# EARTHQUAKE HAZARD AWARENESS AND MITIGATIVE ACTION: A CASE STUDY OF TWO COMMUNITIES

by

Catherine Lee Carnrite

B.A., University of Calgary, 1990

THESIS SUBMITTED IN PARTIAL FULFILMENT OF THE

REQUIREMENTS FOR THE DEGREE OF

MASTER OF ARTS

in the Department

of

Geography



SIMON FRASER UNIVERSITY

April 1996

## APPROVAL

Name: Catherine Lee Carnrite

Degree: Master of Arts

Title of Thesis: Earthquake Hazard Awareness And Mitigative Action: A Case Study Of Two Communities

Examining Committee:

Chair: L. Lesack, Assistant Professor

---

R.B. Horsfall, Assistant Professor
Senior Supervisor

---

I. Hutchinson, Associate Professor

---

P.S. Anderson, Assistant Professor,
Communications Department
Simon Fraser University
External Examiner

Date Approved: March 22, 1996

# PARTIAL COPYRIGHT LICENSE

I hereby grant to Simon Fraser University the right to lend my thesis, project or extended essay (the title of which is shown below) to users of the Simon Fraser University Library, and to make partial or single copies only for such users or in response to a request from the library of any other university, or other educational institution, on its own behalf or for one of its users. I further agree that permission for multiple copying of this work for scholarly purposes may be granted by me or the Dean of Graduate Studies. It is understood that copying or publication of this work for financial gain shall not be allowed without my written permission.

**Title of Thesis/Project/Extended Essay**

Earthquake Hazard Awareness And Mitigative Action:

A Case Study Of Two Communities

**Author:** _____
(signature)

Catherine Lee Carnrite
(name)

March 22, 1996
(date)

## ABSTRACT

In 1990 the City of Richmond instituted a proactive emergency preparedness program involving the community of Burkeville located on Sea Island. An emergency coordinator was hired to establish neighborhood disaster response teams and to teach community self-reliance in an emergency situation. The end result was the creation of an all-hazards, all-phase, "generic" disaster plan. This was the first community in Canada to be involved in this program that had been modelled after a program established in the United States in the 1980's.

Three years later I undertook research to determine whether the process of preparing and educating the residents for a future earthquake had any lasting effect. The question asked was: 'were the residents more aware of the hazard and had they taken more mitigative action than they would have had they not been involved in the program'?

Since no attempt had been made to establish the knowledge base and preparedness level of the residents in advance of the establishment of the disaster plan, it was necessary to do a comparative study. A self-administered questionnaire was delivered to households in two communities. The residents of the community of Burkeville and of Bridgeview in Surrey were surveyed. Both communities are relatively isolated within their cities and both areas would be faced with similar effects if an earthquake were to occur.

When the results were tabulated, and the comments that respondents volunteered were analyzed, it became apparent that the respondents in Burkeville were more aware of the hazard and had taken more mitigative action

than the respondents in Bridgeview. The research points to a modest legacy of increased awareness and preparedness at the household level.

## Acknowledgements

*There are many people who helped me along the way and I would like to take this opportunity to thank you. Bob, your patience and guidance through this whole process was invaluable. I would still be wallowing in numbers if it were not for you. And Ian, I will never forget the accommodation, dust, blackberries, potato fields, snakes and diatoms of Comox.*

*Laurel, you were the first to celebrate my acceptance to grad school and have always been there for me. Debbi, you kept me sane when others couldn't. Thanks to you and to Dan, for your moral support, good food, vacation breaks, and more importantly, for believing in me when I no longer believed in myself. Trudy, Kath, Penny and Chris, you were such good listeners and always willing to be objective and help me deal with the everyday aspects of my life that kept getting in my way. And Mariah, I could always count on you for a laugh as we reflected on life's eccentricities.*

*To Mom and Dad, thank you!*

*To the others in my life along the way, thank you - B.M., M.G. and J.F. An especial thank you to Jim. I wish you could be here to celebrate my success.*

*A special thank you to my two daughters for their patience and support as our lives rode the roller coaster of the excitement and anxiety of adolescence, single parenthood and grad school combined. Thank you Court, for your stalwart support and silent caring. And thank you Jordan, for keeping me firmly grounded in reality.*

# Table of Contents

# List of Tables

# List of Figures

# 1:0 Introduction

In recent decades scientific research on the earthquake hazard in the Pacific Northwest suggests that the hazard is greater than previously recognized. The Lower Mainland of British Columbia lies in this high risk area and would be susceptible to varying degrees of earthquake damage. Since World War II there has been rapid growth in population, and a corresponding increased investment in the built environment which has resulted in an increasing vulnerability to natural hazards. The total expected economic loss in the Lower Mainland in the event of a significant earthquake (Magnitude≥6.5) is estimated to be between $14.3 and $32.1 billion (Munich, p.1, 1992). A worst-case scenario estimates 207 persons dead, with 832 serious injuries and 6240 minor injuries (Munich, p.28, 1992).

As governments become more aware of the financial and human costs involved in a major catastrophe there is a corresponding change in philosophy. Today, a major element of the Canadian government's Earthquake Preparedness Program is the promotion of awareness among citizens of arrangements within Canada for emergency planning and response, and of the responsibility of individual citizens to mitigate the hazard (Report of Parliament, 1989-1990). The responsibility for initial action in an emergency lies with the individual (Report to Parliament, 1988-1989).

In keeping with the conclusions in these reports, there has been a shift in emphasis from disaster-related agencies assuming complete responsibility, to a partnership in which communities are encouraged to be more self-reliant (Stallings and Quarantelli, 1985). Government funds and resources are being redirected from the post-impact phase toward preparation and mitigation.

Local governments do not have the resources or skills to cope with a

large-scale disaster. Emergency departments are turning to the community, concentrating on educating and informing the public in disaster preparedness strategies to reduce loss of life and property (LaCasse, 1992). The trend toward greater public participation is to encourage, motivate and gain commitment from citizens to take on personal disaster responsibility.

Policy makers at all levels of government - federal, provincial and civic - argue for the need to increase public awareness of natural hazards in order to encourage the adoption of self-protective measures (Montz, 1982). The intent is that the public under threat should be aware of both the nature of the risk and the wisdom of taking protective measures. With increased awareness the belief is that the the public would voluntarily adopt protective measures (Sims et al, 1983). It does not necessarily follow that the provision of information will lead to an increase in knowledge or that education will lead to learning. In addition, exposure to information will sometimes lead to increased awareness on the part of individuals but may or may not lead to a change in behavior.

This study will focus on the effectiveness of two different earthquake preparedness programs that exist in two communities in the Lower Mainland. I will assess whether the adoption of either program has led to increased awareness of the hazard, and if so, how much of this awareness has been translated into precautionary action on the part of individual households. Without awareness and action amongst a population, the damages as a result of a hazard event are much greater than where awareness of the danger leads to effective precautionary action (Burton and Kates, 1964). Losses from an earthquake depend not only on event magnitude and the proximity of the epicenter to developed areas, but also on the range of adjustments adopted by a society.

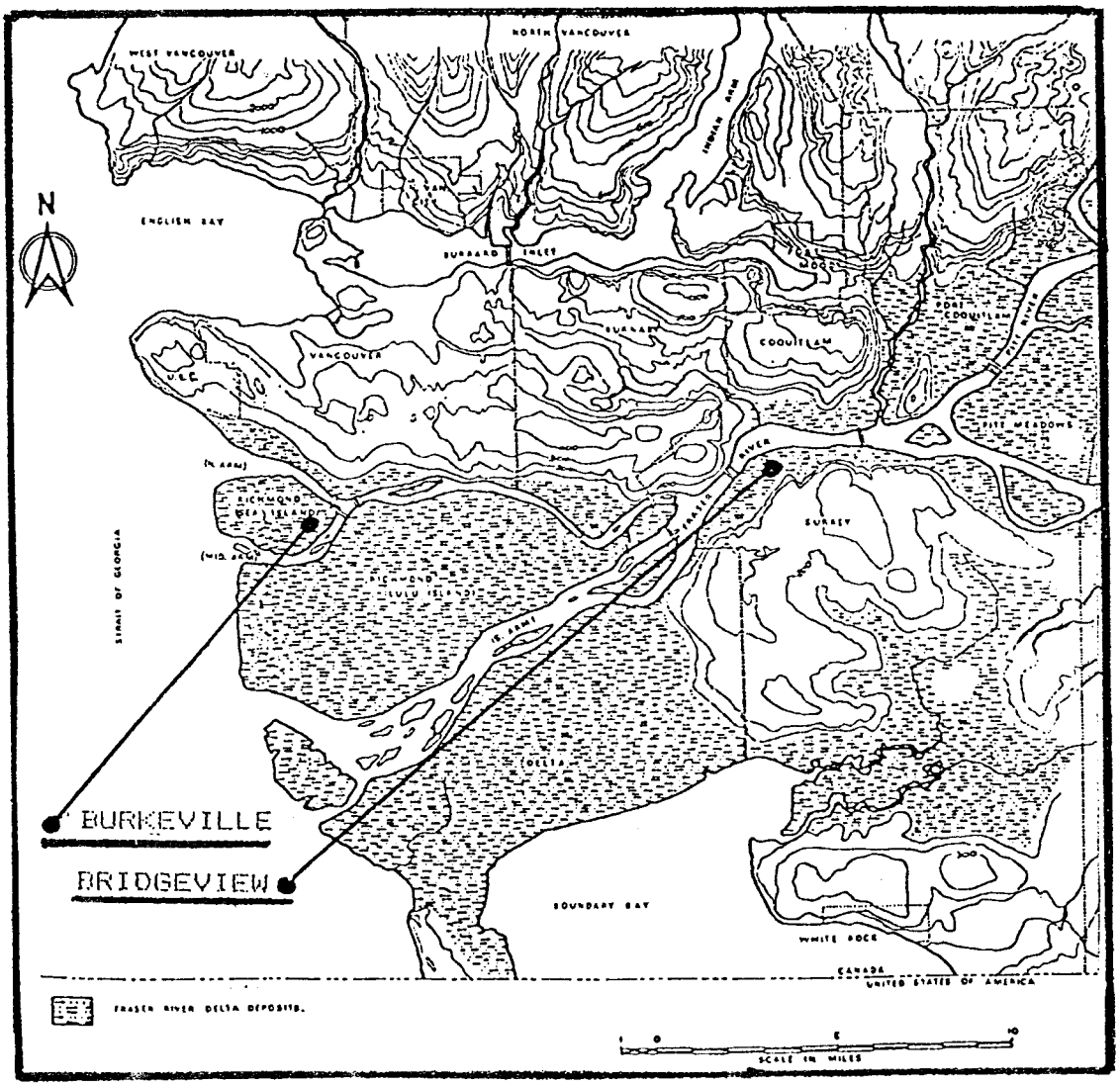
In this study I surveyed the attitudes and perceptions of the residents of the two communities in an attempt to determine their level of awareness about the local earthquake hazard, its salience, mitigative options available, and, to what extent mitigative action had been undertaken by individual households.

