optimize its disaster risk management strategies and resource allocation.
Chapter 3: Case Study Profile

This project focuses on the District of North Vancouver (DNV), both as an individual municipality and in the context of its two neighboring municipalities—the City of North Vancouver (CNV) and District of West Vancouver (DWV). These three municipalities are collectively referred to as the “North Shore” (see Figure 3).

The North Shore represents 3 of the 22 municipalities of the Greater Vancouver Regional District (“Metro Vancouver”), a region with 2.3 million inhabitants. Located north of the City of Vancouver, DNV is home to approximately 88,000 people. CNV and DWV have estimated populations of 51,000 and 44,000 respectively (BC Stats, 2013).

DNV was selected as the study focus area for a number of reasons, chief among them the support of the municipal government for a comprehensive analysis of local natural hazard risks and the existence of a concurrent earthquake risk modeling project conducted by Natural Resources Canada. Following a fatal landslide event in 2005, DNV has taken a proactive approach to addressing local natural hazard risks. This commitment was recognized in 2011 by the District’s receipt of the United Nations Sasakawa Award for excellence in disaster risk reduction.

Among other actions, DNV has established a Natural Hazards Task Force composed of engaged citizens who serve as both a sounding board and advisory group to municipal decision makers on risk-related issues. DNV has also developed a rich geographic information system (GIS) database of municipal infrastructure and land features as well as a comprehensive local building inventory, which facilitate more detailed physical risk analyses. In addition to integrating risk-based planning throughout numerous municipal departments, DNV has a strong working relationship with the North Shore Emergency Management Office (NSEMO). NSEMO is the tri-municipal agency responsible for emergency management planning and coordination on the North Shore (NSEMO’s role in this project is discussed is Chapter 5).
DNV’s commitment to disaster risk reduction led to a partnership with the Public Safety Geoscience Program of Natural Resources Canada (NRCan) to pilot a hazard risk assessment methodology. This project is part of broader efforts spearheaded by the Canadian Safety and Security Program to develop a national all-hazards risk assessment framework. Assessment methods are based on “Hazus;” Hazus is a standardized loss estimation methodology originally developed in the United States by the Federal Emergency Management Agency (FEMA) to aid communities in risk assessment and mitigation planning efforts (Journey, 2014). The pilot focuses specifically on earthquake risk assessment, and project results serve as inputs to this study’s economic loss model, discussed later.

### 3.1 DNV Business Profile

The DNV business license registry was selected as the primary data source for this study given the required licensing of all businesses operating within the municipality, regular updating of the registry, and inclusion of salient business characteristics such as sector and location. Just over 3,400² businesses are licensed in DNV. The municipality has a wide portfolio of business sectors (sectors aggregated from NAICS codes according to groupings used by the loss model, discussed in the next chapter). As shown in Table 1, service providers are the most numerous among these, comprising more than half of all local businesses; followed by those engaged in the mining, construction, transportation, communication and utilities trades; and the wholesale and retail trade sector.

Collectively, these businesses employ nearly 22,000 individuals (2006 Census of Canada).³ While employees-per-establishment counts are not available at the municipal level, based on provincial annual

<table>
<thead>
<tr>
<th>Table 1. DNV Business License Registry by Sector</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aggregated Sector (sector code)</td>
</tr>
<tr>
<td>Count</td>
</tr>
<tr>
<td>All Other Services (SVC)</td>
</tr>
<tr>
<td>Mining, Construction, Transportation,</td>
</tr>
<tr>
<td>Communication &amp; Utilities (MCT)</td>
</tr>
<tr>
<td>Wholesale &amp; Retail Trade (TRD)</td>
</tr>
<tr>
<td>Finance, Insurance &amp; Real Estate (FIR)</td>
</tr>
<tr>
<td>Manufacturing (MFG)</td>
</tr>
<tr>
<td>Health Services (HTH)</td>
</tr>
<tr>
<td>Total</td>
</tr>
</tbody>
</table>

Source: District of North Vancouver, 2011

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² A disparity between counts of businesses in the DNV license registry (3,432) and Statistics Canada Business Register’s Canadian Business Patterns (8,000+) is likely a product of several factors, notably the differing definition of a “business.” The Business Register’s definition is much broader, including any entity with a corporate tax account, GST account or employing someone. This can include non-active businesses and those who employ, for example, a housekeeper or in-home childcare provider (none of these would hold a municipal business license). For the purpose of this study, the municipal license registry is considered a more appropriate representation of businesses actively contributing to local revenue generation.

³ The DNV’s business license database does not include data on number of employees per business.
industry employment counts and gross domestic product (GDP) data, it is inferred that the DNV business community generates an estimated annual gross regional product (GRP) of approximately $1.93 billion, as indicated in Table 2. A significant share of these businesses are small (fewer than 50 employees) and often home-based. This is reflective of the broader Metro Vancouver business profile—small businesses account for 98% of all businesses in Metro Vancouver, and 81% of all businesses are considered microbusinesses with 5 or fewer employees (Metro Vancouver, 2012). This is especially relevant to community resiliency planning initiatives as small independent businesses typically have fewer resources available to devote to mitigation and business continuity planning than do franchised or large businesses (see Chapter 4 for further discussion).

In addition to sector and size, the type of building in which a business resides is a significant factor when assessing potential economic loss risk from earthquakes. Different building structural types have varying levels of resilience in earthquake shaking (see, for example, Ventura et al., 2005). Using address information from the DNV business license registry and building structural type data from DNV’s building inventory, business and building addresses were geocoded and cross-referenced to identify both the types of structures in which businesses reside as well as the intensity of use for each structure. The resulting data indicate that a majority of businesses in DNV are found in wood light frame structures, as shown in Table 3, which have a relatively high level of performance during earthquake shaking. These are primarily small businesses, often home-based. High concentrations of businesses (5

<table>
<thead>
<tr>
<th>North American Industry Classification</th>
<th>DNV Employment</th>
<th>Estimated Share of DNV Annual GRP ($)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Retail trade</td>
<td>2,670</td>
<td>113,701,392</td>
</tr>
<tr>
<td>Educational services</td>
<td>2,405</td>
<td>164,535,771</td>
</tr>
<tr>
<td>Professional, scientific &amp; technical services</td>
<td>2,310</td>
<td>140,594,618</td>
</tr>
<tr>
<td>Manufacturing</td>
<td>2,120</td>
<td>149,540,610</td>
</tr>
<tr>
<td>Health care &amp; social assistance</td>
<td>1,945</td>
<td>112,721,013</td>
</tr>
<tr>
<td>Accommodation &amp; food services</td>
<td>1,695</td>
<td>52,057,107</td>
</tr>
<tr>
<td>Other services</td>
<td>1,445</td>
<td>70,640,134</td>
</tr>
<tr>
<td>Transportation &amp; warehousing</td>
<td>990</td>
<td>89,761,697</td>
</tr>
<tr>
<td>Finance &amp; insurance</td>
<td>955</td>
<td>123,037,719</td>
</tr>
<tr>
<td>Arts, entertainment and recreation</td>
<td>885</td>
<td>29,343,577</td>
</tr>
<tr>
<td>Wholesale trade</td>
<td>880</td>
<td>84,269,327</td>
</tr>
<tr>
<td>Construction</td>
<td>830</td>
<td>70,873,891</td>
</tr>
<tr>
<td>Real estate &amp; rental &amp; leasing</td>
<td>695</td>
<td>467,229,938</td>
</tr>
<tr>
<td>Administrative &amp; support, waste mgmt.</td>
<td>695</td>
<td>34,586,020</td>
</tr>
<tr>
<td>Information &amp; cultural industries</td>
<td>620</td>
<td>77,217,668</td>
</tr>
<tr>
<td>Public administration*</td>
<td>620</td>
<td>81,080,690</td>
</tr>
<tr>
<td>Mining &amp; oil &amp; gas extraction</td>
<td>70</td>
<td>37,710,842</td>
</tr>
<tr>
<td>Utilities</td>
<td>55</td>
<td>25,843,373</td>
</tr>
<tr>
<td>Agriculture, forestry, fishing &amp; hunting</td>
<td>50</td>
<td>2,947,462</td>
</tr>
<tr>
<td>Management of companies &amp; enterprises</td>
<td>10</td>
<td>2,571,698</td>
</tr>
</tbody>
</table>

TOTAL 21,945 $ 1,930,264,546

Source: Statistics Canada, 2006

*Public Administration excluded from study
or more) within a single building tend to be found most frequently in unreinforced masonry structures (53 of the 119 DNV buildings containing 5+ businesses are unreinforced masonry structures). In contrast to light frame wood structures, unreinforced masonry buildings tend to perform poorly in earthquakes.

Finally, it is important to note the geographic distribution of businesses within the municipality. In addition to the proximity of other infrastructure (such as transportation networks or lifelines critical to business operations), other geographically-dependent factors such as site amplification, liquefaction susceptibility and landslide potential are important to consider when evaluating earthquake risk. In the DNV context, two areas of highest business density are located along the waterfront area (see Figure 4). It is not coincidental that commercial and industrial areas are heavily concentrated in close proximity to

<table>
<thead>
<tr>
<th>Building Structural Type</th>
<th>Businesses</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wood, Light Frame (&gt;5,000 sq. ft.)</td>
<td>1514</td>
<td>44%</td>
</tr>
<tr>
<td>Unreinforced Masonry Bearing Walls (Low-Rise)</td>
<td>899</td>
<td>26%</td>
</tr>
<tr>
<td>Wood, Greater than 5,000 sq. ft.</td>
<td>354</td>
<td>10%</td>
</tr>
<tr>
<td>Concrete Shear Walls (Low-Rise)</td>
<td>301</td>
<td>9%</td>
</tr>
<tr>
<td>Concrete Moment Frame (Low-Rise)</td>
<td>140</td>
<td>4%</td>
</tr>
<tr>
<td>Concrete Shear Walls (Mid-Rise)</td>
<td>67</td>
<td>2%</td>
</tr>
<tr>
<td>Reinforced Masonry Bearing Walls w/Precast Concrete Diaphragms (Low-Rise)</td>
<td>40</td>
<td>1%</td>
</tr>
<tr>
<td>Structural Type Unidentified</td>
<td>37</td>
<td>1%</td>
</tr>
<tr>
<td>Concrete Shear Walls (High-Rise)</td>
<td>25</td>
<td>1%</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>3411</strong></td>
<td><strong>100%</strong></td>
</tr>
</tbody>
</table>

*Source: District of North Vancouver, 2011*

**Table 3. Building Structural Types & DNV Business Counts**

*Figure 4. Map of DNV Buildings Containing Businesses*
rail and port infrastructure. This spatial pattern has important implications for earthquake risk, particularly in terms of liquefaction, which will be discussed later.

### 3.2 Georgia Strait Earthquake Scenario

As mentioned in the previous section, DNV and NRCan are currently piloting a risk assessment methodology focused on earthquake hazards. Hazus Canada (adapted from the original US version for use in Canada) is the loss estimation tool being used to undertake the assessment. Hazus is a “quantitative risk assessment and decision-support tool for natural hazard risk mitigation and emergency management...a GIS-based tool that models physical damage and economic and social losses from natural hazards such as earthquakes, floods and hurricanes” (Hazus Canada, 2014).

Using Hazus, NRCan selected and modeled four plausible earthquake event scenarios intended to represent the diversity of earthquake risk facing the region. These included:

- M8.2 offshore Cascadia Subduction Zone inter-plate earthquake
- M6.8 intra-plate earthquake along the Benioff zone in the Georgia Strait/Puget Sound area
- M7.3 shallow crustal earthquake triggered by a reverse fault in the Georgia Strait
- M6.8 shallow crustal earthquake triggered by an oblique slip fault near the Canada-US border

Assessment findings indicated that the M7.3 Georgia Strait earthquake (Figure 5) represented the ‘worst case’ scenario among those tested, resulting in significantly higher estimated damage and loss (Journeay, 2014). The NRCan research team, DNV, Natural Hazards Task Force and other local stakeholders elected to move forward with the Georgia Strait scenario for more detailed analysis and an evaluation of its potential to serve as the planning scenario for local mitigation and emergency management strategies. Consistent with this selection, the M7.3 Georgia Strait earthquake event is the scenario used in this study as well.
Chapter 4: Risk Analysis - Economic Loss Model

As discussed in Chapter 2, the process of modeling disaster economic loss and recovery is complex. It involves deliberate choices around how to conceptually address this complexity, such as: what of many potential variables the model should include, at what geographic and temporal scales the modeling should take place, the appropriate unit of analysis, how to quantify uncertainties, and how to deal with the often prevalent challenge of data availability limitations. This chapter briefly reviews salient research on disaster-related business disruption, describes the research methodology and process used in this study, and summarizes model results.

4.1 Disaster Impacts & Business Disruption

Recent disasters have highlighted the vulnerability of business communities to disruption-related losses, particularly in the case of small businesses:

- The U.S. Department of Commerce estimates total business losses from Hurricane Sandy to be USD $8.3B in the state of New Jersey alone; included in that total are the nearly 19,000 small businesses that suffered losses of USD$250,000 or more (Henry, et al., 2013)
- A year after the Tohoku Earthquake a reported 20% of the more than 27,000 businesses affected had still not reopened (The Jakarta Post, 2012)
- A year and a half after Hurricanes Katrina and Rita more than 20,000 businesses in the state of Louisiana had failed, and the highest failure rate (23.5%) was among the state’s microbusinesses (Terrell & Bilbo, 2007)

Pinpointing underlying contributors to these business disruptions and failures is essential to developing more robust models and effective risk reduction programs. Studies of earlier disaster events have demonstrated that lifeline loss is among the primary causes of business closure following a disaster (e.g., Chang, 2003; Tierney, 1994, 1997; Tierney & Nigg, 1995; Webb, Tierney, & Dahlhamer, 2000). In addition to lifeline disruption and direct damage, a review of business disaster preparedness surveys by the University of Delaware’s Disaster Research Center (DRC) indicated that businesses also struggle with offsite issues, including: supply chain disruption, decreased employee productivity resulting from disrupted commuting patterns and/or household damage, reduced customer traffic and changes in the types of goods and services customers demand after a disaster (Webb et al., 2000).

These findings underscore the fact that businesses are not independent entities; they function in complex networks. Infrastructure and lifelines play a critical role in that network. Public utilities such as
water and power are vital to daily operations. Businesses also rely on transportation networks to facilitate the movement of goods, employees and customers. Disruption or damage to any of these systems will impact the businesses that rely on them. Some industry operations are more sensitive to certain types of utility loss than others, which must also be considered when assessing risk and potential risk reduction measures (Chang et al., 2008).

In addition to infrastructure dependencies, businesses also rely on supporting industries and supply chain partners for necessary goods and services to operate. While an individual business may be fortunate enough to remain directly unaffected by a disaster event, the indirect impacts of disruption to its partner businesses and/or customer base may still have serious impacts on that business’s operational capability and revenue (see Rose & Guha, 2004). Thus the need to locate businesses within their broader social, economic and built environment systems when estimating hazard vulnerability.

These are valuable lessons to carry forward to the British Columbia context. According to seismic studies, there is at least a 30% chance that a damaging earthquake will occur in southwestern British Columbia in the next 50 years (Natural Resources Canada, 2010). A recent study by the Insurance Bureau of Canada estimated that a Cascadia subduction event could cause the region nearly $62 billion in property damage and $13 billion economic disruption loss (AIR Worldwide, 2013). Some experts believe, based on the outcomes of 2010 earthquakes in Haiti and Chile, that between 20% and 50% of economic losses following an earthquake in British Columbia will result from failed critical infrastructure (Kovacs, 2010).

4.2 Model Structure

The economic loss model [“DNV model”] applied in this study estimates direct economic losses of DNV business using several factors discussed earlier in this chapter, including: business sector, average economic production level, location, building damage state and lifeline access. The DNV model makes use of NRCan Hazus building and lifeline infrastructure damage estimates in the M7.3 Georgia Strait earthquake scenario to investigate the role of various sources of disruption in total economic loss. It is based on earlier economic loss models implemented for the Memphis (Shinozuka et al., eds., 1998; Chang et al., 2002; Chang and Shinozuka, 2004) and Los Angeles [“LA model”] (Chang et al., 2008) regions. Business disruption data derived from surveys of more than 2,000 businesses after the 1994

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4 Losses resulting from disruption to business operations caused by damage at the business’s location
Northridge and 1989 Loma Prieta earthquakes (provided by Tierney and colleagues at the DRC) form the empirical basis of the model.

Based on the survey data, the LA model developed an algorithm to evaluate the combined disruptiveness of three factors—building damage, electric power outage, and water outage—by producing an overall indicator of disruptiveness measured in terms of probability of temporary business closure. A Monte Carlo simulation approach (discussed in the next section) is used to estimate number of businesses closed based on closure probabilities.

The DNV model also includes a refinement over its predecessor models by incorporating neighborhood damage. Damage to the surrounding areas, particularly when it impedes employee and customer access, has shown to be a significant factor in affecting business operations following a disaster (Kroll, Landis, Shen, & Stryker, 1991; Webb, Tierney, & Dahlhamer, 2000; Chang & Falit-Baiamonte, 2011). This ‘neighborhood effect’ is represented in the model through the use of a scenario specifying that if the percentage of businesses closed within a defined neighborhood in the initial scenario exceeds a certain threshold level, then all businesses in that neighborhood are considered closed in the neighborhood effects scenario. This is graphically represented in Figure 6.

Scenarios are run with and without lifeline disruption and neighborhood effects to estimate how losses can be attributed to these various factors. In each scenario, resulting closure rates and normal daily production levels are used to estimate direct business disruption loss. Figure 7 illustrates model inputs and overall structure. Models outputs include the percent of businesses open and associated daily production loss in dollars and as a percent of GRP. Note that indirect economic losses (i.e., those due to economic interdependencies, such as damage to a business’s supplier rather than to the business itself) are outside the scope of this analysis.
It should be highlighted that the DNV model differs from the methodology used by Hazus (and other loss models) to estimate direct business income loss in several key ways. First, the Hazus model uses a spatial unit such as a census tract, whereas the DNV model uses the individual business as the unit of analysis. This enables the DNV model to better capture correlations between individual business characteristics and economic loss, as well as to model the impact of simultaneous sources of disruption on individual businesses without double-counting (see Chang et al., 2008 for further discussion).

Additionally, businesses in the Hazus model are differentiated by building occupancy class but by business sector in the DNV model. The building damage state, estimated building repair time, construction time modifiers, income-to-floor area ratios, and a recapture factor are the basis for estimating business interruption loss in the Hazus model, whereas the DNV model uses empirical disruptiveness categories and probabilities of temporary closure derived from its predecessor models. Finally, the main driver of business interruption loss in the Hazus model is building damage, as opposed to the DNV model which considers building damage, lifeline outage and neighborhood damage.

### 4.3 Simulation Approach & Model Scenarios

A Monte Carlo simulation approach is used with the DNV model. Monte Carlo simulations are a useful tool for complex scenarios such as a natural hazard event. Uncertain parameters are represented by
probability distributions, and simulations are run using randomly-generated values to sample from these distributions in order to produce deterministic results. The results from many simulation runs are analyzed to estimate likely event outcomes (Grossi & Windeler, 2005).

In this model, empirical data gleaned from business surveys of the Northridge and Loma Prieta earthquakes were used to develop business disruptiveness probability distributions according to individual sources of disruption (specifically, building damage, water service loss and electric service loss), as well as for business operating status based on the cumulative disruptiveness of all three sources (see Appendix A for probability disruptions).

Building damage states were drawn directly from NRCan Hazus Georgia Strait results and assigned a disruptiveness level according to model parameters. As water and electric utility infrastructure damage estimates were not yet available at the time of this study, lifelines were either considered fully functional or fully nonfunctional depending on the scenario modeled. In scenarios where lifelines were nonfunctional, the model projected associated disruptiveness levels for each business. Using the cumulative impact of modeled disruption sources, businesses were then estimated to be open or closed. If closed, the business’s estimated normal daily production was considered a loss. Cumulative production loss is totaled for each simulation run to estimate aggregate business economic loss in dollars and as a percent of DNV daily GRP.

Several scenarios were simulated. The ‘baseline’ scenario accounted for building damage only. Results are a lower bound estimate of loss as no lifeline outages or neighborhood damage were considered. A second scenario included the impacts of building damage and complete lifeline outage (‘building damage + no utilities’ scenario). Service loss of this magnitude is unrealistic but provides a hypothetical upper bound estimate of lifeline-related losses (a real-life scenario would fall somewhere between the baseline and no utilities scenario). Baseline and ‘building damage + no utilities’ scenarios were then run again with the neighborhood\(^5\) effect applied. For this study, 50% or greater businesses closed in the predecessor scenario was used as the threshold. 100 simulations were run for each scenario.

\(^5\) No standard definition of a “neighborhood” exists so three different sets of criteria were developed to delineate different neighborhood patterns based on factors such as pedestrian traffic, building proximity, natural barriers and zoning classifications. The results from simulations run using these criteria were very similar, so loss estimates from only one set are reported here. Criteria used for this neighborhood definition included: 1) minimum cluster of 5 or more zoned commercial/industrial/mixed use buildings, 2) use of natural barriers and major thoroughfares as boundaries in in areas with large clusters, and 3) consideration of pedestrian traffic patterns.
4.4 Results

Model results are discussed in this section, including answers they provide regarding the first question posed by this study:

(1) What potential disruption to the DNV business community (and resulting economic loss) might be produced by an M7.3 Georgia Strait earthquake?

4.4.1 Patterns of Disruption - Sector

Table 4 summarizes businesses by sector estimated by the model to be open the first day of the disaster in each scenario, averaged over 100 simulations (results for all simulation runs are summarized by scenario and sector in Appendix B).