The communities were selected, in part, because of similarities in topography and geologic setting: both are located on recent deposits of the Fraser River (Figure 1), Burkeville is located on Sea Island in the municipality of Richmond and Bridgeview is located on the flood plain of the Fraser River in the municipality of Surrey

The Fraser Delta is the most hazardous area of the Lower Mainland from an earthquake perspective. An earthquake with an epicenter in southwestern British Columbia could cause destruction due to a variety of effects:

1) Amplification and resonance of waves generated by an earthquake would wreak havoc in the area underlain by unconsolidated deltaic and floodplain sediments.
2) Buildings may collapse or be structurally damaged and loose objects within buildings would be moved posing risks to anyone in the vicinity.
3) Liquefaction of the underlying sand or sediments could lead to settlement and/or lateral displacement of buildings (Watts et al, 1992; Naesgaard et al, 1992: Byrne et al, 1992).
4) Roads, rail lines and airport runways would be affected by the lateral displacement of fills and/or by differential ground movement. This could result in the airport being closed, bridge ramps being displaced and roads being impassable.
5) Water, sewer, gas, electrical and telephone lines would be severed in places disrupting essential services and communication networks

**Figure 1: The Location of the Communities of Burkeville and Bridgeview**




(Adapted from Blunden, 1973)

(Koppel, 1989).

6) Differential ground settlement may cause large cracks in local dikes which could result in flooding at high tides (Koppel, 1989).

7) Slumping of the delta foreslope could generate a tsunami in Georgia Strait leading to flooding of the delta surface (Byrne et al, 1992).

8) In any urban earthquake event there is always the possibility of conflagration, and fire fighting capabilities would be severely restricted due to damaged water lines and impassable roads.

With these concerns in mind some residents of Burkeville spearheaded a campaign that eventually led to the creation of a neighborhood disaster preparedness plan in 1990, but, the residents of Bridgeview had not been directly involved in any emergency preparedness plans at the community level.

In 1993 a self administered questionnaire was distributed to households in the two communities to identify the differences that exist between the two populations in terms of their perception of the earthquake hazard and their preparedness activities.

# 2.0 Background Information

The following section gives a brief description of the earthquake hazard in the area under study.

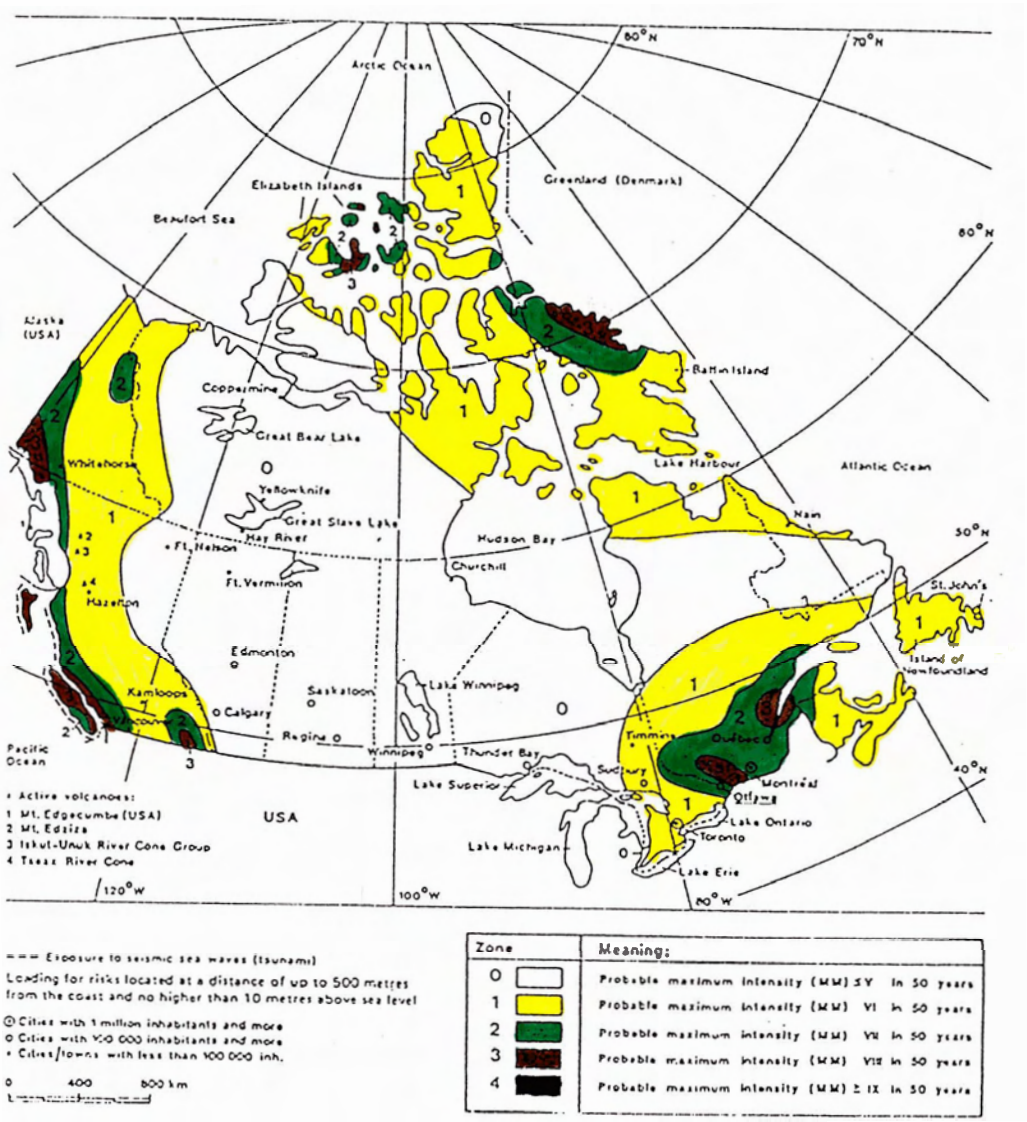
## 2.1 The Hazard

Although the Canadian seismic zoning map shows that southwestern British Columbia lies within Zone 3 (Figure 2), there are substantial uncertainties regarding the earthquake hazard in this region, meaning an area susceptible to earthquakes with a probable maximum intensity (MM) of VII in 50 years. (A definition of the Richter Magnitude Scale (M) and Modified Mercalli Intensity Scale (MM) is available in Appendix A.)

Over the past few decades research into the earthquake hazard in the Lower Mainland of British Columbia has shown that the region is vulnerable to three types of earthquakes (Rogers, 1992, A.M. Rogers et al, 1991). They are described as: continental crustal earthquakes, subcrustal earthquakes and subduction earthquakes, and are classified by their location within the earth's crust. The history of large damaging earthquakes of all types in southwestern British Columbia and northwestern Washington (Seattle and north) is presented in Table 1. The epicenter of these and other M>5 events recorded from 1899 - 1966 are shown in Figure 3.

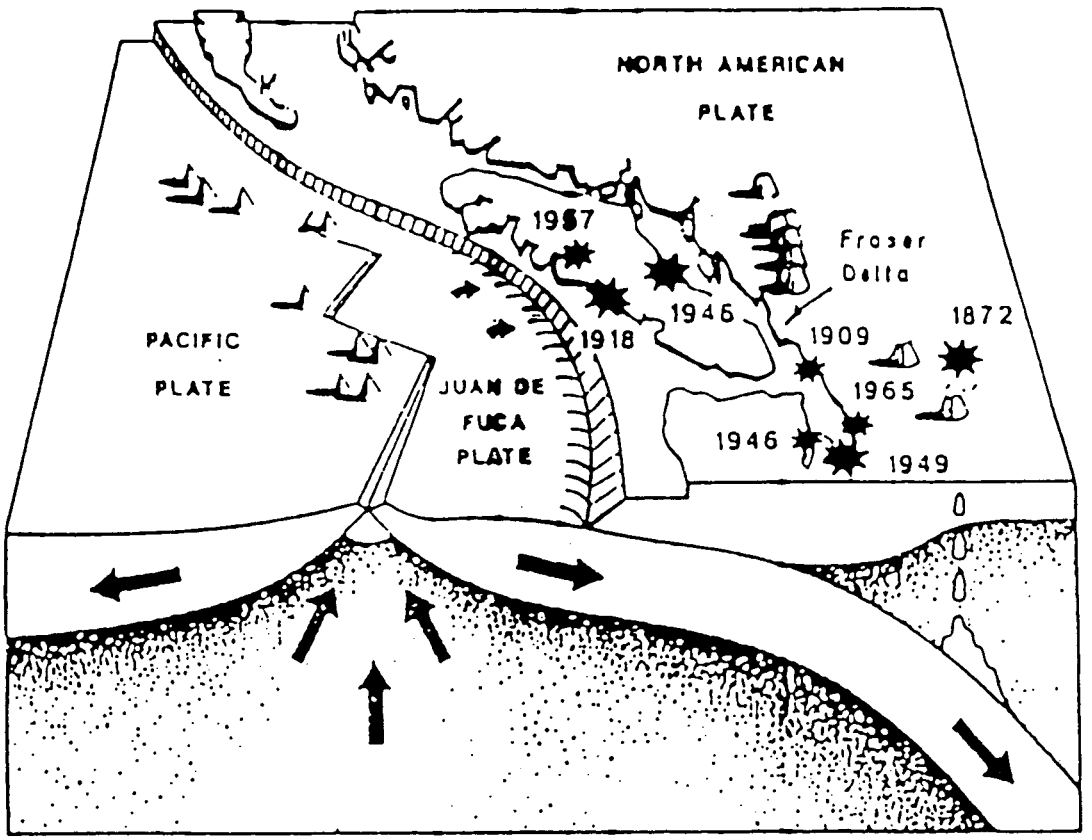
Continental crustal earthquakes occur as a result of stresses associated with convergence between the North American Plate and the Juan de Fuca Plates (Figure 4). Most of the 200 earthquakes recorded annually in southwestern British Columbia (Government of Canada, 1989) are of this sort, and are too weak to be felt by the local population. The subducting plate is colder than the athenosphere and as a result absorbs much of the heat flowing from the interior of the earth leaving the overlying plate brittle and more

## Figure 2: Seismic Zoning Map of Canada




(Source: Munich, 1992)

## Figure 3: Tectonic Setting




(Source: Byrne et al, 1992)