<table>
<thead>
<tr>
<th>Aggregated Sector**</th>
<th>Damage Scenario (Range · St. Dev.)***</th>
<th>Building Damage [Baseline]</th>
<th>Building Damage + Neighborhood Effect</th>
<th>Building Damage + No Utilities</th>
<th>Building Damage + No Utilities + Neighborhood Effect</th>
</tr>
</thead>
<tbody>
<tr>
<td>FIR</td>
<td>65% (58% - 75% · 3%)</td>
<td>59% (49% - 75% · 5%)</td>
<td>25% (17% - 33% · 3%)</td>
<td>10% (6% - 14% · 1%)</td>
<td></td>
</tr>
<tr>
<td>HTH</td>
<td>75% (63% - 85% · 5%)</td>
<td>72% (59% - 85% · 5%)</td>
<td>21% (11% - 29% · 4%)</td>
<td>8% (1% - 14% · 2%)</td>
<td></td>
</tr>
<tr>
<td>MCT</td>
<td>72% (67% - 76% · 2%)</td>
<td>68% (59% - 76% · 3%)</td>
<td>33% (29% - 39% · 2%)</td>
<td>25% (22% - 30% · 2%)</td>
<td></td>
</tr>
<tr>
<td>MFG</td>
<td>58% (45% - 69% · 4%)</td>
<td>51% (23% - 63% · 7%)</td>
<td>22% (15% - 32% · 3%)</td>
<td>2% (0% - 5% · 1%)</td>
<td></td>
</tr>
<tr>
<td>SVC</td>
<td>71% (68% - 75% · 1%)</td>
<td>66% (59% - 73% · 3%)</td>
<td>28% (24% - 30% · 1%)</td>
<td>18% (16% - 19% · 1%)</td>
<td></td>
</tr>
<tr>
<td>TRD</td>
<td>65% (57% - 73% · 3%)</td>
<td>57% (45% - 70% · 6%)</td>
<td>25% (19% - 32% · 2%)</td>
<td>4% (2% - 7% · 1%)</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>69% (66% - 72% · 1%)</td>
<td>64% (45% - 70% · 3%)</td>
<td>28% (25% - 30% · 1%)</td>
<td>15% (14% - 17% · 1%)</td>
<td></td>
</tr>
</tbody>
</table>

* Percent of businesses open, averaged over 100 simulations
** HTH = health services; FIR = finance, insurance, real estate; MCT = mining, construction, transportation, communications, utilities; MFG = manufacturing; SVC = all other services; TRD = wholesale and retail trade
***Range and standard deviation of open rates, over 100 simulations

At the aggregate level, the baseline scenario estimates that 69% of businesses will remain open on the first day after the disaster if accounting only for the impact of building damage. This is generally borne out across business sectors, though health services (HTH) demonstrate the least sensitivity to building damage and manufacturing (MFG) the most at 75% and 58% open rates respectively. Given that manufacturing operations commonly have a larger physical footprint and tend to be equipment-
intensive, this sensitivity to building damage is not surprising. The application of a neighborhood effect to this scenario produces a minor reduction of 5% in the average open rate for all industries. This reduction is largely consistent across sectors, though MFG and wholesale and retail trades (TRD) experience slightly larger relative drops.

Open rates decline precipitously when lifeline outages are included in the model. The average open rate in the ‘building damage + no utilities’ scenario falls to 28%. The most marked deterioration occurs in the health sector, where the number of businesses that would remain open after the earthquake decreases by 54%. The dependence on water and electricity for safety, instrumentation, and sanitation needs in health care provision may help to partly explain this vulnerability to lifeline loss. When all sources of disruption are considered, just 15% of businesses are estimated to remain open. Manufacturing and trade sectors are the most significantly affected when the neighborhood effect is added to building damage and utility loss; their average open rates decline to a miniscule 2% and 4% respectively. As manufacturing companies are generally confined to the limited industrial zones—putting them in close proximity to one another—and retail businesses are often clustered to take greatest advantage of customer traffic patterns, the magnified impact of the neighborhood effect on their operational status is not unexpected.

4.4.2 Patterns of Disruption - Spatial

The spatial distribution of business disruption is also important to note. Figure 8 overlays the business map shown earlier with liquefaction susceptibility as modeled by NRCan. Events like 2011 Christchurch Earthquake demonstrate that liquefaction can cause substantial damage and disruption (Wilkinson, et al., 2013). Two of the three areas with the highest business concentrations—Marine Drive/Norgate and Lynnmour South—are located in zones highly susceptible to liquefaction. These areas also contain the majority of DNV’s industrial land, another likely contributor to the high level of vulnerability estimated by the model for the manufacturing sector.
Figure 8 provides a detailed view of the three business areas highlighted in Figure 8, depicting estimated business closures in a single simulation run (Run001) for each of the four damage scenarios. Buildings are assigned “open” status if the majority of businesses they contain are open, “semi-operational” if half of businesses are open, and “closed” if the majority of businesses are closed. Comparisons between the upper two scenarios, which assume utilities are functional, and the lower two, which model complete utility loss, visually illustrate the substantial impact that lifeline outages have on business operating status. Comparing across business areas, a greater share of businesses in Marine Drive/Norgate close as a result of building damage. Valley Centre and Lynnmour South appear to be more affected by lifeline outage.
Figure 9. Building-Level Operating Status Across Damage Scenarios in Three Business Areas
4.4.3 Economic Loss

Table 5 summarizes estimated economic loss associated with a single day of business closures as described in the previous section, both in dollars and as a percent of normal DNV economic activity.

<table>
<thead>
<tr>
<th>Damage Scenario</th>
<th>Building Damage [Baseline]</th>
<th>Building Damage + Neighborhood Effect</th>
<th>Building Damage + No Utilities</th>
<th>Building Damage + No Utilities + Neighborhood Effect</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Average Daily Loss</strong></td>
<td>$1.64 ($1.45 - $1.80 · $.07)</td>
<td>$1.95 ($1.48 - $2.46 · $.19)</td>
<td>$3.63 ($3.49 - $3.77 · $.06)</td>
<td>$4.35 ($4.18 - $4.43 · $.04)</td>
</tr>
<tr>
<td><strong>Dollar loss [$ million]</strong></td>
<td>33%</td>
<td>39%</td>
<td>73%</td>
<td>88%</td>
</tr>
<tr>
<td><strong>% difference from baseline</strong></td>
<td>--</td>
<td>+19%</td>
<td>+121%</td>
<td>+165%</td>
</tr>
<tr>
<td><strong>Loss as a % of GRP</strong>*</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* According to percent of businesses closed, averaged over 100 simulations
** Range and standard deviation of dollar loss, over 100 simulations
*** Gross regional product, where region is DNV

The difference in estimated loss from the single-source disruption scenario to the scenario considering all sources is substantial; the ‘building damage + no utilities + neighborhood effect’ scenario estimates $4.35 million/day in economic loss, an increase of 165% over the baseline estimate of $1.64 million/day. The former figure represents 88% of DNV normal daily production. Prolonged business disruption at this level would have a severe impact on the local economy. Comparing differences between the one- and two-source disruption scenarios also highlights the relative impact of each disruption source: lifeline outage (if utility loss was complete) accounts for greater economic loss ($1.99 million) than either building damage ($1.64 million) or neighborhood effects ($0.31 million).

Figure 10 summarizes the average production loss by sector as a percent of GRP in each of the damage scenarios. Service (SVR) and finance, insurance and real estate (FIR) sectors are the largest contributors to GRP loss by a significant margin. When all sources of disruption are modeled, SVR and FIR represent GRP losses of 36% and 26% respectively. Of the six sector groupings used in this study, SVR is the most numerous, containing 52% of the total business population (see Table 1), thus it is reasonable to assume that losses aggregated at the sector level would be high relative to other sectors with much smaller populations. FIR, while representing a minor share of the total business population (8%), accounts for approximately 30% of DNV’s normal GRP (see Table 2). From a production standpoint, disruption to even a relatively small number of FIR businesses will produce a significant economic impact.
4.4.4 Key Findings

This model investigated the impacts of simultaneous multi-source disruption (building damage, lifeline outage, and neighborhood effects) resulting from an M7.3 Georgia Strait earthquake event to the DNV business community. Of the disruption sources modeled, lifeline outage appears to be the most significant cause of business closure and subsequent economic loss.

The DNV model highlighted a number of vulnerabilities for consideration by both researchers and policymakers. From an industry perspective, the manufacturing and trade sectors demonstrated the highest levels of vulnerability (only 2% and 4% respectively of sector businesses are projected to remain open when all disruption sources are considered).

Spatially, businesses located in close proximity to the waterfront (specifically, the Marine Drive/Norgate and Lynnmour South areas) are the most susceptible to disruption. Several important transportation network links are also located in this area (port and rail infrastructure). In terms of lost economic production, the service and finance/insurance/real estate sectors collectively accounted for 71% of estimated loss when all disruption sources are considered, signifying a 62% GRP loss. Finally, it is also valuable to examine vulnerability from a jobs perspective. While the service sector is among the more resilient of the DNV industries, it represents by far the largest share of local employment (aggregated from Table 2). The high closure rates estimated in utility loss damage scenarios would represent many lost wage hours, a serious hardship for individuals and households dependent on those wages if disruption at those levels were to persist for a significant duration.

Figure 10. Production Loss by Sector in Each Damage Scenario as a Percent of GRP
As this section demonstrates, there are many different ways to analyze and interpret risk and vulnerability. How they are subsequently prioritized and addressed at the community level is a policy question. Some of the implications of these findings for policymakers are discussed later in Chapter 6.
Chapter 5: Risk Perception & Preparedness Behavior - North Shore Business Preparedness Survey

To better understand the North Shore business community’s attitudes regarding natural hazard risks, as well as their current level of preparedness activity, an online survey was conducted among municipally-licensed businesses. This survey was part of a larger project undertaken by the author—the North Shore Business and Employer Emergency Preparedness (BEEP) project—in partnership with the North Shore Emergency Management Office (NSEMO).

The goal of NSEMO’s BEEP project is to increase disaster and emergency preparedness levels among North Shore businesses by developing business preparedness resources, easy-to-use tools and community education and engagement activities (North Shore Emergency Management Office, 2014). 2013-2014 project actions serve as a foundation for NSEMO’s development of a comprehensive local business preparedness program in the future, and the North Shore Business Preparedness Survey was one of those project actions.

5.1 Survey Development

The North Shore Business Preparedness (NSBP) survey was designed to address both cognitive factors demonstrated to influence risk reduction behavior adoption (perceived magnitude of risk and risk consequences, knowledge of risk reduction options, self-efficacy) and business characteristics shown to correlate with preparedness and recovery levels (size, age, facility ownership, location pattern, customer base, sector, past disaster experience—see Corey & Deitch, 2011; Han & Nigg, 2011; Howe, 2011 for overviews of previous research on these topics). Survey content was also informed by several earlier business disaster preparedness surveys, including: Jackson County, Oregon’s Business Recovery Questionnaire (2006), National Federation of Independent Business’s (NFIB) National Small Business Poll (2004), and the DRC business surveys (an overview of the DRC surveys can be found in Webb, Tierney, & Dahlhamer, 2000).

The NSBP survey contained questions on the following topics:

- Business characteristics
- Disaster preparedness concerns and planning activities
- Disaster preparedness planning information and resources

Though earthquake hazards were highlighted in a small number of questions, the survey took an all-hazards approach to better support NSEMO all-hazard planning efforts.
• Engagement with existing communications resources

Business characteristics questions were intended to enable three main avenues of inquiry: how representative the survey respondent pool is of the broader North Shore business population, existence of any relationships between business characteristics and preparedness activities and concerns, and consistency with trends identified in similar topical surveys.

Respondents were then asked to describe their organization’s preparedness levels and current activities, as well as their concerns regarding certain hazard impacts and their feelings on the relative disruptiveness of those impacts. To provide a more comprehensive picture of preparedness, respondents were asked to both identify what they feel to be their current level of preparedness as well as the actual preparedness actions they have taken, an effort to overcome the challenge of skewed preparedness perceptions that sometimes results from questioning only how prepared respondents “feel” (Bird, 2009). Preparedness questions were designed to evaluate community preparedness levels, identify and prioritize preparedness gaps for NSEMO to address, and evaluate relationships between perceived disruptiveness and potential disruptiveness estimated by the DNV model.

Questions regarding resources were intended to identify what businesses perceive as barriers to adopting risk reduction measures (specifically, the development of an emergency preparedness plan), as well as resources that would help motivate them to act. Questions were also designed to gauge the value businesses place on scientific risk information and the role it plays in their decision making processes.

Finally, a series of questions were asked to identify businesses’ level of connectivity to existing municipal communication channels regarding emergency risks and preparedness.

Attentive to the approaching holiday season and the daily time constraints of business employees, the survey was intended to be completed in 15 minutes or less in an effort to maximize the number of willing participants. The survey was also designed to be anonymous, so questions regarding identifiable information were limited to only the most salient for research purposes. Survey questions can be found in Appendix B. The remainder of this chapter discusses survey results from the businesses characteristics, risk perception and risk resources sections.
5.2 Survey Distribution

The initial aim of the survey was to invite the entire business population\(^7\) of the North Shore to participate, with the assistance of municipal departments who retain contact information for these populations. As an incentive to participate, NSEMO offered respondents entry in a drawing to win a preparedness workshop for their organization.

Because NSEMO does not maintain a database of email contact information for local businesses (though some publically-available business email addresses were gathered for survey invitation purposes), several BEEP project partners were enlisted to distribute project information and survey invitations electronically to their constituents through existing outreach channels. Only one municipal licensing department (DNV) had the ability to mass email their licensed businesses directly, so other organizations were recruited to aid in the outreach to CNV and DWV through social media and online newsletters. Outreach was staggered across channels and over various time periods from September 2013-early December 2013; social media posts occurred on average 3-4 times for a three-week period per organization, newsletter articles sent twice over two months by each Chamber, and NSEMO and DNV each sent a single direct email. A summary of distributing organizations, methods, and approximate constituent audience numbers can be found in Appendix C.

Several known factors limited the survey response rate, including:

- Inability to ensure survey invitations reached the appropriate personnel at each business
- Limited effectiveness of social media in reaching business populations (most followers are individuals, many businesses do not use social media as an information-gathering service)
- Technical difficulties with email and newsletter distributions (i.e. survey link was broken in one WV Chamber newsletter and omitted in one NV Chamber newsletter; malfunction of DNV’s mass email tool caused the survey email to be sent 5-10 times at once to some businesses, discouraging them from participating)
- Lack of outreach to any businesses without contact emails on file with project partners (particularly in CNV and DNV where no direct email was sent from the municipal licensing departments), and with businesses who do not use email

\(^7\) For the purposes of this study, the entire business population of the North Shore is defined as all businesses physically located the City of North Vancouver, District of North Vancouver or District of West Vancouver possessing a valid municipal business license.
Approaching holiday season reduced the attention many businesses had to devote to nonessential activities like surveys.

5.3 Results

The NSBP survey received 51 valid responses from North Shore businesses (6 additional responses were excluded from the final count as participants completed only the business characteristics portion of the survey).

Table 6 compares survey sample characteristics with the broader population. Sample and population characteristics are moderately aligned, excepting DNV’s overrepresentation among the three municipalities (most likely a product of reaching DNV’s entire business license registry via email, which was not possible with the other two municipalities). As the small size of the sample limits the level of analysis that can be performed, results are analyzed at the aggregate North Shore level only. Though survey findings cannot be generalized to the larger population, they nonetheless provide interesting insights into the views and behaviors of a portion of North Shore businesses and can help to inform future research and decision making in this area.

Table 6. Comparison of Survey Sample and Population Characteristics by Municipality, Sector and Size

<table>
<thead>
<tr>
<th>By Municipality</th>
<th>RESPONSE COUNT</th>
<th>RESPONSE %</th>
<th>POPULATION %</th>
</tr>
</thead>
<tbody>
<tr>
<td>CNV</td>
<td>9</td>
<td>18%</td>
<td>30%</td>
</tr>
<tr>
<td>DNV</td>
<td>34</td>
<td>67%</td>
<td>42%</td>
</tr>
<tr>
<td>DWV</td>
<td>8</td>
<td>16%</td>
<td>28%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>By Sector*</th>
<th>RESPONSE COUNT</th>
<th>RESPONSE %</th>
<th>POPULATION %</th>
</tr>
</thead>
<tbody>
<tr>
<td>FIR</td>
<td>2</td>
<td>4%</td>
<td>18%</td>
</tr>
<tr>
<td>HTH</td>
<td>6</td>
<td>12%</td>
<td>7%</td>
</tr>
<tr>
<td>MCT</td>
<td>7</td>
<td>14%</td>
<td>13%</td>
</tr>
<tr>
<td>MFG</td>
<td>5</td>
<td>10%</td>
<td>3%</td>
</tr>
<tr>
<td>SVC</td>
<td>27</td>
<td>53%</td>
<td>44%</td>
</tr>
<tr>
<td>TRD</td>
<td>4</td>
<td>8%</td>
<td>16%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>By Size*</th>
<th>RESPONSE COUNT</th>
<th>RESPONSE %</th>
<th>POPULATION %</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-19</td>
<td>41</td>
<td>80%</td>
<td>89%</td>
</tr>
<tr>
<td>20-49</td>
<td>4</td>
<td>8%</td>
<td>7%</td>
</tr>
<tr>
<td>50-199</td>
<td>5</td>
<td>10%</td>
<td>3%</td>
</tr>
<tr>
<td>200+</td>
<td>1</td>
<td>2%</td>
<td>1%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Total (All Sections)</th>
<th>RESPONSE COUNT</th>
<th>RESPONSE %</th>
<th>POPULATION %</th>
</tr>
</thead>
<tbody>
<tr>
<td>CNV</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DNV</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DWV</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>FIR</td>
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<tr>
<td>HTH</td>
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<tr>
<td>MCT</td>
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<td>MFG</td>
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<tr>
<td>SVC</td>
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<tr>
<td>TRD</td>
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<td></td>
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<tr>
<td>0-19</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>20-49</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>50-199</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>200+</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* Aggregated responses from all North Shore municipalities

** Aggregated from CNV, DNV & DWV municipal business license registries

Establishment size data is not available at the North Shore municipal level; Vancouver Census Metropolitan Area is the closest comparable population; source: 2006 Census of Canada
5.3.1 Profiling the Average NSBP Survey Respondent

Table 7 provides a summary of the characteristics of participating businesses. An overview of risk perception-related information is provided in Table 8 and an overview of preparedness behavior in Table 9.

Based on this data, the average survey respondent can be characterized as a two-decade old service business in DNV that rents its facility, has a main customer base local to the North Shore, and has no recent experience with business disruption. This business’s greatest disaster-related concerns are power loss, telecomm loss and building damage. It does not have a written disaster preparedness plan because it lacks the knowledge to create one, nor does it participate in any regular preparedness drills, and feels somewhat ambivalent about its overall preparedness level. This business does believe, however, that if forced to close by a disaster it could survive at least a week before experiencing serious financial loss. Risk assessment information is moderately important to its preparedness decision making process, and it expresses some

<table>
<thead>
<tr>
<th>Table 7. Overview of Respondents’ Business Characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Location:</strong> DNV - 67% · CNV - 18% · DWV - 16% n=51</td>
</tr>
<tr>
<td><strong>Business Model:</strong> 98% Independent · 2% Franchise n=51</td>
</tr>
<tr>
<td><strong>Mean Age:</strong> Range: 23.5 years 6 months – 120 years n=51</td>
</tr>
<tr>
<td><strong>Main Customer Base:</strong> North Shore - 48% Metro Vancouver - 34% Beyond Metro Vancouver - 17% n=29</td>
</tr>
<tr>
<td><strong>Sector:</strong> SVC - 53% · MCT - 14% · HTH - 12% MFG - 10% · TRD - 8% · FIR - 4% n=51</td>
</tr>
<tr>
<td><strong>Facility:</strong> Rent - 62% · Own - 38% n=51</td>
</tr>
<tr>
<td><strong>Experienced Past Disruption:</strong> No - 86% · Yes - 14% n=49</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Table 8. Overview of Respondents’ Risk Perceptions</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Greatest Business Disruption Concerns</strong>*:** Losing power - 67% Losing telecomm - 63% Building damage - 59% Trans. network disrupted - 51% Employees unable to come to work - 51% n=49</td>
</tr>
<tr>
<td><strong>Serious Financial Loss if Closed for:</strong> &gt;Week - 45% · 4-7 Days - 20% Unsure -16% · 2-3 Days - 8% 1 Day - 8% · &lt;1 Day - 2% n=49</td>
</tr>
<tr>
<td>** (%) Chance of Earthquake in Next 50 Years:** (80-100%) - 29% · (20-40%) - 23% (0-20%) -19% · (60-80%) - 17% (40-60%) - 12% n=48</td>
</tr>
<tr>
<td><strong>Role of Risk Assessment Info in Planning</strong>:** Somewhat important - 40% Very important - 29% Not important - 18% n=45</td>
</tr>
<tr>
<td><strong>Would Change Plans Based on New Risk Info</strong>:** Somewhat likely - 59% Very likely - 17% Not likely - 11% n=46</td>
</tr>
</tbody>
</table>

*Could select several, top five listed
**Unsure/No Plans - 13%

<table>
<thead>
<tr>
<th>Table 9. Overview of Respondents’ Preparedness Behavior</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Feel Business Is:</strong> Unprepared (very/somewhat ) - 52% Prepared (very/somewhat ) - 48% n=50</td>
</tr>
<tr>
<td><strong>Emergency Plan:</strong> Have plan - 25% · No plan - 75% n=51</td>
</tr>
<tr>
<td><strong>Reason for No Plan:</strong> Lack of knowledge - 49% Not a priority - 25% Lack of resources - 24% n=36</td>
</tr>
<tr>
<td><strong>Priority of Preparedness Planning:</strong> Very high/high - 52% Medium -34% Low/very low -18% n=11</td>
</tr>
<tr>
<td><strong>Fire Drill Frequency:</strong> Never - 56% · 2+/year - 21% 1/year - 17% · 1/few years - 6% n=48</td>
</tr>
<tr>
<td><strong>Earthquake Drill Participation:</strong> No - 78% · Yes - 22% n=49</td>
</tr>
</tbody>
</table>
degree of willingness to consider adjusting its plans if confronted with new risk information that differs significantly from its current understanding of risks.

Though this ‘average’ business is only theoretical (and not generalizable to the whole North Shore business population), creating a descriptive profile such as this can still be a useful working construct for risk managers and policymakers when developing community preparedness and risk communications strategies, especially in the absence of better available information. The working profile can illustrate potential challenges from a community preparedness perspective that may merit further examination on the part of community risk managers, such as the low adoption of preparedness behaviors but high confidence of financial resilience in the event of extended business disruption, or perceived low self-efficacy regarding the ability to successfully develop a preparedness plan (lack of knowledge).

5.3.2 Exploring Risk Perceptions

A more detailed look at survey risk perception data helps to answer the second and third research questions posed in this study:

(2) How do DNV businesses perceive the likelihood and significance of earthquake-related risks to their operations?

(3) What level of interest do DNV businesses express in accessing scientific risk assessment information, and how significant a role does this information play in their risk-related decision making processes?