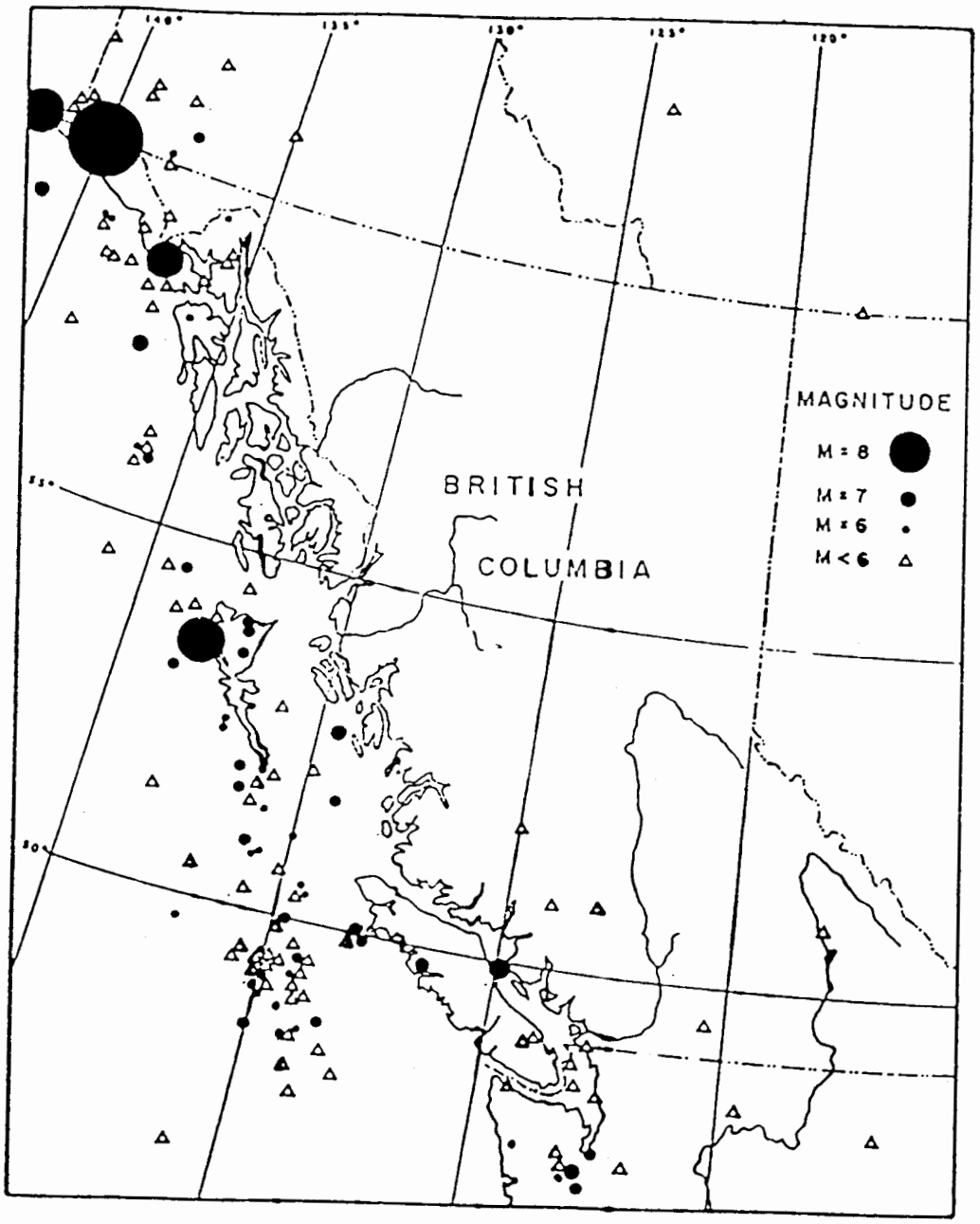
The stars and dates represent the epicenters of major earthquakes. The arrows represent the direction of plate movement and the upwelling of magma from the athenosphere. The cones represent volcanos.

susceptible to fracture. There is a pattern of persistent crustal micro-earthquake activity in this region despite a lack of any distinct active faults. The earthquakes occur at depths of twenty kilometers, therefore there has been little correlation with mapped surface faults. A subset of on-going small earthquakes have occurred in the upper 10 kilometers of crust. These are shallow events with long aftershock sequences (Rogers, 1992; A.M. Rogers et al, 1991).

Subcrustal earthquakes occur within the subducting Juan de Fuca plate. Their maximum size ranges up to M=7.5 and is limited due to the thickness of the young plate that affects rupture lengths. Subcrustal events are concentrated in two places. A band occurs beneath Vancouver Island as the oceanic plate subducts and is formed into a 10 to 20 degree dip from its horizontal position. The second band occurs below Georgia Strait and Puget Sound where the subducting oceanic plate bends further to 30 degrees. The subducting plate moves from a positive to a negative buoyancy by phase changes in the rocks of the oceanic crust in this region, resulting in earthquakes at depths of 45 to 65 kilometers (Rogers, 1992; A.M. Rogers et al, 1991).

Plate boundary earthquakes occurring at the interface of the Juan de Fuca Plate and the North American Plates are recognized as a significant local hazard. (Adams, 1990; Atwater, 1987; Heaton, 1990; Heaton and Hartzell, 1987; Heaton and Kanamori, 1984; A.M. Rogers et al, 1991; Rogers, 1992, 1988a and 1988b; Savage et al, 1991). The Juan de Fuca plate is a young and buoyant oceanic plate which subducts beneath the western margin of the North American Plate. Unlike other young subduction zones, no plate-boundary earthquakes have been recorded from the Cascadia subduction zone during the period of recorded history. Geologic evidence suggests however that plate boundary earthquakes have occurred, approximately every 500 years on

Figure 4: Epicenters of Earthquakes Greater Than Magnitude 5 in Western Canada (1899 - 1966)




(Source: Byrne,1976)

**Table 1**

## LARGE EARTHQUAKES IN SOUTHWESTERN BRITISH COLUMBIA AND NORTHWESTERN WASHINGTON

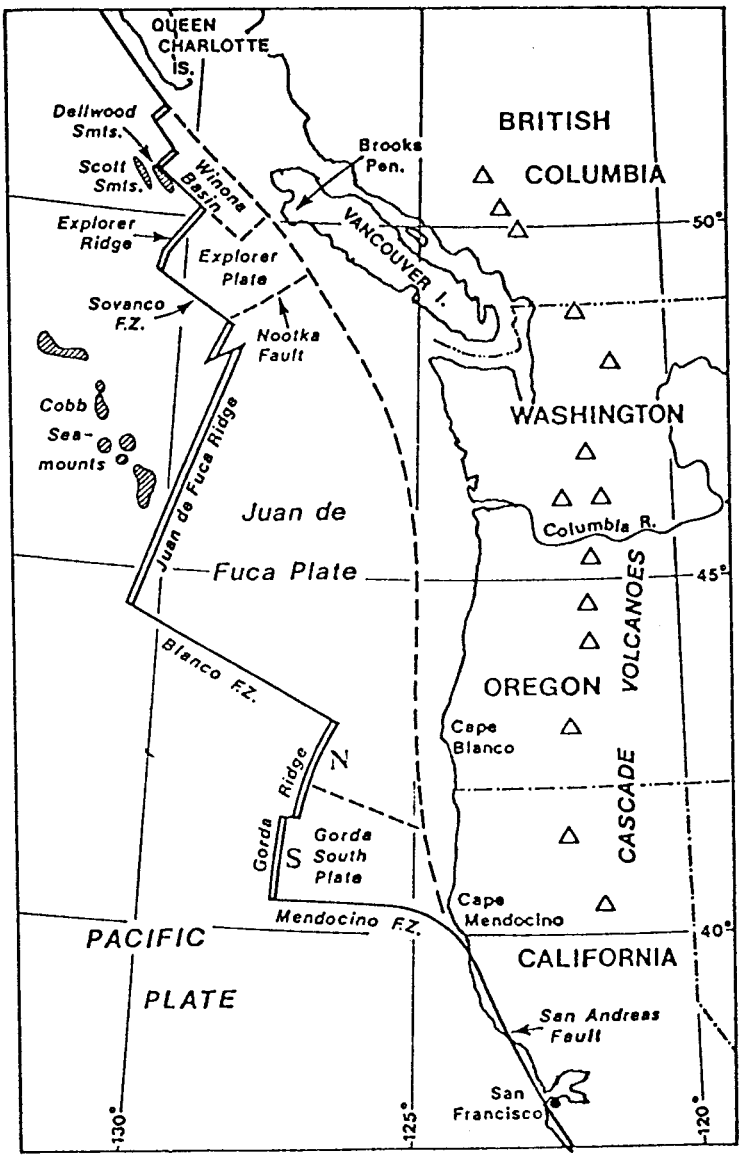
| Year (A.D.) | Crustal | Subcrustal | Subduction | Location |
|---|---|---|---|---|
| 1990 | 4.8 | | | Deming, Washington |
| 1976 | | 5 - 6? | | Gulf / San Juan Is. |
| 1975 | 4.9 | | | Georgia Strait |
| 1965 | | 6.5 | | Puget Sound |
| 1949 | | 7.1 | | Puget Sound |
| 1946 | 7.3 | | | Central Van. Island |
| 1920 | | 5 - 6? | | Gulf / San Juan Is. |
| 1918 | 7 | | | Vancouver Island |
| 1909 | | 5 - 6? | | Gulf / San Juan Is. |
| 1904 | | 5 - 6? | | Gulf / San Juan Is. |
| 1872 | 7.4 | | | Lk. Chelan, Washington |
| 1864 | | 5 - 6? | | Gulf / San Juan Is. |
| Approx. 1700 | | | 8.2 - 9.3? | Cascadia Subduction |
| Approx. 900 | Approx. 7.0 | | | Seattle, Washington |

Measurements are expressed using the Richter Magnitude Scale (M). See Appendix A for definitions.

(Source: Rogers, 1992 and A.M. Rogers et al, 1991.)

average, with the last event (M>9) occurring approximately 300 years ago (Adams, 1990; Atwater, 1987; A.M. Rogers et al, 1991; Yeats et al, 1990). A map of the location of the Cascadia Subduction Zone illustrating the relevant plates, active volcanoes and the zone of convergence (represented by the dashed line) is shown in Figure 5.

## Figure 5: The Cascadia Subduction Zone




---------Represents Zone of Convergence

(Source: Riddihough, 1984)

# 3.0 The Problem

In the Lower Mainland, the earthquake hazard lacks salience for many people. This is due to two factors. The first is the absence of significant events in living memory. The second is the lack of visible evidence of historic events of the magnitude that is now commonly recognized by the scientific community and by government policy makers as a reality for the region. The hazard must be salient to people before awareness can translate into a belief that their own lives and property are susceptible to danger (Palm, 1981).

The government of Canada recognizes the importance of the individual, and individual households, in assuming responsibility in emergency management (Report to Parliament, 1988-1989). Emergency preparedness and response are shared responsibilities of individuals, corporations and governments. The division of responsibility amongst these shareholders is established in a wide range of legislation, regulations and by-laws, as well as by custom and practice (Summary of Federal Emergency Preparedness in Canada). In 1988 the Emergency Preparedness Act replaced the War Measures Act as the federal government legislation establishing emergency preparedness as a government responsibility. In the same year the Emergencies Act was enacted: 1.) to provide contingency legislation designed for invocation in the event of a national emergency, and, 2.) to prescribe constraints upon and emergency powers available to the different levels of government. To optimize planning-and-response resources, the approach taken is an "all-hazards" one and the result is a generic set of plans that are applicable to most situations.

Each province has its own emergency legislation. The province is responsible for encouraging and coordinating municipal emergency planning.

On November 1, 1993 in British Columbia the Emergency Program Act (S.B.C.,1993, c.41) came into force, replacing the old Act (R.S.B.C., 1979, c.106). The old Act had been enacted during the cold war era and dealt with war-related concerns. The new Act emphasizes public safety in all emergencies or disasters. It was developed with the advice and assistance of the Union of British Columbia Municipalities as well as emergency preparedness specialists from provincial government ministries, crown corporations and agencies. The municipality is required to direct and control emergency response within its jurisdictional area and the Provincial Emergency Program continues to exist as the provincial governments coordinating body. The roles and responsibilities of local governments are clarified. The Act specifically requires each municipal government to create and maintain an emergency preparedness organization. It enables provision of Disaster Financial Assistance to victims of all disasters and provided exemption from civil liability to all emergency service workers.