From the standpoint of earthquake occurrence likelihood, survey participants demonstrated little consistency in their responses. Responses ranged across all probability categories, though a slight plurality indicated that they believe there is an 80-100% chance of damaging earthquake occurring in the next 50 years. This is somewhat surprising given the prevalence of the 30% figure (as estimated by NRCan, 2010) in local earthquake risk dialogue. It may be true that though this figure is commonly used, it does not resonate strongly with public consciousness. A recent survey of 1000 southwest British Columbia residents by the British Columbia Automobile Association (BCAA) indicated that just over half were aware of the 30% likelihood of a significant earthquake in the next 50 years; NSBP survey findings therefore may be reflective of wider uncertainty or lack of awareness in the region surrounding earthquake likelihood (British Columbia Automobile Association, 2013).
When examining what disaster-related disruptions sources are of greatest concern to North Shore businesses, NSBP survey respondents identified losing power service, losing telecommunications service, building damage, damage to the transportation network and employees unable to come to work as their top five. In terms of relative disruptiveness, businesses were asked to rate the four disruption sources modeled in the DNV model using the same scale (summarized in Table 10). Consistent with early rankings of greatest disruption sources, power loss and building damage were perceived to be more disruptive than the impacts of either water service loss or neighborhood effects.

As NSBP survey participants expressed mixed opinions regarding earthquake probability, they also variously rated the importance of risk assessment information (like earthquake probability) in their preparedness planning process: 29% (n=13) said it plays a very important role, 40% (n=18) somewhat important, and 18% (n=8) not at all important. If faced with risk assessment information indicating a hazard was twice as likely to occur in the area as they had previously thought, the majority (59%, n=27) indicated they would be somewhat likely to make changes to their preparedness plans as a result, 17% (n=8) would be very likely to make changes, and 11% (n=5) were not likely to make any changes at all.\(^8\) Though mixed in their responses regarding the importance and motivating quality of risk assessment information, respondents expressed somewhat higher levels of interest in obtaining more information on local risks. 48% (n=20) felt it would be very valuable in supporting their planning efforts, second only to information on government assistance programs (51%, n=22) among the several types of resources described in terms of perceived value.

### 5.3.3 Associating Attributes with Behavior

The overall lack of a written preparedness plan among North Shore businesses in the survey—only 25% (n=13) reported having one—is moderately consistent with recent surveys by various research and industry organizations, including:

- 2004 NFIB Small Business Poll - 38% of surveyed businesses had an emergency preparedness plan

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\(^8\) In both questions 13% (n=6) were unsure or lacked any preparedness plans.

<table>
<thead>
<tr>
<th>Disruption Source</th>
<th>Disruptiveness Level*</th>
<th>VD</th>
<th>D</th>
<th>NV</th>
<th>NAA</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>Building Damage (Severe)</td>
<td></td>
<td>46%</td>
<td>38%</td>
<td>15%</td>
<td>2%</td>
<td>N=48</td>
</tr>
<tr>
<td>Electric Power Loss</td>
<td></td>
<td>60%</td>
<td>23%</td>
<td>17%</td>
<td>0%</td>
<td>N=47</td>
</tr>
<tr>
<td>Water Service Loss</td>
<td></td>
<td>28%</td>
<td>30%</td>
<td>38%</td>
<td>4%</td>
<td>N=47</td>
</tr>
<tr>
<td>Neighborhood Effects</td>
<td></td>
<td>10%</td>
<td>23%</td>
<td>57%</td>
<td>10%</td>
<td>N=30</td>
</tr>
</tbody>
</table>

*VD - very disruptive; D - disruptive; NV - not very disruptive; NAA - not at all disruptive
• 2006 Jackson County Business Disaster Survey - 36% of surveyed businesses had an emergency response plan; 17% of businesses had an emergency recovery plan

• 2007 Office Depot Disaster Preparedness Survey\(^9\) - 29% of surveyed small businesses had a disaster plan

• 2011 study of New Orleans business recovery – 43% of small businesses had an emergency plan (Corey & Deitch, 2011)

Though the small sample size limits the level of analysis that can be performed, comparisons of survey answer frequency do indicate potential associations of some business characteristics and risk perceptions with having a written preparedness plan among respondents, which helps to address the fourth question posed by this study:

(4) What relationships, if any, exist between businesses’ risk perceptions and preparedness activities undertaken?

Table 11 provides an overview of selected business characteristics and risk perception attributes with the corresponding percentages of respondents who stated they had a written preparedness plan.

\(^9\) The "Disaster Preparedness" survey, conducted by TNS NFO for Office Depot, was designed to better understand the attitudes and perceptions that inhibit small business from investing in business continuity planning. The poll of 2,500 people (representative of the U.S. household population 18+ on age, gender, geographic division, income, household size; household designation and market size) was conducted February 13-16, 2007. In order to qualify for this study, respondents must have stated that they were either a business owner or a decision maker (e.g. Executive/Senior Management).
Establishment size appears to be most strongly associated with having a written preparedness plan among NSBP survey respondents, as only 15% (n=6) of businesses with fewer than 20 employees reported having an emergency plan, whereas 70% (n=7) of businesses with 20 more employees indicated they had one. This is consistent with other studies that found business size to be among the strongest predictors of preparedness behavior adoption (e.g. Dahlhamer & D’Souza, 1997; Webb, Tierney & Dahlhamer, 2000).

Age also appears to have some correlation with preparedness plan adoption among respondents; those in business less than 10 years were somewhat more likely to have a plan than those in business 10 years or more.

Consistent with the discussion of risk perception influences on behavior in Chapter 2, survey respondents who expressed a greater belief in earthquake likelihood were also more likely to have a preparedness plan.

There may also be some association between having a preparedness plan and the importance respondents attribute to the role of risk assessment information in their preparedness plan, as well as the likelihood that they would make adjustments in their plans if presented with new information indicating much higher risk. The more importance is attributed to risk information, the more likely respondents are to have a preparedness plan.

Finally, there appears to be a fairly strong association between having a preparedness plan in place and general belief of organization preparedness among survey respondents.

### 5.3.4 Key Findings

While the sample size for the NSBP survey is small and not generalizable to the wider North Shore, it does provide a useful window into the mindsets and actions of a portion of local businesses. Overall, participating businesses reported being generally unprepared for a disaster. Among respondents, larger, younger businesses that are more receptive to risk assessment information and have a higher perception of earthquake risk were more likely to adopt a preparedness plan. Lack of knowledge was identified as the greatest barrier to preparedness plan adoption for those who had not done so. In terms of risk perceptions and concerns, businesses have very mixed views on the likelihood of an earthquake event in the region and would find the loss of power, telecomm services and building damage to be the most disruptive disaster consequences. The implications of NSBP survey findings for public risk management efforts are discussed in the next chapter.
Chapter 6: Risk Management - Implications for Public Decision Making

One of the challenges facing local decision makers with regard to risk management policy development is a “lack of available time to thoroughly analyze and evaluate long-term planning options due to the large number of daily decisions that require immediate action;” providing decision tools to aid in this analysis is critical to supporting the ability of local governments to make effective risk management decisions (Kunreuther & Miller, 1985). One of the goals of this research is to develop a clearer picture of the local business risk, vulnerability and preparedness landscape to better support North Shore public decision making processes around community risk management and communication strategies.

Some researchers posit vulnerability as a function of hazard exposure, access (to information, services, etc.), and resources (financial, human, etc.) (Wisner, 1998), which is a useful conceptualization for investigating this study’s findings. The DNV model estimates sector and spatial patterns of exposure to earthquake-related disruptions, and the NSBP survey provides greater insights into the ways that access and resources influence risk perceptions and preparedness behaviors, all of which contribute to exacerbating or reducing business vulnerability to earthquakes.

This chapter examines the implications for decision makers of model and survey findings on business risk and vulnerability and provides recommendations for risk management and communication based on these findings.

6.1 Considering Risk Analysis, Perception and Behavior

Literature has established that risk analysis information, risk perception, and risk reduction behaviors are linked, though the precise nature of these relationships is a subject of continued investigation. This study seeks to examine these relationships in the DNV context in part through the posing of its fifth research question:

(5) How does the potential risk of disruption modeled by the economic loss study compare with the perceptions of risk and disruptiveness by DNV businesses?

Modeled & Perceived Disruptiveness

Returning to the ranking of disaster-related concerns in the NSBP survey, respondents identified loss of electric power as their greatest concern (67%, n=33) among all potential options. Building damage (59%, n=29) and water service loss (45%, n=22) were considered somewhat lesser concerns. These views were
consistent when respondents were asked to rate the relative disruptiveness of the four sources addressed in the DNV model, as the largest percentage indicated that power loss would be very disruptive (58%, n=28), followed by building damage (45%, n=22), water loss (27%, n=13), and neighborhood effects (6%, n=3). While no scenarios were modeled that considered individual lifeline impacts separately, the belief that utility loss is more disruptive to businesses than either building damage or neighborhood damage is consistent with model estimates.

When looking specifically at the disruptiveness of power and water loss, as illustrated in Table 12, there is striking similarity between the way that respondents rated the disruptiveness of power loss and the distribution used in the model. The breakdown for water outage disruptiveness does not have quite the same degree of similarity; NSBP respondents view the loss of water service as slightly less disruptive than estimated by model parameters. This would suggest that current perceptions of survey respondents regarding the risk of disruption to their businesses from these various sources are moderately aligned with model findings, even though survey respondents have never been presented with model data.

**Economic Loss & Financial Resilience Beliefs**

While perceptions of individual source disruptiveness expressed by NSBP survey respondents and estimates by the model seem generally aligned, there appears to be some potential incongruity between the estimated magnitude of financial loss and respondents’ beliefs of financial resilience when considering closures resulting from simultaneous disruption.

The DNV model produced hypothetical lower and upper bound loss estimates when considering building damage, lifeline outage and neighborhood effects impacts. A more realistic scenario would fall somewhere between these two, meaning that an M7.3 Georgia Strait earthquake event might produce business disruption-related losses of somewhere between 33% and 88% of DNV daily GRP on the first

<table>
<thead>
<tr>
<th>Disruption Source</th>
<th>Disruptiveness Level</th>
<th>(N)</th>
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<tbody>
<tr>
<td></td>
<td>VD</td>
<td>D</td>
</tr>
<tr>
<td><strong>Electric Power Loss</strong></td>
<td>Model</td>
<td>53%</td>
</tr>
<tr>
<td></td>
<td>Survey</td>
<td>60%</td>
</tr>
<tr>
<td><strong>Water Service Loss</strong></td>
<td>Model</td>
<td>42%</td>
</tr>
<tr>
<td></td>
<td>Survey</td>
<td>28%</td>
</tr>
</tbody>
</table>

*VD= very disruptive, D=disruptive, NV=not very disruptive, NAA=not at all disruptive

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10 These distributions were based on empirical disruptiveness data from businesses following the Northridge and Loma Prieta earthquakes (see Chang et al., 2008).
11 The model does not contain disruptiveness probability distributions for building damage or neighborhood damage, so no comparisons can be made with survey responses.
day. 45% (n=22) of respondents indicated that they believed their business could weather a closure of one week or more before suffering a serious financial impact. Even lower bound losses (an unrealistic scenario which considers utilities to be completely functional following the earthquake) over the course of a week would seem to represent a not insignificant level of loss, especially from a small business perspective.