All of these legislative changes were enacted within months of my completing the field studies for this thesis. Prior to this legislation, municipalities defined their own level of involvement in local preparedness, as no clearcut boundaries existed. With the new Act, municipalities are legally required to take on responsibility for emergencies within their geographic jurisdictions. The primary responsibility for emergency preparedness now lies with the local authorities. The findings of my field research might prove useful as a base line for future research into the effectiveness of municipal level involvement in emergency preparedness and how that involvement affects community members.

In anticipation of the upcoming changes, some municipal emergency

departments had begun to seek community input into their disaster plans. Their policies are designed to encourage individuals to be responsible for themselves in an emergency event and to realize that there are actions that they can take to promote self-help. By increasing awareness of a hazard, and thereby its salience within an at-risk population, it is believed that the loss potential would be reduced as individuals undertake mitigative actions.

In a city-wide disaster, local government resources will likely be overwhelmed. Hours or days may pass before emergency response personnel can arrive in any given community. It will be left to the individual to assess an emergency situation and to react.

A number of variables affect post-emergency responses. Although neighborhood rescue and aid teams may emerge spontaneously in the disaster area, their efficiency depends on the social and demographic character of the community.

The process of planning allows the community to identify those who are at special risk in advance. It provides for training of search and rescue volunteers and emergency medical volunteers. It reinforces the need for individuals to take responsibility for themselves and their households. The end result is that community participation can shorten the recovery period (LaCasse, 1992).

Much of the effort of the three levels of government has been concentrated on educating and informing the public about disaster-preparedness strategies to reduce the loss of life and property. Emergency departments, the focal agencies in disaster planning, have been responsible for this. The trend in planning is toward greater public participation in areas which have in the past been exclusively the government's domain. Disaster planning

is one area in which public input and involvement is crucial to the "success" of a disaster response (LaCasse, 1992).

Two types of disaster planning process have evolved to facilitate educating citizens to potential hazards in their environment.

The first planning process may be charaacterized as "top-down". Emergency departments provide brochures, consultants, and information sessions to the community at large; these resources and resource people are available only on request. There is limited public participation in the disaster plans that are developed.

The vehicle for the "top down" planning process is a municipal education program organized by an emergency coordinator, who provides emergency planning expertise and is available to special interest groups who wish to tap into his/her expertise. The coordinator provides a link to the community and offers information about specific risks and contingency plans. This is accomplished through the use of pamphlets made available in public institutions, by public displays during Emergency Preparedness Week, and by giving information sessions upon request. Any particular household or individual is educated to the risks by initiating an information search, by local media coverage, or by attending one of the information sessions.

The "top-down" approach is predominantly facilitative and passive. In contrast, "bottom up" approaches which emerged out of United States disaster policy in the 1980's, stress community involvement. Since World War II the different levels of government in the United States have had to absorb the rapidly escalating costs of natural disasters (earthquake, floods, tornadoes, hurricanes, etc.). They are now actively seeking solutions to spread the costs of recovery, and/or, to pass it on to those who are at greatest risk.

The new strategy was to seek community involvement; this was enhanced with the development of neighborhood disaster response teams. Through training and education, neighborhoods were taught to be self-sufficient for a minimum of three days (LaCasse, 1992).

A "bottom-up" disaster planning process involves municipal experts going into a community to initiate an education program and teach local residents to take responsibility for their own safety in a disaster. Inherent in this type of program is a shift of responsibility for immediate post-event management to the community level. The community establishes a community-based emergency-preparedness plan.

The "bottom-up" approach gives residents an opportunity to encourage each other in the adoption of recommendations, as well as to encourage networking within the community. It is designed to keep members committed to the project through a sense of satisfaction that will facilitate and sustain protective behavior. In this setting it is more likely that someone will have experienced the hazard and this will lead to vicarious sharing of the reality of the hazard (Slovak et al, 1974)

### 3.1 The Two Communities

In Surrey, the city provides a "top-down" disaster planning process. Residents in the Surrey community of Bridgeview have not been systematically exposed to information on the hazard potential or the mitigative options available to them, nor have they been consulted for input into the development of the city Disaster Plan (Consultation with Ted Wilson, Emergency Coordinator, Surrey, December 11, 1992).

In the community of Burkeville, the City of Richmond has attempted to

institute a "bottom-up" disaster planning process to encourage hazard awareness and mitigative action on the part of the community as a whole and households individually. The community developed its own emergency preparedness plan (Consultation with Don MacIvor, Emergency Coordinator, City of Richmond, February 11, 1992).

By comparing the populations of Bridgeview and Burkeville, it may be possible to determine which type of planning process is more effective in raising hazard awareness and hazard competence. A comparison should also lead to some insight into whether differences in hazard perception are reflected in the mitigative actions undertaken by individual households within the two communities.

### 3.2 Disaster Planning Review

The "bottom-up" planning process was designed to set up neighborhood disaster-response teams to teach community self-reliance in an emergency event. It is a proactive approach to building community participation into emergency plans. Prior to the 1980's there had been no attempts to involve communities in the disaster planning process. "Top-down" disaster planning had been, and continues to be, product-oriented instead of being process-oriented. Product-oriented planning involves professional emergency personnel drawing up written emergency plans. In process-oriented planning the residents and groups most likely to be affected become participants in the emergency planning process (Stallings et al, 1985; Anderson et al, 1990). Planners develop emergency response plans with little outside involvement except by recognized professional groups such as fire and police departments.

Citizens within communities are often seriously uninformed regarding

existing hazards and are therefore unaware of how to minimize the hazard and reduce the damage to property and persons residing within the community (Anderson et al, 1990).

The smallest effective decision making unit is the individual/household (Palm, 1990). It must perform as the primary and secondary response agent, as government agencies may be unable to meet all of the emergency needs that may arise in a crisis situation. Although the government has traditionally been responsible for disaster relief and for providing financial assistance for rehabilitation and reconstruction, the Emergency Planners employed by governments need to teach self sufficiency and the fallacy of depending on the government to aid citizens in massive crisis situations. In effect, the society as a whole shares the cost of hazard events (UNESCO, 1978).

Every citizen has a responsibility to mitigate the risk of living in his/her community (Anderson et al, 1990). It is unknown how much knowledge, once received by those at risk, is actually translated into action. Whether the mitigation action undertaken at the household level is enhanced by public information with which the individual comes into contact is not known. Information sources include: government campaigns, general knowledge pool, neighbors, co-workers, and popular media (Michaels, 1990).

Social science researchers cannot offer policy makers any assurance that a change in attitude stemming from heightened awareness will lead to behavioral changes, or if behavior change will lead to a change in attitude, or both.

Thus, awareness is a necessary but perhaps insufficient condition for action. It appears that those objectively at risk must believe their lives and property are at risk before any mitigative action is initiated (Jackson, 1974).

To date, to my knowledge, there has not been a study comparing the effectiveness of the "bottom-up" and the "top-down" disaster planning processes. The only way to ascertain effectiveness in increasing community preparedness, and individual awareness and preparedness, is by comparing a "bottom-up" community such as Burkeville to a community like Bridgeview that has only been exposed to the more traditional "top down" disaster planning process.

### 3.3 Objectives

A basic goal of hazard perception research is to understand why people carry out their current practices and how they perceive the environment and the options available to them (Burton, Kates and White, 1978). Identifying which approach, "bottom-up" or "top-down", if either, is more effective in increasing hazard awareness has implications for emergency preparedness planning. It may aid in designing more effective programs to assist individuals who are most at risk.

Improvements in public education policies and provision of information which specifically addresses areas of knowledge deficit could lead to a broader view of the complete range of theoretically possible adjustments available to individuals and households who are at risk (Saarinen, 1974b).

Understanding of the perception of a particular hazard held by the population at risk will aid in assessing an individual's ability to perceive and understand the world around him and in choosing appropriate courses of action. The extent of voluntary adoption of mitigative options is dependent in part on the degree of risk perceived.

### 3.4 Hypothesis

To evaluate the comparative success of the two approaches to disaster planning the research was designed to test the following hypotheses:

H1 The hazard knowledge base of the residents in Burkeville will be greater than that of the residents of Bridgeview.

H2 The awareness of risk expressed by the residents in Burkeville will be greater than that expressed by the residents of Bridgeview.

H3 The level of salience accorded the hazard as expressed by residents in Burkeville will be greater than that expressed by the residents of Bridgeview.

H4 The awareness of mitigative options available to individual households will be greater among residents of Burkeville than among residents of Bridgeview.

H5 The number of mitigative actions undertaken in individual households will be greater in Burkeville than in Bridgeview.

H6 The number of mitigative actions planned in individual households in Burkeville will be greater than those planned in Bridgeview.

H7 Increased hazard awareness will be manifested by increased mitigative activity in individual households in both communities.

# 4.0 Field Research

The description of the research component of the thesis has been divided into two parts. The first part contains some observations on the communities. The second presents a brief description of the methodology.

## 4.1 Community Profiles

This thesis compares the community of Burkeville in Richmond (Figure 6) to the community of Bridgeview in Surrey (Figure 7). Both communities are relatively isolated within their cities and have the potential to be isolated from the resources necessary to expedite recovery after a disaster.

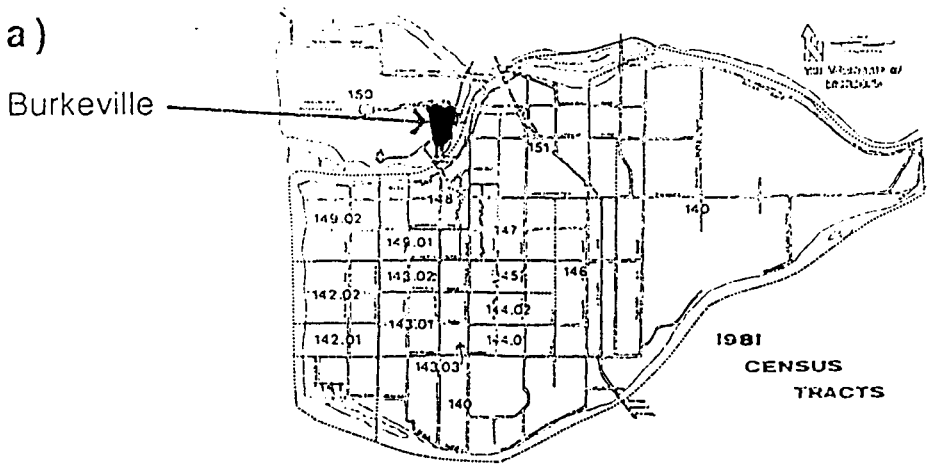
Bridgeview is bounded by the Fraser River and Canadian National Rail lines to the north and west, the King George Highway to the south, and, 136th Street on the Surrey Upland to the east. Due to periodic flooding of the lowland area, there has been limited residential and commercial investment in the community, but considerable industrial development along the river.

Burkeville is a closed and compact, entirely residential community located on Sea Island. Its boundaries are clearly defined by MacConachie Way (the main road into the airport), the Middle Arm of the Fraser River and the airport lands.