Many small businesses fund their operations from weekly cash flow, thus the survival rate among such businesses forced to close for any significant length of time from a disaster is quite low; moreover, these businesses are frequently the primary source of household income for owners and closure can have devastating impacts on families (Runyan, 2006). These familial impacts can be compounded if owners access personal savings for business recovery funding (Alesch et al., 2001). Given the dual impacts of such business disruption, the relative confidence of survey respondents regarding their ability to absorb closures of a week or more without serious financial loss might merit additional investigation on the part of local risk managers. Does this confidence come from excellent insurance coverage (unlikely, given survey responses regarding the desire for more insurance information), assumptions of government responsibility for providing financial assistance (possibly, given the level of interest expressed in government assistance information), significant financial savings that can carry the business through a lean period, or some other source? Uncovering answers to this question can provide important information to local risk managers on how to develop more targeted risk education strategies.

**Risk Perception, Role of Information and Preparedness Behavior**

Empirical evidence suggests there is a positive relationship between decision makers’ perceptions of risk and level of business disaster preparedness activity (Han & Nigg, 2011). This is generally borne out among survey respondents, as those who indicated a belief in a higher probability of earthquake occurrence were more likely to have a written disaster preparedness plan in place. Preparedness behavior among respondents also appears to have some association with their receptiveness to risk assessment information (i.e. the importance of the role it plays in their decision making processes and how likely they are to change plans based on new risk information).

Respondents also indicated they generally viewed risk assessment information as a valuable resource to support their preparedness planning efforts (84%, n=35, indicated they would find it somewhat or very valuable). Given the relatively low level of preparedness behaviors undertaken by survey respondents, and the identification of lack of knowledge as the greatest barrier to preparedness plan adoption, the valuing of and desire for more information regarding local risks would seem to indicate an opportunity
for local risk managers to both improve community knowledge around hazard risks and spur individual action to better prepare for them.

6.2 Implications for Public Risk Management and Decision Making

The final question posed in this research study is:

(6) What implications might findings on risk assessment, risk perception, and preparedness activity have for municipal-level risk management decisions?

Businesses operate within a larger economic system, so even though a single business may be well-prepared to handle a disaster at its own facility, disruptions to its broader business network can cause significant negative impacts to its operations; thus it is important to approach preparedness from both the community and individual scales (Lindell & Prater, 2003). With a systems perspective in mind, this section looks at the implications of research findings for both community-level risk management decisions and efforts to promote preparedness behavior at the individual business level.

6.2.1 Community-Level Risk Management

Knowledge of the community’s economic base, both type and spatial distribution, and identification of vulnerabilities within that base, is a critical precursor to local governments developing effective preparedness and recovery plans (Lindell & Prater, 2003). This study contributes to this body of knowledge in the North Vancouver context, characterizing a number of vulnerabilities from spatial, business sector, economic production and employment perspectives. Prioritizing these vulnerabilities is a policy decision for community leaders, and can subsequently help inform several planning and development decision making processes.

Infrastructure & Land Use Planning

Spatial vulnerability patterns, especially identification of high liquefaction risk areas near the waterfront, can serve as inputs into future land use decisions. If estimated risks exceed levels deemed acceptable by the community, then local leaders may wish to consider changing the type and intensity of use in these areas through zoning code adjustments and other future development decisions. Vulnerability data can also help to inform decisions on local infrastructure maintenance and improvement strategies; for example, knowing which areas are likely to suffer the greatest business disruption and subsequent economic loss as a result of lifeline outages could help prioritize infrastructure upgrades in those areas.
Response & Recovery Planning

Knowledge of where building damage and lifeline outages are most likely to occur can also help guide the development of response and recovery strategies. For example, if critical facilities—like healthcare—are especially susceptible to disruption from utility loss, then identifying those vulnerable facilities in advance can aid in ensuring service is restored to priority areas first. Estimating areas of greatest potential building damage can also guide response planning, sending safety personnel first to those areas where damage and injury may be greatest. Loss estimation model data can also be used to inform restoration strategies in order to decrease economic losses; for example, a study by Rose and Benavides found that economic losses following a New Madrid Earthquake could be substantially reduced if electricity restoration was prioritized based on the GRP contributions of affected sectors (Rose & Benavides, 1999).

Strategic Vulnerability Targeting

Model and survey data can also aid decision makers in determining where to best direct business risk education and preparedness planning support. Given limited municipal budgets, risk managers want to target efforts to where they will be the most effective. As previously discussed, there are several vulnerability attributes for local leadership to consider when developing risk management strategies. When conceptualizing vulnerability as a product of exposure, access and resources, deliberately seeking to increase the accessibility of pertinent information to vulnerable businesses is one way to work towards risk reduction.

From a business characteristics standpoint, past disaster events have demonstrated that small businesses—which are the vast majority of businesses on the North Shore—are typically more vulnerable to the impacts of disasters, and have fewer preparedness and recovery resources at their disposal, than their larger counterparts. This is often compounded by the fact that many small business owners also suffer personal losses in a disaster and must juggle recovery challenges in both spheres (Alesch & Holly, 1998; Howe, 2011; Kroll et al., 1991; Runyan, 2006; Webb et al., 2000; Zhang et al., 2009; ). Study results indicated that this trend of small business unpreparedness is true in the context of NSBP survey respondents, providing further evidence that local risk managers may want to consider efforts to bolster preparedness among North Shore small businesses.

From an industry perspective, the DNV model indicated that the manufacturing and trade sectors are the most vulnerable to closure as a result of earthquake-related disruptions. In the case of trade, this is consistent with findings from several studies (Chang, 2010; Chang & Falit-Baiamonte, 2011; Kroll et al.,
In terms of GRP, service and finance/insurance/real estate sectors represent the majority of estimated loss. The service sector possesses the greatest loss potential from an employment perspective. These are other areas of vulnerability for risk managers to consider when determining direction for preparedness support efforts.

6.2.2 Promoting Preparedness at the Individual Business Level

Conventional wisdom would indicate that preparedness and mitigation planning would have a positive impact on businesses’ capacity to reduce potential losses and overcome disruption. Some studies support this assumption (Flynn, 2007; Alesch & Holly, 1998) while others do not find a significant association between preparedness and business disaster recovery (Alesch et. al, 2001; Chang & Falitu-Biamonte, 2011; Corey & Deitch, 2011). These latter studies theorize one likely reason for such findings is a predominant focus by businesses on measures to protect life safety, with insufficient attention paid to business continuity measures designed to address reasons for subsequent economic loss like lifeline outage, supply chain disruption and changing customer activity.

Preparing for high risk, low probability events like disasters is a challenging task for businesses for a number of reasons, including: present issues frequently winning decision-makers’ attention over long-term concerns (Levinthal & March, 1993), the cost-benefit ambiguity of investing present resources in anticipation of a future event that may never occur (March, 1981), and the difficulty in demonstrating a return on investment for preparedness activities (Tamuz & Lewis, 2008).

Taking these findings into account, promoting preparedness behaviors that consider both life safety (the more traditional approach) and business continuity (the need highlighted by this study and others mentioned) seems like a prudent course of action for local governments. To do so effectively, public agencies need to make a strong enough case for preparedness action to overcome the inertia that the obstacles mentioned above can create for businesses. If local decision makers have already selected target audiences for risk education and preparedness support efforts (as discussed in the preceding section), then the question becomes what and how to communicate in order to successfully foster increased (and effective) business preparedness behavior. This section provides recommendations on messaging structure, format and content based on results of the DNV model and NSBP survey as well as other relevant studies.
Risk Communication - Structure & Format

A summary of risk literature indicates that changes in public opinions about risk and the spurring of risk reduction activity are achieved when risk communication meets the following conditions: “provides guidance about what to do, is distributed over multiple communication channels, is consistent and received over multiple messages, and is confirmed by cues such as seeing others getting ready” (Mileti & Darlington, 1997, p. 4). Essentially, the more explicit and regularly reinforced risk messages are, the more likely they are to prompt action among local residents. Building on local partnerships—such as those NSEMO has already developed with local police and fire departments, Chambers of Commerce, and commercial centers through the BEEP project—to coordinate messaging is one way to help increase the exposure of local businesses to risk communications.

Considering the sources of messaging raises another risk communication concept discussed earlier, that of trust. An understanding of which sources the public values, respects and strongly believes aids decision makers in selecting effective channels through which to convey risk information to (and gather information from) the public (Earle, 2010). According to a recent U.S. nationwide study undertaken by Wood et al., the single strongest predictor of preparedness actions is the observation of preparedness actions taken by others (2012). This suggests that the most influential form of communication may come from peers. Recruiting local business leaders to share their preparedness strategies and advice may be an effective method for both educating the broader business community and motivating them to act. 72% (n=31) of NSBP survey respondents indicated that they would find community discussions on actions other local businesses are taking to be prepared very or somewhat valuable, indicating a degree of local interest in a peer-based approach.

Beyond a workshop or roundtable-style community discussion, other risk communication formats have also been shown to be effective. A review of public information strategies regarding earthquake risk by Mileti et al. found that a comprehensive brochure from the state government had the greatest impact on the public’s risk perception and understanding in California (1992). They emphasize the importance of first priming the public through coordination with media and other local organizations so they [public] are sufficiently interested and motivated to keep the brochure to maximize its effectiveness. A recent study of business hurricane preparedness behavior in Florida concluded that developing interactive, participatory online tools to communicate risk information and preparedness recommendations would be an effective motivator to business action (Howe, 2011). Both these types of formats are being
discussed as future outputs in the NSEMO BEEP project; the risk and audience analysis data gathered in this project could help to inform the development of these communications.

Finally, when considering the structure of risk communications in the North Shore, the importance of two-way communication should be re-emphasized. One of the keys to developing widely-supported decisions regarding risk management is to engage in a responsive dialogue with the public (Slovic & Gregory, 1999). As mentioned in Chapter 2, knowing the audience is critical to effective messaging, and dialogic communication helps to develop that knowledge. It also supports a more participatory approach to community risk management, giving the public a greater sense of investment and ownership of risk management decisions as well as providing more clarity and transparency to the process.

**Risk Communication - Messaging Themes**

Understanding how to communicate effectively is only half of the process; establishing what optimally should be communicated is necessary to successfully promoting behavioral change among North Shore businesses.

Though findings in risk perception and protective behavior literature are mixed, there is enough evidence of a link between higher risk perceptions and increased adoption of protective behaviors to make a case for focusing some North Shore risk communication efforts on discussing the salience of earthquake (and other hazard) risks to local businesses. That the NSBP survey also demonstrated a high degree of variance in earthquake probability beliefs as well as some association between risk perception levels and preparedness action among respondents provides additional support for this recommendation.

Research indicates that to more effectively motivate businesses to take preparedness steps, received risk information must also be actionable—contain clear, feasible measures they can select from to implement (Wood, et al., 2012). This is reinforced by findings from Miliotis and Darlington in their review of earthquake preparedness activity in the San Francisco Bay area, who note that the receipt of specific information is a significant predictor of preparedness actions (1997). As NSBP respondents identified lack of knowledge on how to develop one as the greatest barrier to preparedness plan adoption, developing a set of clear instructions on how to create a preparedness plan would likely be a fruitful effort for North Shore risk managers. This activity is already underway as part of the BEEP project.
In addition to feasibility, attitudinal research indicates that mitigation measures must be very cost effective in order to entice stakeholders into voluntarily adopting them (Kleindorfer & Kunreuther, 2000). Simple, low cost multi-hazard protection activities are preferred over those that are more complicated and expensive (Webb et al., 2000). This speaks to the self-efficacy issues mentioned earlier—businesses are much more likely to take preparedness steps when they are convinced they can carry them out successfully (which includes having the requisite financial resources to do so).