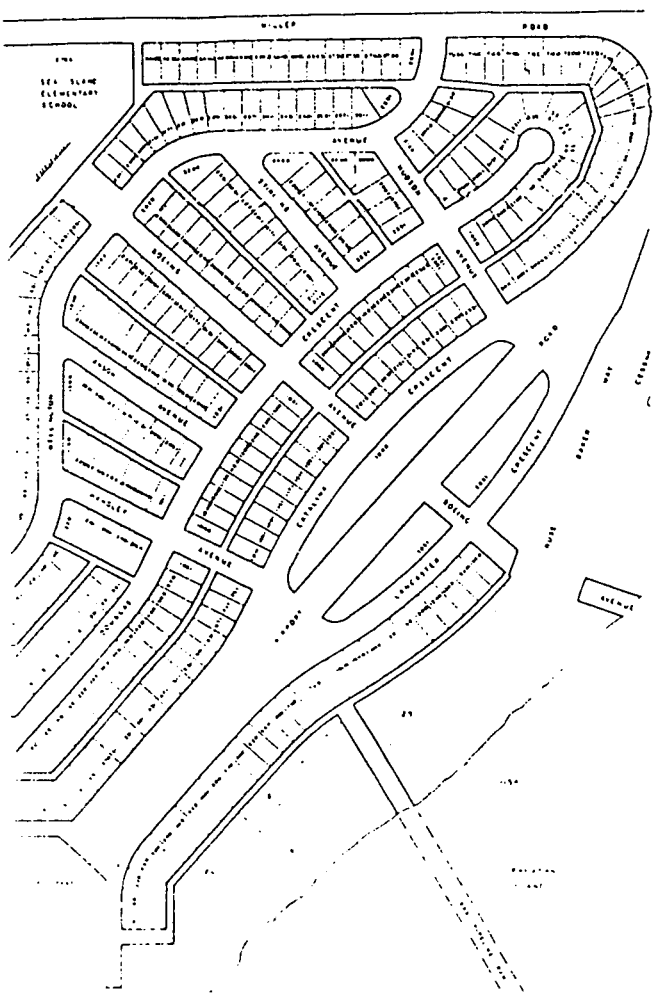
Burkeville is the only remaining residential community on Sea Island. It shares the island with the Vancouver International Airport and an area of farmland. Sea Island is flat, situated just above sea level and underlain by Fraser River deltaic deposits. Substrate sediments are predominantly sands, which are prone to liquefaction and differential ground settlement. The dikes that surround part of the island may fail in an earthquake, resulting in flooding during subsequent high tides.

**Figure 6: a) Richmond, showing the location of Burkeville**
**b)Street map of Burkeville**

a)

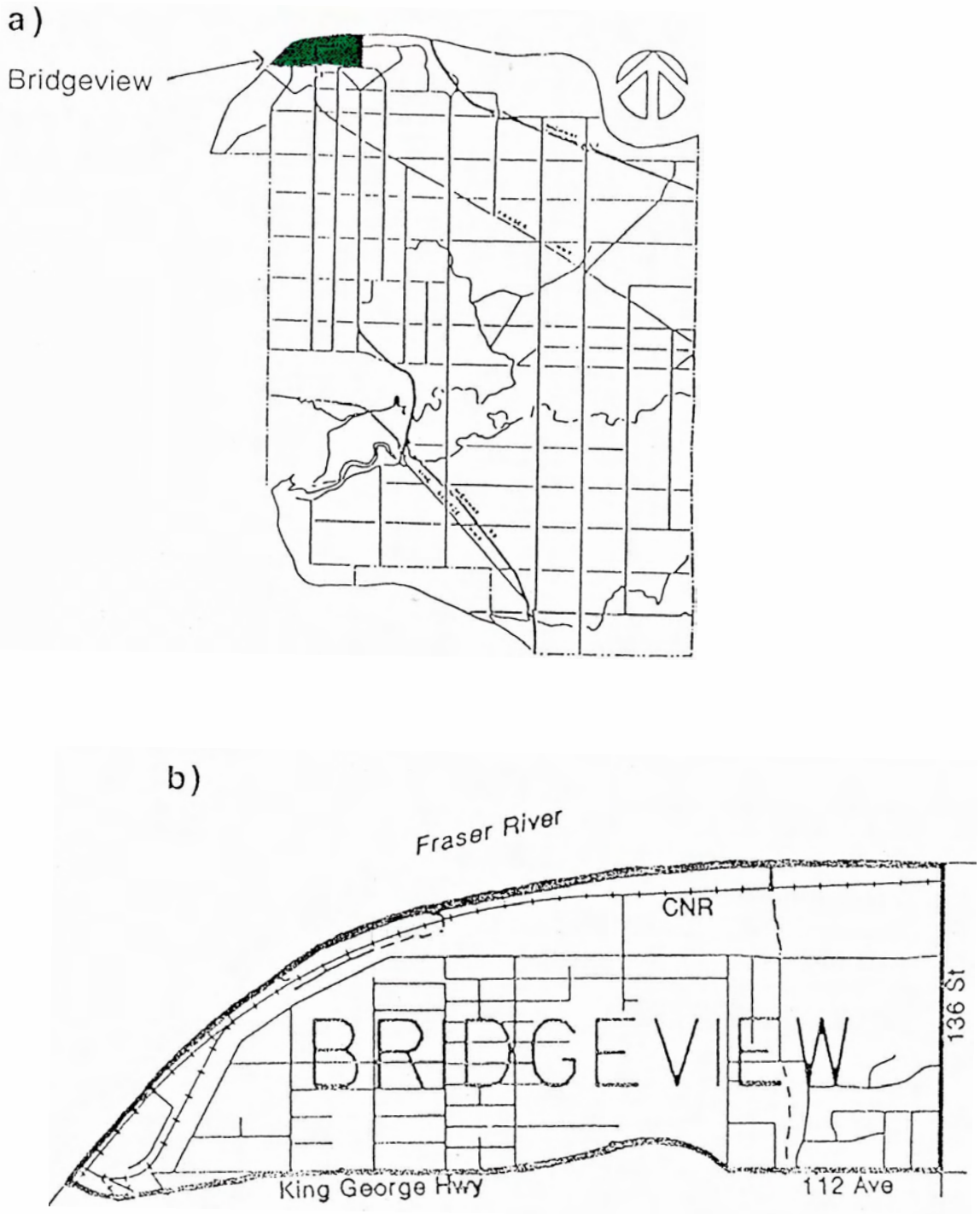



b)



(Source: Richmond: A Statistical Profile, 1985; Burkeville Emergency Response Plan, 1991)

**Figure 7: a) Surrey, showing the location of Bridgeview**
**b) Street map of Bridgeview**




(Source: Surrey Stats, 1986)

Bridgeview has a topography similar to that of Burkeville, in that it is a relatively flat, low-lying area. The community is primarily located on an area of flood plain that is an adjunct of the Fraser River. The flood plain is made up of Fraser River sediments overlain by peat. The local area may be prone to the same liquefaction and ground-settlement problems as Burkeville.

Burkeville had a population of 707 residents in 1991. There were 298 dwellings with an average of 2.37 residents per household (Newton, 1993). Burkeville is a community that has been shrinking in both population and number of dwelling units over the past few decades. It offers limited access to schools (up to Grade 3 within the community) and the school building doubles as a community center.

Bridgeview had a population of 2585 residents in 1986 living in 875 dwellings with an average of 2.95 residents per household (Surrey, 1986). It is a growing and expanding community, with the number of dwelling units and population continuing to increase. The community offers both a community center and schooling up to Grade 7 (plus a Grade 10 Challenge Program).

The housing types were similar in both communities. In Burkeville questionnaires were delivered to 143 single family houses and seven duplexes (some of the presumed single family houses may also have been duplexed).

In Bridgeview the questionnaires were delivered to 212 single family houses, 8 duplexes and 5 mobile homes (again, it would be difficult to identify single family homes that were duplexed).

Walking around the two communities on two separate occasions yielded the distinct impression that, for the most part, the residents of Burkeville took more pride in their homes and community than did the residents of Bridgeview. Yards were neat, houses were in good repair, no junky cars were abandoned in

backyards, no large-item garbage was abandoned in yards or on vacant lots. That is not to say that immaculate homes and gardens did not exist in Bridgeview, there were just not as many in this state. The Bridgeview community displays a greater variety of housing qualities than does Burkeville.

Bridgeview contains large areas of undeveloped land that give the neighborhood an unpolished look. There also appeared to be an abundance of guard dogs at many residences in Bridgeview. On more than one occasion I had to cross the street to pass some residences where dogs were actively guarding their owners' property. It appears that some residents have the dogs as a form of security against intruders.

Bridgeview impresses one as a community in transition. There was evidence of a wide variety of housing types reflecting the varied socioeconomic backgrounds of the residents. Some of the older dwellings and vacant lots were being redeveloped to provide larger and more substantial single family housing units.

In Burkeville, the community was made up of small but well cared for dwellings. There was evidence everywhere of owners investing money to enlarge and modernize their homes. At two locations major structural changes were taking place, one house having another level added to it and the other being a new structure built on the site of a preexisting house. In general the socioeconomic status of Burkeville appeared to be more uniform, with less variance in lifestyle and material values than was the case in Bridgeview.

Burkeville is a strictly residential area. Any persons who were employed would need to leave the community to work, as would any students in Grades 4 and above. There are economic activities on the island associated with the airport, including hotels, car rental companies, courier services, and

warehousing, but they are located outside of Burkeville.

Bridgeview contains a variety of economic activities, including a hotel, a school, used car lots, warehousing, junkyards, a wood-processing plant, CNR rail yards, and a number of small industries. The economic activities are clustered along the river and the highway, but do fall within the geographical boundaries of the community.

In 1990 Burkeville became the first Canadian community to follow the United States lead in setting up neighborhood-disaster response teams to teach community self reliance. The community initially approached the Emergency Social Services Director asking that an information session be presented in Burkeville to address the local earthquake hazard. (This followed the San Francisco earthquake in 1989.) Burkeville was then targeted by Richmond to be the site of a pilot project because it was a compact and isolated community with a strong community organization.

Over the following two years the creation of an all-hazards, all-phase, 'generic' disaster plan evolved. The community was inundated with specialists in emergency preparedness. It hosted planning meetings. An emergency coordinator was assigned to the community. Residents were contacted by local volunteers to register them in a central registry and encourage active participation. Residents were exposed to extensive emergency planning literature.

In contrast, the residents of Bridgeview have not been exposed to intensive community level education programs that would have provided information on hazard potential and mitigative options available to therm.

## 4.2 Methodology

Self-administered questionnaires (Appendix B) were delivered to a sample of households in the two communities. They were accompanied by an introductory cover letter (Appendix C) and postage paid return envelope.

The respondent was asked to reply to a number of questions/statements which assessed household emergency-preparedness and knowledge of the local earthquake hazard. In addition, the respondent was asked to provide some basic demographic information to identify how similar/dissimilar the two samples were.