Russell et al., in a longitudinal study of California earthquake preparedness, highlight the importance of public risk managers clearly articulating preparedness action priorities for the community, noting that in the absence of explicit priorities, individuals will select the easiest preparedness measures to implement (Russell, Goltz, & Bourque, 1995). This indicates that not only should North Shore risk managers provide clear instruction emphasizing the feasibility and cost-effectiveness of preparedness options, they should also explicitly note which are the most important for businesses to take and why.

Life safety is traditionally emphasized in business preparedness planning, and rightfully so as ensuring employee and customer safety is always the first priority in an emergency. However, this type of preparedness is insufficient to protect businesses’ operational capabilities, as noted earlier. To address this challenge, North Shore risk managers should also focus on communicating business continuity-oriented preparedness information. In particular, preparedness measures that address lifeline outage should be highlighted, as both previous studies and findings from the DNV model demonstrate that they are a significant source of disruption and loss for businesses. A variety of potential preparedness measures can be communicated—from the simple, such as identifying in advance dry ice or emergency water suppliers, to the more resource-intensive, like installing a back-up generator or additional water storage tanks—for businesses to consider and select the most appropriate to their situation.

In addition to preparedness measures that focus on the physical aspects of disruption to a business, risk communication should also address the financial resource component of vulnerability. In British Columbia only one government program exists to make recovery funding available to affected businesses following declared disasters, and program requirements narrow the pool of eligible businesses considerably. In order to apply to the BC Disaster Financial Assistance program, businesses must, among other requirements, have fewer than 50 employees, less than $1 million in annual sales, be the major source of income for all owners, and demonstrate that without assistance the business’s future could be in jeopardy (Emergency Management British Columbia, 2012). Survey results indicate the high level of interest among North Shore businesses in government funding sources, highlighting the
importance of sufficient public education around government assistance funding so that businesses are aware of the limitations and eligibility requirements and can make appropriate financial contingency plans.

Another important aspect of post-disaster financial resources is insurance coverage. A survey of small businesses following the 1994 Northridge Earthquake indicated confusion surrounding insurance coverage was a significant barrier to recovery, with many owners assuming they had much greater coverage than they had in actuality (Alesch & Holly, 1998). Given the contrast between the relatively high percentage of NSPB respondents who believe they can weather closures of a week or more without serious financial loss and very low percentage (7%, n=3) of respondents who indicated they already had enough information regarding relevant insurance coverage options, it would be beneficial for North Shore risk managers to incorporate insurance-related education into the risk communication program.
Chapter 7: Future Research Considerations & Conclusion

The Organization for Economic Cooperation and Development’s Global Science Forum recently conducted an extensive review of global natural hazard risk modeling practices and concluded that risk analyses should be embedded within larger risk management frameworks; clear and deliberate linkages should be drawn between the risk analysis process and the community risk policy questions under discussion (2012). This research set out to make these connections between research, policy and practice in the context of business earthquake vulnerability in the District of North Vancouver.

7.1 Summary of Findings

Using a loss model that considers simultaneous disruptions to DNV businesses in the form of building damage, lifeline outages and neighborhood damage following an M7.3 Georgia Strait earthquake event, this study estimates that the community could experience potential GRP losses of between 33% and 88% on the first day following the disaster (depending of the magnitude of lifeline outage and neighborhood effects). Lifeline outage is demonstrated to be a more significant source of business disruption than building damage. The model also highlights areas of particular vulnerability from sector, spatial, economic and employment perspectives.

This research also investigates the risk perception and preparedness behavior landscape of the North Shore business community through an online survey. Survey findings suggest moderate alignment of model estimates and respondent perceptions of the relative disruptiveness of the individual sources mentioned above, but a wider degree of disparity between the two when considering the economic impacts of business closure resulting in simultaneous disruption. The survey also indicates a generally poor level of disaster preparedness among respondents. However, respondents demonstrate some receptiveness to risk assessment information, and there are indications that better education of the business community on relevant preparedness measures would lead to increased adoption of preparedness behaviors.

Taking model and survey results into account, as well as other relevant risk research, this study also makes several recommendations on how findings can inform both community-level risk management decision making and risk communication strategies designed to promote individual business-level preparedness. In particular, this study suggests the use of findings to target the most vulnerable business populations for risk management and preparedness support efforts, especially small
businesses. These findings can be integrated into a larger Business and Employer Emergency Preparedness (BEEP) project currently underway on the North Shore.

One of the primary aims of this research is to support the development of effective public risk reduction strategies, sharing the view that loss estimation should not be conceived as a “passive pursuit, but one with the major objective of actively reducing negative impacts either through mitigation or post-disaster private decisions and public policies” (Rose, 2004b, p. 31). Ultimately, study findings highlight both hazard risks and opportunities for reducing them within the North Shore business community.

In addition to providing relevant analysis to support risk management policy and practice on the North Shore, this study contributes to the wider body of knowledge on natural hazard risks by taking a more comprehensive approach to examining factors affecting business disaster vulnerability. Specifically, this study highlights the contribution of lifeline outages to business disruption and subsequent economic loss, as well as the association of various risk perception attributes with business preparedness behavior.

### 7.2 Future Research Opportunities

The other primary goal of this study is to support future research into hazard risk and reduction opportunities on the North Shore. Findings and limitations of the current study suggest a number of areas for future inquiry that would make valuable contributions to both the body of natural hazard risk research and the practice of managing risks on the North Shore. Two broader future research opportunities are discussed below, as well as suggested refinements for both the model and survey.

**Data Improvements**

One of the most significant constraints of both the model and survey stems from data limitations.

*Model* - Because individual establishment size counts and economic production levels were not available, these were inferred based on provincial-level census data and distributed evenly across all DNV businesses in the model. More accurate data in this regard would produce a stronger model which better captures the impact of spatial damage patterns to the local economy. Additionally, lifeline outage data was not yet available at the time of this study so two extreme scenarios were used—power and water service as completely functional or no utility service at all. A more realistic scenario would fall somewhere between the two. Incorporation of estimated lifeline outage and restoration data would
enable both better spatial estimates of loss, as well as temporal loss estimates accounting for the change in service levels over time.

_Survey_ - The small sample size limited both the level of analysis that could be performed as well as its generalizability to the larger North Shore business population. A larger, representative sample would provide for richer analysis with broader applicability. A more detailed characterization of respondents would also improve vulnerability analyses, such as identifying if respondents are located in high liquefaction risk zones, are home-based/sole proprietorships, and the structural type of building in which they reside.

_Resilience_
A second area where both model and survey have opportunity for deeper investigation is the consideration of actions that contribute to greater business resilience.

_Model_ - One of the values of a loss model such as the one used in this study is the ability to estimate the potential return on investment of various loss reduction measures. Incorporating scenarios that consider mitigation measures and other resilience activities such as preparedness and business continuity planning into model simulations could aid policy makers in identifying those actions that hold the greatest potential value for the community.

_Survey_ - Inclusion of a section on business-level mitigation measures, both those already undertaken and additional measures businesses would consider taking, would allow policy makers to better estimate both the current level of mitigation in the community and those measures businesses would be most likely to adopt in the future. In addition, a better understanding of what resources businesses perceive to be available to support their recovery (e.g. insurance, government assistance, financial savings, etc.) would provide greater insights into why a significant percentage of NSBP survey respondents believe they have the financial resilience to absorb losses from a closure of a week or longer.

7.2.1 Additional DNV Model Refinements

_Regional Impacts_
Currently the model considers economic impacts to DNV in isolation; in reality, damage, disruption and resource flow patterns in neighboring municipalities and the larger Metro Vancouver region will affect DNV response and recover capabilities. Incorporating methods for estimating regional impacts will create more realistic scenarios from which to estimate potential local business loss.
**Neighborhood Effects**

In the current model, simple judgment-based criteria were used to define neighborhoods and a neighborhood effect threshold. Further research into more appropriate local neighborhood definitions and neighborhood effect thresholds may produce new insights on potential disruption and loss patterns.

**Variations in Economic Production**

A number of known variables have either been excluded or simplified in the current model. One of these is economic production level, which the model considers to be either at normal level (“open” status) or at zero (“closed” status). Future refinements should consider how factors such as changing customer demand, transportation network impacts, supply chain disruptions and other interdependencies would lead to a range of new production levels—from zero to exceeding the previous “normal.”

**Telecommunications Service**

Past research has demonstrated the negative consequences of telecommunications loss to both businesses and the wider community following a disaster (for an overview, see Townsend & Moss, 2005), and this is echoed in the NSBP survey by identifying telecomm loss as one of respondents’ greatest disruption concerns. Little to no research has been done, however, to examine telecomm outage relative to other sources of business disruption in terms of contributing to business closure and economic loss. Future investigation into ways telecomm-related disruption might be considered in the model would help to address this gap in the literature.

**Transportation Network**

NSBP survey respondents identified transportation network disruption as one of their chief concerns. Past studies have demonstrated that damage to transportation networks can have significant impacts on supply chain operations, customer traffic and employee commutes, all of which can influence business production levels. Incorporating transportation network damage into the model will produce stronger estimates of business disruption.

**7.2.2 Additional NSBP Survey Refinements**

**Decision Stages**

Research on risk-based decision processes points out that different types of information are more influential to decision makers at different stages in the process. Better characterization of decision stages in the survey (e.g. “have not done,” “considering,” “plan to do,” “have done”), would enable analysis of how different information behaviors are associated with these stages in the North Shore context.
Longitudinal Benchmarking

Longitudinal community surveys can demonstrate the change in hazard awareness and preparedness activity over time (King, 2002). Running a refined version of the NSBP survey at regular intervals would enable risk managers and policy makers to investigate changes in behavior and risk perceptions over time, as well as to explore the potential impact of risk education and communication campaigns.

7.3 Conclusion

As natural disasters are expected to continue to increase in frequency, the importance of fostering more resilient urban systems cannot be overstated. This study sought to contribute to resiliency-building in the North Vancouver context in by examining the potential vulnerability of the North Vancouver business community to earthquake hazards and suggesting several potential measures for addressing identified vulnerabilities, as well as by demonstrating the value of explicitly linking research and practice to better support risk reduction goals. The previous chapter summarized the patterns of vulnerability identified by model and survey findings and offered several recommendations for addressing them from a public risk management perspective, both in terms of community-level decision making and promoting preparedness behavior at the individual level. Along with the future research opportunities discussed in this chapter, it also illustrated how study designs and outputs can be structured to contribute more directly to public decision making. This approach offers a way to not only improve the value of future risk studies to communities but also enable communities to better contribute to future study efforts by developing deliberate, iterative connections between risk research and management.
References


Appendix A: Loss Model Disruptiveness Probability Distributions

Probability distributions were developed by Chang et al., 2008

<table>
<thead>
<tr>
<th>Disruptiveness Codes</th>
<th>Building Damage Disruptiveness</th>
</tr>
</thead>
<tbody>
<tr>
<td>Disruptiveness Level</td>
<td>HAZUS Damage State</td>
</tr>
<tr>
<td>Not at all disruptive</td>
<td>None</td>
</tr>
<tr>
<td>Not very disruptive</td>
<td>Slight</td>
</tr>
<tr>
<td>Disruptive</td>
<td>Moderate</td>
</tr>
<tr>
<td>Very Disruptive</td>
<td>Extensive</td>
</tr>
<tr>
<td></td>
<td>Complete</td>
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| Industry Codes | | |
|----------------|------------------|
| AGR            | Agriculture |
| FIR            | Finance, Insurance, Real Estate |
| HTH            | Health Services |
| MCT            | Mining, Construction, Transportation, Communication & Utilities |
| MFG            | Manufacturing |
| SVC            | Other Services |
| TRD            | Wholesale & Retail Trade |

<table>
<thead>
<tr>
<th>Disruptiveness of Loss of Water Service</th>
<th>Disruptiveness of Loss of Electric Power</th>
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<tbody>
<tr>
<td>Industry</td>
<td>Disruptiveness Level</td>
</tr>
<tr>
<td>---------</td>
<td>----------------------</td>
</tr>
<tr>
<td>AGR</td>
<td>NAA</td>
</tr>
<tr>
<td>MCT</td>
<td>8%</td>
</tr>
<tr>
<td>MFG</td>
<td>0%</td>
</tr>
<tr>
<td>TRD</td>
<td>10%</td>
</tr>
<tr>
<td>FIR</td>
<td>5%</td>
</tr>
<tr>
<td>HTH</td>
<td>2%</td>
</tr>
<tr>
<td>SVC</td>
<td>7%</td>
</tr>
<tr>
<td>All Industries</td>
<td>7%</td>
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<table>
<thead>
<tr>
<th>Temporary Business Closure from Multiple Sources of Disruption</th>
</tr>
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<tbody>
<tr>
<td></td>
</tr>
<tr>
<td>Case</td>
</tr>
<tr>
<td>a</td>
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<tr>
<td>b</td>
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<td>c</td>
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<tr>
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Appendix B: DNV Model Simulation Run Results
Percentage of Open Businesses by Sector:
'Building Damage + No Utilities + Neighborhood Effect' Scenario
Appendix C: North Shore Business Preparedness Survey Questions

BUSINESS INFO

1. Where is your business?
   (City of North Vancouver, District of North Vancouver, District of West Vancouver,)

2. Does your business also have locations outside the North Shore? (Y/N)

3. Is your business independent or part of a franchise/chain? (Independent, Chain/Franchise)

4. How many full-time employees does your business have? [North Shore locations only]
   (1-4, 5-19, 20-49, 50-99, 100-199, 200+)

5. How many years has your company been in business? __________

6. Where are your customers mostly from?
   (Within the North Shore, Within the Metro Vancouver region, Outside the Metro Vancouver region, Unsure)

7. What category does your business fit into? [NAICS Code #]
   • Agriculture, forestry, fishing, hunting [11]
   • Mining, quarrying, oil and gas extraction [21]
   • Utilities [22]
   • Construction [23]
   • Manufacturing [31-33]
   • Wholesale trade [42]
   • Retail trade [44-45]
   • Transportation and warehousing [48-49]
   • Information (e.g. broadcasting, publishing, telecommunications, film production) [51]
   • Finance and insurance [52]
   • Real estate and rental and leasing [53]
   • Professional, scientific and technical services (e.g. legal, engineering, environmental) [54]
   • Administrative and support services (e.g. employment services, business support, security, travel agencies) [56]
   • Waste management [56]
   • Educational services [61]
   • Health care and social assistance [62]
   • Arts, entertainment and recreation [71]
   • Hospitality and food services [72]
   • Other[81], please specify: __________________________

8. Do you own or rent your building? (Own/Rent)

PLANNING FOR A DISASTER

9. How prepared do you feel you are to keep your business running if a disaster happened tomorrow? (Very prepared, Somewhat prepared, Somewhat unprepared, Very unprepared)
10. If a disaster happened tomorrow, what would be your business’s greatest concern(s)?

[select all that apply]
- Losing power service
- Losing water service
- Losing telecommunications service
- Damage to the transportation network (roads, bridges, rail, port)
- Losing critical business data
- Building damage
- Inventory damage
- My suppliers’ closing
- Employees unable to come to work
- Customers unable/unwilling to come to my business
- Other, please specify: _________________

11. If a disaster happened tomorrow, how disruptive do you think these situations would be to your business operations?

(Very Disruptive, Disruptive, Not Very Disruptive, Not at All Disruptive, Do Not Know/Unsure)
- • Your business lost power and you can’t rely on service being restored in the next week
- • Your business lost water service and you can’t rely on it being restored in the next week
- • Your business lost power AND water and you can’t rely on either service being restored in the next week
- • Your business’s telecommunications networks are down and it is uncertain how long it will take to restore them
- • Your business’s main building is severely damaged (assume water & power service are still functioning)
- • Major damage to the local transportation network occurs (e.g. if Lions Gate or Ironworkers Memorial Bridge, Trans-Canada Highway or rail lines were closed due to damage)
- • Other businesses in your neighborhood/nearby are forced to close because of building damage, power loss, etc. (assume that your building is undamaged, still has power, etc.)

12. If a disaster shut down your business, how long can your business stay closed before it becomes a serious financial concern?

(A matter of hours, 1 day, 2-3 days, 4-7 days, More than 1 week, Do Not Know/Unsure)

13. Has your business experienced a disaster or had to close due to an unexpected disruption in the past 5 years? (Y/N)

14. Do you have a written plan in place today to keep your business running in the event of a disaster? (Y/N)  
---( if Y, skip to #15a; if N, skip to #15b)---

15. (A) How important would you say planning for a disaster is to your business?

(Very High Priority, High Priority, Medium Priority, Low Priority, Very Low Priority)  
---(skip to #16)---
15. (B) What is your business’s biggest reason for not having a disaster plan in place?
   • Disaster planning is not a priority
   • Don’t have the staff resources to develop a disaster plan
   • Don’t have the financial resources to develop a disaster plan
   • Don’t know how or don’t have enough information to develop a disaster plan
   • Other, please specify: ____________________________

16. What does your disaster plan include? (select all that apply)
   - Who is in charge of developing and carrying out the plan [Leadership/Ownership]
   - What kinds of risks your business faces and how those risks might affect business operations (e.g. how likely is it that your business might have to deal with a flood; and if a flood happens, what parts of your business might be impacted and how) [Risk & Business Impact Analysis]
   - What steps the business can take to reduce those risks (e.g. flood protection for the building) [Mitigation Measures]
   - How the business will respond if a disaster happens (e.g. emergency communication plan, evacuation plan, return-to-work strategy, data recovery strategy, supply chain disruption contingency plans, etc.) [Emergency Response Plan]
   - Activities to regularly test the plan to make sure it works effectively and employees understand it [Testing & Evaluation]

17. Have you ever discussed your disaster plans (plans other than a fire drill) with your: Y/N)
   - Employees
   - Suppliers
   - Customers

18. Have you ever tested your disaster plans? (Y/N)
   If yes, how often? _______

19. Have you ever needed to use your disaster plan in the past? (Y/N) (if N, skip to #20)
   What caused you to need to use the plan? (e.g. fire, flood, etc.) __________________
   How effective was your plan?
   (Very effective, Effective, Somewhat ineffective, Not at all effective)

20. How often does your business hold a fire drill?
   (2+ times a year, Once a year, Once every few years, Never)

21. In this area, how likely does your business think a damaging earthquake is to happen in the next 50 years?
   (80-100% chance, 60-80% chance, 40-60% chance, 20-40% chance, 0-20% chance)

22. Did your business participate in BC’s 2-minute earthquake ShakeOut drill? (Y/N)
RESOURCES & SUPPORT
23. If they were available, how valuable might you find these resources in supporting your business's disaster planning efforts? (Very Valuable, Somewhat Valuable, Not Valuable, Already Have)

- Online library of business disaster planning information (templates, examples, etc.)
- Information on local risks and potential impacts (e.g. likelihood of floods, earthquakes, etc. happening; potential damage and economic loss expected if disasters do happen)
- Information on government resources and assistance available for business risk disaster risk reduction and disaster recovery
- Information on types of business insurance to consider to help cope with disaster impacts
- In-person local business disaster planning seminar
- Community discussion on what other businesses are doing to plan for disaster (best practices, concerns, etc.)

Any other kinds of resources you would find helpful? _____________________________

24. What kind of role does risk assessment information (e.g. studies on how likely a flood or earthquake would be in the area) play in your business’s disaster preparedness plans? (Very important role, Somewhat important role, Not at all important role, Unsure/don’t have disaster preparedness plans)

25. Imagine that university research came out tomorrow saying, for example, that a landslide or earthquake was twice as likely to happen in your area the next 50 years as you thought. How likely would your business be to make changes to your disaster preparedness plans as a result of this research? (Very likely, Likely, Somewhat likely, Not at all likely, Unsure/don’t have preparedness plans)

COMMUNICATION
26. Have you ever visited NSEMO’s website? (Y/N)
   If yes, how often do you visit the site? (weekly, monthly, every few months, once or twice a year)

27. Do you follow NSEMO (@NorthShoreEMO) on Twitter? (Y/N/My business doesn’t use Twitter)

28. Do you follow NSEMO (facebook.com/NorthShoreEMO) on Facebook? (Y/N/My business doesn’t use Facebook)

29. Is your business signed up to participate in NSEMO’s Rapid Notify emergency notification system? (Y/N)
Appendix D: Survey Distribution

<table>
<thead>
<tr>
<th>Organization</th>
<th>Distribution Method</th>
<th>Audiences</th>
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</table>
| North Shore Emergency Management Office           | social media, direct email, website | Facebook ~260 followers*  
|                                                   |                           | Twitter ~3,000 followers*  
|                                                   |                           | Email ~450 businesses (public addresses gathered from North Shore business websites) |
| City of North Vancouver Fire Department (via main City accounts) | social media               | Facebook ~1,800 followers*  
|                                                   |                           | Twitter ~1,100 followers* |
| District of North Vancouver Fire Department       | social media               | Facebook ~550 followers*  
|                                                   |                           | Twitter ~1,000 followers* |
| District of North Vancouver Community Development Department | direct email | Email ~ 3,000 businesses (all licensed local DNV businesses with contact emails on file) |
| North Vancouver Royal Canadian Mounted Police Detachment | social media               | Twitter ~1,850 followers* |
| District of West Vancouver Fire Department        | social media               | Facebook ~50 followers*  
|                                                   |                           | Twitter ~1,300 followers* |
| District of West Vancouver Police Department      | social media               | Facebook ~200 followers*  
|                                                   |                           | Twitter ~1,750 followers* |
| North Vancouver Chamber of Commerce               | social media, email newsletter | Facebook ~300 followers*  
|                                                   |                           | Twitter ~1,250 followers*  
|                                                   |                           | Newsletter ~1,600 subscribers** |
| West Vancouver Chamber of Commerce                | social media, email newsletter | Facebook ~250 followers*  
|                                                   |                           | Twitter ~1,300 followers*  
|                                                   |                           | Newsletter ~1,300 subscribers** |

*followers are not confined to businesses located on the North Shore; many are individual citizens and can also be located in other geographic areas

**subscribers are not limited to Chamber members; anyone may subscribe to the newsletters