On the questionnaire space in which to make comments was allocated in two places. The comments are listed in Appendix D. Initially the questionnaires were delivered by hand to one hundred households in each of the two communities. In Burkeville, the questionnaire was left at every third household using the elementary school as a starting point and choosing the house located nearest the main doors as house number one. A questionnaire was delivered to every third house along the street until the end of the street was reached. Then, questionnaires were delivered down the other side of the street. The nearest adjacent street was covered next, and so on, until all of the streets had been covered. In Bridgeview much the same pattern of delivery was executed, only in this case the front doors of the community center acted as the starting point and the questionnaires were delivered to every sixth house.

At the end of two weeks, it became apparent that the response rate was insufficient for any statistical analysis. Only 27 usable questionnaires had been returned in Burkeville and 21 usable questionnaires returned in Bridgeview. At this point, reminder notices (Appendix C) and a second copy of the questionnaire were delivered to those households that had not as yet

responded. A numbering system on the questionnaire had been used to track who had, and who had not, responded to the original questionnaire. The response to the reminder was an additional 12 usable questionnaires in Burkeville and 9 in Bridgeview.

At the time of the delivery of the reminder notices an additional fifty questionnaires were delivered to uncanvassed households in Burkeville and one hundred and twenty five were delivered to uncanvassed households in Bridgeview. Reminder notices were not delivered to any of the households as it was determined at that time that enough households had responded to do a comparative analysis. The total count of usable questionnaires was 58 in Burkeville and 52 in Bridgeview, yielding 38.7% and 23.1% samples respectively.

In Burkeville two spoiled/blank questionnaires were returned and in Bridgeview four spoiled/blank questionnaires were returned. Four completed questionnaires were returned with the community identification removed, therefore, they were invalid and were discarded.

Questionnaire data were evaluated for statistical significance, using Chi-Square tests. Observed frequency and associated Chi-Squares for the results appear in Appendix E.

# 5.0 DATA ANALYSIS

The analysis of the data is presented in four parts. The first part reports on the questionnaire. The second part presents the results of the survey. The third part is a synthesis of the comments that the respondents volunteered. In the last part, the data collected in the community are applied to test the hypotheses that the research was designed to evaluate.

## 5.1 Questionnaire

The response rate in Burkeville was far greater than in Bridgeview. The author has been unable to explain this. In Bridgeview, 52 usable questionnaires were returned out of 225 delivered (23% return), as opposed to 58 usable questionnaires returned out of 150 delivered in Burkeville (39% return). The summer is a time of vacations for many people and this would account for a poor response, but this should be applicable to both communities. The questionnaire involved considerable time commitment on the part of the respondent which could account for the low response rate in both communities. It seems that apathy is more rampant in Bridgeview. This could possibly be due to less/lower awareness of the hazard and mitigative options available. Alternatively, conceivably members of a more transient population were less concerned about living in a high hazard area (Figure 9).

The questions fall into three sub-sets. The first set of questions (1 to 5), was designed to establish the respondent's knowledge of past earthquakes, his/her concern about future earthquakes, and his/her assessment of how the community would be affected by future seismic events.

The second set of questions comprised one number, 6, which asked about earthquake preparations using twenty-three criteria and asked whether or

not the respondent's household had preplanned for a disaster.

A third set of questions, numbers 1 to 9 on pages 3 and 4, was designed to identify demographic characteristics of the respondent and his/her household.

## 5.2 Survey Results

The third set of questions, identifying the demographic characteristics will be presented first to to establish the similarities and differences of the two populations under study.

DEMOGRAPHICS - THIRD SET OF QUESTIONS

The third set of questions, numbers 1 to 9 on pages 3 and 4 of the questionnaire, deal with population characteristics. The respondents from the two communities did not differ significantly in terms of gender with 50% in one community and 54% in the other being female. Most respondents were in the 25 to 44 age group (60% in Burkeville and 54% in Bridgeview). Burkeville had a greater number of respondents in the over 45 age group (36% as opposed to 30%) than did Bridgeview which had more respondents in the under 24 age group (12% as opposed to 3%). Individual households in each community reporting having no children under 18 was 66% in Burkeville and 64% in Bridgeview.

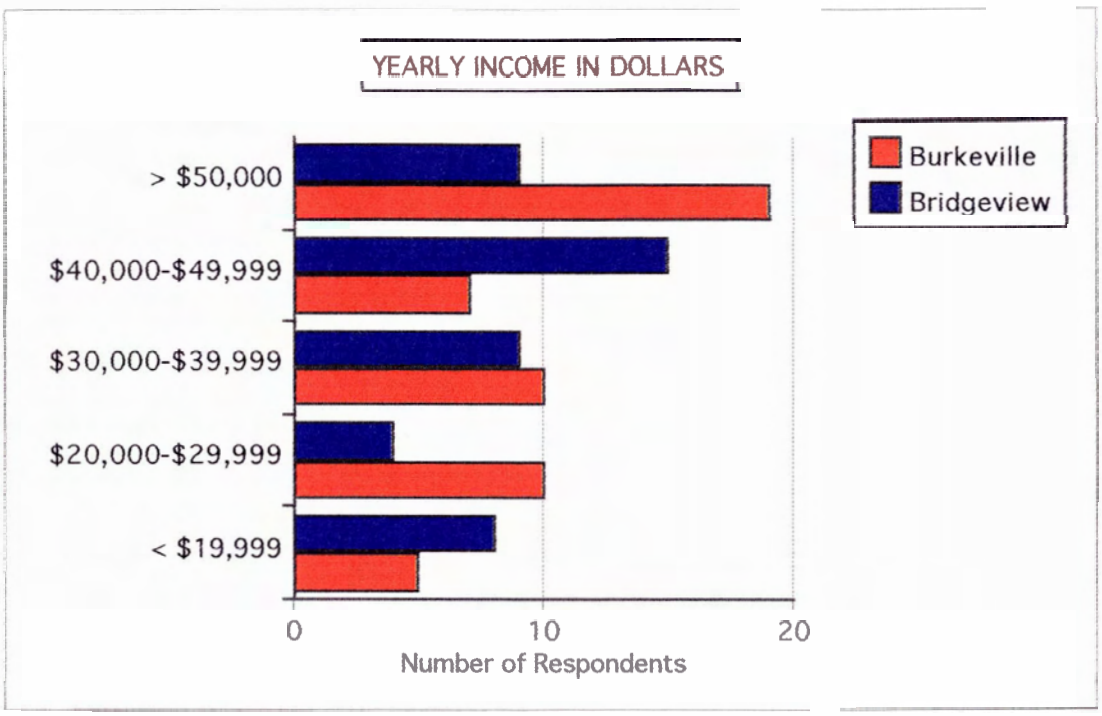
The samples did not differ in housing type (single or other) or in type of construction (wood frame or other). A slightly greater although not significant portion of the Burkeville sample owned their homes.

It should be noted that the income reported per household in both communities did not indicate any statistically significant differences between the two locations. There are only two economic differences of note that are

apparent.

In Bridgeview a larger proportion of households reported earnings below $20,000 per year than was the case in Burkeville (Figure 8).

**Figure 8**




At the other end of the scale of household earnings, 37% of the residents in Burkeville reported earning more than $50,000 per year and in Bridgeview that number falls to 20%.

The large number of high end income earners in Burkeville suggests a greater degree of economic homogeneity.

The number of years in the community could also indicate an aging population that has more retirees. In Burkeville 37% of the population have lived in the community for more than ten years, compared to 20% in Bridgeview.

Reported education did not differ significantly between the two samples. In Bridgeview, 23% of the population reported having an education consisting of a high school diploma or less and in Burkeville that segment of the

population represented 16% of the total, which is consistent with the previously discussed demographic measures. The Burkeville sample is slightly better off and slightly more homogeneous than is the Bridgeview sample.

The question of education level was directed only to the householder who chose to complete the questionnaire and does not reflect the education of other household members. This question was somewhat ambiguous; in retrospect, the question on education should have asked only for years of schooling.

The two demographic variables that proved statistically significant are listed below.

1. - "*number of adults per household*" (Chi-Square=6.538; $P= 0.038$)

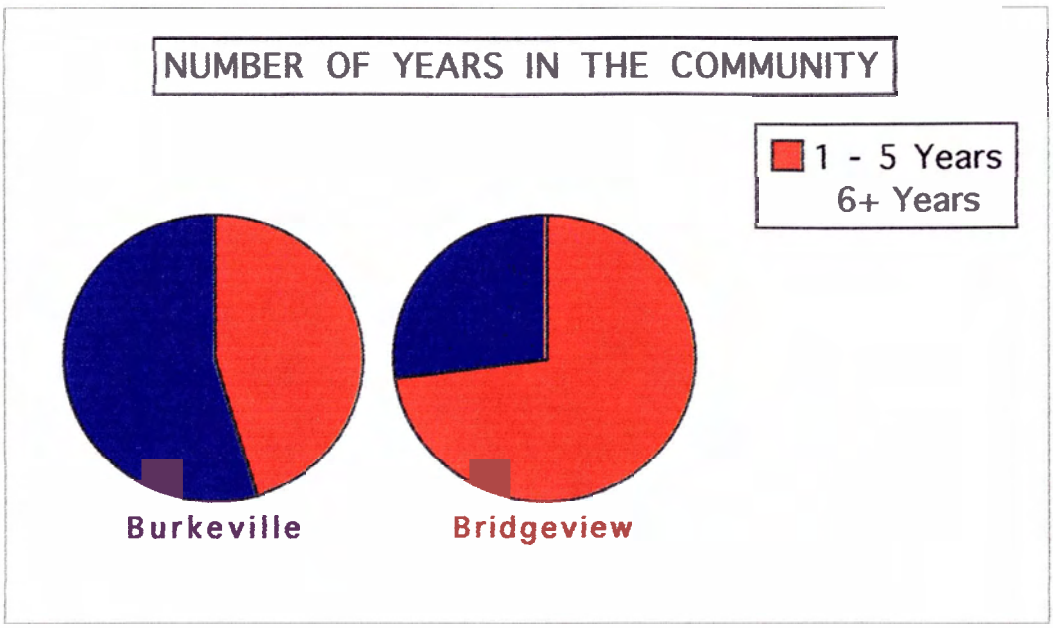
Single adult (single parent?) households in Bridgeview comprised 20% of the sample and in Burkeville they made up 14%. This could reflect the socioeconomic background of the two communities.

82% of households in Burkeville and 63% of households in Bridgeview had two adults in residence. This could be a reflection of the more traditional values of the community of Burkeville that appears to be a family-oriented community.

16% percent of the households in Bridgeview contained three or more adults. In Burkeville only 3% of the households contained more than two adults. This might result from the higher number of rental units in Bridgeview (21% as opposed to 12% in Burkeville), indicating housing that is being shared by a number of unrelated adults.

2. - The question regarding the "*number of years the respondent had lived in the community*" resulted in Chi-Square=7.980, $P=0.0047$.

**Figure 9**




The populations of Bridgeview and Burkeville differ markedly in residential stability (Figure 9). 73% of residents in Bridgeview have lived in the community for five years or less. This lack of long-term residency could result in less concern regarding the potential earthquake hazard. In Burkeville, 46% of the respondents have lived in the community for less than five years. The length of residence is reflected in a greater sense of community and commitment to the activities that are happening in the community.

HAZARD AWARENESS - FIRST SET OF QUESTIONS

Replies to the first set of questions, numbers 1 to 5, showed that the respondents in both communities had a similar knowledge base in terms of past events, level of concern and how the community would be affected.

In Burkeville, 28%, and in Bridgeview, 25%, of the respondents believed that a damaging earthquake had occurred in the previous 100 years. 52% of the Burkeville respondents and 44% in Bridgeview chose No as a response to this question. In reality, in 1946 an earthquake was felt in the Lower Mainland

and it caused damage in the City of Richmond.

When asked how seriously they took the prediction of a major earthquake happening within their lifetime and affecting this area, 79% of the Burkeville and 67% of the Bridgeview respondents indicated that they took the prediction seriously or very seriously.

Similar results were garnered when asked if their property would be affected if a major earthquake happened in this area. In Burkeville 79% of the respondents and 53% in Bridgeview indicated that there would be a serious or very serious affect on their property.

In Burkeville, 86%, and in Bridgeview, 77%, of the respondents believed that their community would definitely or probably be affected by flooding in a major earthquake. When asked about violent shaking the two groups are in even closer agreement, the results being 88% and 85%. In Bridgeview the concern about a post-earthquake fire was greater with 65% of the respondents indicating their community definitely or probably would be affected and that number drops to 52% in Burkeville. 38% of the respondents in Burkeville were concerned about a tsunami and only 25% in Bridgeview. In Burkeville 83% of the respondents expressed concern about liquefaction and in Bridgeview 71% were concerned.

There were only two areas in which the respondents' answers differed significantly.

In Burkeville, the respondents expressed concern about dike failure and how it would affect them (Chi-Square=12.383; $p=0.002$). It would appear that there is an understanding of the risk of dike failure in the event of an earthquake in the area. The local media frequently report the risks inherent in living behind dikes in terms of flooding, and of possible dike failure in an earthquake event.

The local population is therefore well aware of the hazard.

In Bridgeview, more respondents expressed concern about the possibility of slope failure (Chi-Square=11.571; $p=0.009$). A closer examination of who expressed concern about slope failure indicated that residents on the slope of the Surrey Uplands did not differ from residents living on the flood plain. I can offer no plausible explanation for this response pattern. There was no evidence of recent slope failure and there was a sizable green belt buffer zone between the two residential areas which would leave the flood plain residents free from any direct effects of slope failure.

Bridgeview is a community in which new housing is replacing older housing. Before construction of the new dwelling can take place the developer has to compact the building site with sand and raise the level of the lot above grade to protect the structure from flood damage and/or from differential settling. Any residents observing this may consider the differential settling problem as a form of slope failure, which may account for local concern about slope failure. A number of buildings in the community show evidence of having settled and have a decided lean.

The final question in this section asked if the respondents concern about a damaging earthquake striking this area had increased in the past year. 21% indicated that their concern had increased and 72% indicated that their concern had remained the same in Burkeville. Interestingly, 5% indicated that their concern had decreased in the past year. In Bridgeview, 39% indicated increased concern and 61% indicated that their concern had remained the same.

PREPAREDNESS - SECOND SET OF QUESTIONS

The second set of questions (Question #6) asked how respondents

reacted to the earthquake preparations that are recommended by a number of agencies as helping to alleviate the effects of an earthquake event. Question 6 was divided into 23 parts. Each part was answered on a scale with four options - 1. Have Done For Earthquake, 2. Have Done For Other Reasons, 3. Plan To Do, and, 4. Don't Plan To Do. For many of the actions mentioned, the two populations' responses were not significantly different. The following is a list of the actions for which the two communities were similar.

Have a working flashlight.
Have a first aid kit.
Emergency food stored.
Secured cupboard latches.
Rearranged cupboard contents.
Contacted neighbors for information.
Inquired about earthquake insurance.
Purchased earthquake insurance.
Structurally reinforced home.
Secured water heater.
Secured heavy furniture and appliances.
Instructed household members on what to do in an earthquake.
Know when to shut off utilities going into your house.
Know how to shut off utilities going into your house.
Have taken a basic First Aid course.
If you have children, know the emergency provisions in place at their school(s).

On seven of the actions, the responses of the two populations were significantly different. They are listed below, with suggestions as to why there may be a difference between the two populations.

1. - The response to "*Have a working battery operated radio*" resulted in a

difference between the two communities (Chi-Square=8.152; P=0.017).

Over half of the respondents (35 out of 54) in Burkeville had a working battery-operated radio whereas in Bridgeview less than half of the respondents (19 out of 47) had one. There are several possible explanations for this disparity.

First, the extensive exposure of the population of Burkeville to the earthquake-preparedness education process as spearheaded by the community association had taught them to think of their car radios as a battery-operated radio. When this question is first posed to respondents they may not be able to visualise their cars as providing a battery- operated radio; instead they may be thinking of a small radio with batteries stored in their homes and to be used just for emergencies.

Second, Burkeville is located on an island and its population may be more attuned to an 'island mentality'. Richmond is situated on a number of islands at the mouth of the Fraser River delta. The islands are almost entirely surrounded by dikes designed to divert flood waters around the community. In addition to this hazard the City of Richmond is situated on land that is particularly prone to liquefaction in an earthquake event and as a result isolation due to bridge and tunnel failure is a very real possibility. The hazards that are unique to this city are compounded by the presence of an international airport on Sea Island and the potential for a major air disaster. These factors could explain in part the willingness of the city Emergency personnel to actively facilitate emergency preparedness at the community level.

At the community level past experience with power outages, loss of water or sewer services, and storms which down telephone lines may have taught the residents the importance of maintaining an alternative communication link to the

rest of the city.

2. - The question "*Storing of drinking water*" resulted in a discrepancy between the two populations (Chi-Square=7.050: P=0.0295).

The residents of Burkeville were more likely to have water stored or have plans to store water than the residents of Bridgeview.

The fact that Sea Island is surrounded by salt water may make the residents of the area more aware of the need to store potable water in case of emergency. If there was bridge failure they could conceivably be cut off from potable water for an extended period of time.

The storage of drinking water could also reflect the current trend by urban residents to purchase bottled water for domestic consumption. Many residents in the Lower Mainland are switching to bottled water in their homes. The more stable and affluent residents of Burkeville may have adopted this fad more quickly than the residents of Bridgeview. Once settled in an area the residents look at ways of improving their quality of life, and the establishment of a safe domestic water supply could be one of them.

3. - When asked if the household had "*Participated in community preparedness plans*" there is a statistically significant difference between the two populations (Chi-Square=20.830; P=0.0001).

There are two readily apparent reasons for this being so. First, the residents of Burkeville are noted for being particularly community minded; an important factor in the city of Richmond's decision to set up its pilot project in the community. Residents are active in community functions and keep abreast of community happenings.

Second, it appears that active soliciting by the city and local leaders in

the previous three years has resulted in local residents being involved in community preparedness activities.

4. - When asked if "*Attended neighborhood meetings*", Burkeville and Bridgeview differed (Chi-Square=7.971; P=0.0048).

Over the three previous years, many meetings had been organized for the local residents of Burkeville in the process of preparing them to look after their own community for seventy hours in the event of a major catastrophe. In contrast no meetings had been organized in Bridgeview to facilitate earthquake or hazard awareness.

5. - When asked if they had "*Made emergency procedures within the household*" there again is a difference (Chi-Square=5.160; P=0.023).

In Burkeville twice as many respondents as in Bridgeview indicated that they had established in-house emergency procedures. Again, this could be a reflection of the extensive exposure to preparedness information that the community had received through the education program.

This could also reflect an 'island mentality' and the very real possibility that the community could be temporarily isolated from the rest of the city. It is important to recognize that few of the Burkeville residents work or attend school in the community and any family members at home could be isolated from other family members in an emergency event. It would be appropriate that all members of the household know what procedures to follow in the event of an emergency. The community of Bridgeview is not nearly so isolated and the residents could more easily access stores and services in an emergency.

6. - The respondents were asked if they had "*Made family plans for reunion after an earthquake*" (Chi-Square=14.106; P=0.0009).

31% of the responders in Burkeville indicated that they had made reunion plans for an earthquake and not one responder in Bridgeview had done so. In part, this discrepancy could be credited to a problem with how the statement had been worded. It was assumed that the respondent would know what this statement referred to. It was designed to find whether all of the family members would be able to contact each other immediately following a major earthquake event. It is recommended that family members have a contact person living outside of the Lower Mainland where all family members who are not in touch with each other can call to confirm their whereabouts. It is expected that the local public communication system may be in considerable disarray and that calls made outside of the immediate area will be more easily made than local calls. Anyone who had been exposed to the emergency preparedness information would be aware of this and have made plans within the household to instigate such a scheme should a local emergency happen. It could be that the lack of plans on the part of the Bridgeview residents is a reflection of ignorance of this recommendation. The wording of the statement did not clarify what was meant by the question, as most people who survived a major crisis would probably be interested in having a family reunion at some point in their future to celebrate their survival.

If the answer to this question accurately reflects the thinking of the respondents in Burkeville then some credit might be assigned to the 'island mentality' argument. These people live on an island and are at a greater risk of being isolated in an emergency event.

7. - The last statement that yielded statistically significance is "*Know how to notify rescuers if you do or do not need assistance*" (Chi-Square=13.655; $p=0.0011$).

30% of the respondents in Burkeville knew how to notify rescuers in the event of an earthquake and only 2% knew how to do so in Bridgeview. Yet 24% of the respondents in Burkeville and 42% of the respondents in Bridgeview knew how to notify rescuers for other reasons.

Possible explanations that are readily apparent for '*other reasons*' are toxic spills, flooding and train derailment in Bridgeview and flooding and airplane crashes in Burkeville. This awareness of how to notify rescuers of whether or not assistance is needed translates into over half of the respondents in Burkeville and just under half of the respondents in Bridgeview knowing what to do in some emergency situations. Respondents may have assumed that communications would function for most emergencies, but be disrupted by an earthquake.

In this section on earthquake preparedness, many respondents chose 'Plan To Do" as an option. This response is open to considerable uncertainty. Will their plans translate into action? Will these people make the time to do what they say they will do? Will it be done in a timely manner? Or did respondents choose this option because they felt that they should do something of that nature because it had been pointed out to them that it is appropriate if they care about their family, property and community? It is important that the reader keep these ideas in mind when considering the results of the survey.

### 5.3 Comments

At two points in the questionnaire the respondents were given the opportunity to make comments. A number of interesting comments were made and these are summarized below. Each section will be dealt with separately.

FIRST SET OF COMMENTS

Comments were first requested after question number 5 on page 2. The question asked:*"During the past year, would you say your concern about a damaging earthquake striking this area, has:*

*1. Increased*
*2. Decreased*
*3. Remained the same"*

The question was followed by: "*If your level of concern has changed, please give a brief description of why:"*

Sixteen respondents in each community offered comments. The comments from each community will be described separately.

BURKEVILLE

In Burkeville, eleven of the respondents had indicated that their concern had increased during the past year; two respondents had indicated that their level of concern had decreased; two respondents indicated that their level of concern had remained the same; one respondent did not chose any of the three options that were offered.

The media appeared to have played a role in increasing hazard awareness for five of the respondents. Two respondents referred to an *"increase in earthquakes world wide"*, one referred to *"the San Francisco quake of 1989"* ; two referred to *"hearing more about a local earthquake event being inevitable"*. One respondent indicated that *"conversations with their spouse"* had raised their level of concern about an earthquake. Another respondent indicated they *"had increased awareness and were more concerned"* but did not credit a source for this heightened awareness.

Two respondents expressed increased concern based on local environmental perception. One referred to *"Sea Island as being located below sea level"*, and, the other (who is included below as a participant in

B.E.R.T.[Burkeville Emergency Response Team]) referred to *"an earthquake that had occurred in the area three years previously"*.

Five respondents referred to what was happening in their community in terms of community preparedness as affecting their level of concern. Of the five who referred directly to B.E.R.T., four expressed an increased level of concern. Of these four, two indicated that they had been *"directly involved with B.E.R.T"*. Another one indicated concern due to*"increased attention paid to natural disasters worldwide"*.

The fifth respondent indicated that her level of concern had declined in the past year because *"B.E.R.T. had been less active in the community"*. This is an interesting point because it indicates that once activity designed to educate and prepare a community for an emergency event has begun, any perceived or real decline in activity around this issue could conceivably lead to a decline in concern on the part of local residents. This respondent indicated that *"her primary concern in life was her struggle for survival and she did not want to be reminded of unpredictable possibilities"*.

Of the two respondents who indicated that their attitude had remained the same, one commented that she was *"too old to care"* , and, the other commented that *"the area was due to have one as other areas had had them"*.

The two respondents that indicated that their level of concern had declined included the person listed above who cited her health, less preparedness activity in the community and less media coverage as factors; and another person who indicated that *"the research was preliminary and recent research indicated that there was some uncertainty about the conventional thought."*

BRIDGEVIEW

Of the sixteen Bridgeview respondents who chose to write a comment, fifteen had indicated that their level of concern had increased during the past year and one indicated that his/her level of concern had remained the same.

The media were credited with having played a role in increasing hazard awareness for ten of the respondents. Five respondents referred to an "*increase in earthquakes world wide*".

Of these five, each respondent mentioned one additional factor. One mentioned the *"San Franciso quake"*; another mentioned that "*people are telling us to be prepared*"; another referred to "*increased fear*"; another mentioned the *"media talk of anticipation of a big event*"; the last respondent mentioned *"media attention to earthquakes*". Three respondents referred to the "*San Francisco quake of 1989".* Of these three, one added a comment that referred to the fact that the area "*is situated on a fault and that a local earthquake hazard exists".* The remaining two respondents who referred to the media did so in terms of there being an "*increase in natural hazard events that served to increase their level of concern*".

One of the two mentioned the fact that the "*community was located on an estuary*" and the other referred to "*changing weather patterns*", as well as, a reference to the fact that "*the end of the world was happening*". (One is left to wonder what the respondent was thinking about when she made this statement. The same person took the time to clarify some points on her answers to the questions related to preparedness and under the comments section she expressed some concern about sandbags being made available at the mobile home park in which she lived. The author notes that this observation is not in keeping with the belief that the world was ending!)

Four households raised concerns related to regional geology and the

local environment. Their comments were related to: "*local plates and faults*", the fact that their "*community was located on an estuary*", and, one "*household was located on a ravine*".

Two respondents mentioned personal factors as contributing to their increased concern about the earthquake risk. One volunteered that the *"adults in the household, being older, lacked mobility. They had lived in a safer area in Burnaby*". The other respondent indicated that they were "*new to the province and had not really thought about the earthquake hazard*". One respondent referred to the "*previous history*" as being a factor in his/her increased concern.

The one person who indicated that his/her level of concern remained the same made reference to "*changing weather patterns*". This was the second respondent in Bridgeview to mention the weather; the nature of the perceived relationship between the climate and earthquakes is unclear.

SECOND SET OF COMMENTS

At the end of the of the section of the questionnaire dealing with preparedness, the respondents were given this statement: *"If you have any comments to make about the earthquake hazard in your community, I would appreciate hearing them. Please write them down in the space provided below".*

In Burkeville, fifteen respondents wrote comments. Of these, nine had written comments on the questionnaire in the other space made available for comments.

In Bridgeview, ten people made comments in the space provided; of this group, six had written comments in the other space for comments.

BURKEVILLE

Three respondents mentioned geologic factors in their comments. One

referred to "*liquefaction*", another a "*tidal wave in conjunction with bridge failure*", and the third mentioned the fact that they "*believed that Sea Island residents would be helpless if a tsunami happened*". A number of respondents offered comments that involved practical concerns. Three respondents mentioned "*bridge failure as being a problem for the local residents*". One person stated that they thought that "*their fireplace would end up in their neighbours living room*". Another person inquired about the "*structural safety of Vancouver skyscrapers*". One person asked "*how they were to notify rescuers if they need help*". One respondent, as mentioned earlier, stated she was "*struggling to survive and did not want to be reminded of the unpredictable possibilities*".

Two suggestions were put forward to raise the level of awareness of local residents. One respondent suggested that there should be "*more advertising of information seminars on Sea Island*". The other suggested that a "*very readable and informative report should be prepared for the local paper to publish*".

Six respondents referred directly to "*B.E.R.T*". One said he/she had "*missed the last meeting*". Another said he/she had been a "*door to door canvasser when B.E.R.T. was first getting established in the community*". Another mentioned that "*every household had been canvassed to create a registry (although some apathy existed), and that a working group had been in existence for three years and that a close liaison existed between the local group and Richmond Disaster teams*".

One respondent said that the "*questionnaire had prompted some discussion within the family and some revisions had been made to the household plans for an emergency event*".

Another respondent indicated that their concern about the local earthquake threat had increased since they "*now had a small child who would be at risk*".

One respondent mentioned some of the problems unique to living on an island. "*Bridge failure, dike failure and resultant flooding, conflagration if aviation fuel spilled, air travellers trapped on the island, and, the possibility of a tidal wave*" were all put forward as concerns about living in the community. The respondent went on further and offered some suggestions to expedite post event recovery. He suggested that "*vacuum tanks could be used to assist in debris/slurry remove and to rescue victims? and that jet skis could be used for transportation in the event of flooding*".

As mentioned in the section above one respondent indicated that his concern with the earthquake hazard had declined since the "*community was not as active in preparedness planning*".

In total, six respondents referred to B.E.R.T. and an additional respondent mentioned B.E.R.T. in the other section of the questionnaire. It is of interest that three years after the pilot project had been undertaken in Burkeville twelve percent of the respondents to this questionnaire mentioned it directly. Thirty three percent of the respondents had participated in community preparedness plans and thirty one percent had attended neighborhood meetings. The B.E.R.T. project seems to have left a legacy of increased awareness and participation in emergency preparedness in the community.

BRIDGEVIEW

Most respondents in Bridgeview did not mention any participation in community-level preparedness activities. This is not surprising considering that no government agency or community group had been active in Bridgeview to

organize such activities. There had been neither a "top-down" nor a "bottom-up" initiative undertaken in or on behalf of Bridgeview.

One respondent indicated that there was a "*need for information seminars*" and suggested they be "*held at the local library or community centers*". The same person suggested that "*written information on the risk should be distributed to all households*".

Another respondent asked "*if there was a community preparedness center*" and suggested that a "*preparedness meeting be held in Bridgeview*".

A respondent asked "*what areas in the Lower Mainland are most likely to be hardest hit by an earthquake*" and questioned "*how seriously one should take the hazard when it seems so unlikely to happen*".

Two respondents also raised the question of the "*seriousness of the hazard considering its low profile*". One of them felt that they might "*view the hazard differently if they did not have to seek out the information on their own*".

Some comments offered by the respondents involved practical concerns.

The lady in the mobile home was interested in "*sand bag storage in case of emergency and safe storage of personal effects*".

Another respondent wanted to be able to "*purchase an Earthquake Survival Kit*".

The "*limited mobility of the respondents and the location of their house below sea level*" was a concern for one household.

Another respondent indicated that he/she would like to "*know where and how to shut off the utilities*".

The "*construction of buildings, especially residential, on unstable land*" was a concern of one respondent.

Some respondents in each group did not answer all of the questions on

the questionnaire, especially some of the demographic questions. In Bridgeview one of the respondents took the comment section of the questionnaire and used it as an opportunity to raise her concern about the relevance of the questions about "*income for the household and the education level of the respondent*". It was suggested that the author pass this point on to her superiors, which was done. (The questionnaire was approved by the University Ethics Committee in advance of its distribution.)

### 5.4 Hypothesis Review

A word of caution is needed here, a self-administered questionnaire depends on the respondents being completely honest. To ask a respondent to identify his education and income level, even if anonymity is guaranteed, can leave the respondent feeling vulnerable and unwilling to be fully open to revealing the reality of their situation. The very nature of self-administered questionnaires leaves the results suspect. The researcher is left at the mercy of the integrity of the respondents.

The questionnaire was only answered by a portion of the residents in each of the communities. It is difficult to ascertain whether this is a representative segment of the population. This is especially true in Bridgeview where such a small segment of the households responded to the questionnaire.

Each of the hypotheses refers to the residents of the whole community and it may be a gigantic leap for the researcher and for the reader to assume that the information volunteered by the respondents is relevant to the whole community.

**H 1**

*The hazard knowledge base of the residents in Burkeville will be greater than that of the residents of Bridgeview.*

There was no significant difference between the two populations in terms of their understanding of the history and prediction of earthquakes and how their property will be affected.

When asked to identify how their community would be affected, the two populations were in agreement in the areas of flooding, violent shaking, dike failure, fire and tsunami. However, they did have different concerns about slope failure, which was a concern in Bridgeview, and about liquefaction, which was a concern in Burkeville.

It must be concluded that the HO is invalid. The residents in both communities shared similar knowledge about the local earthquake hazard and only differed in two areas that were readily apparent as being relevant to their respective communities. Bridgeview does have a sloped area and Burkeville is situated on highly liquefiable soils.

**H 2**

*The awareness of risk expressed by the residents in Burkeville will be greater than that expressed by the residents of Bridgeview.*

The respondents of Burkeville, in their comments, indicated that they had considerable knowledge about the way their community would be affected in an earthquake event. There was some misinformation as well, for example the concern expressed by two respondents that a tsunami would seriously affect their community.

Many respondents in Burkeville were active in and/or knew about B.E.R.T. They seemed to be knowledgeable about the need for their community to be prepared for a hazard event that could isolate their community.

In Bridgeview, the level of community involvement in earthquake preparedness was minimal. No information sessions were offered to the

residents within the community that would have increased their awareness of risk.

This hypothesis is supported, Burkeville respondents do have a significantly higher awareness of risk than do Bridgeview respondents.

**H 3**

*The level of salience accorded the hazard as expressed by residents will be greater in Burkeville than that expressed by the residents of Bridgeview.*

A greater proportion of the respondents in Bridgeview took the time to add a personal comment in the comment sections. In their comments, there were more Bridgeview respondents than respondents in Burkeville who expressed an increased concern in the past year about the local earthquake hazard threat. This could indicate an increased concern on the part of the population of Bridgeview, or it could indicate that the residents of Burkeville were already concerned about the local hazard due to their exposure to the activities of B.E.R.T. in the previous two years.

If the respondents in Burkeville have a longer history of concern with, and therefore salience of the earthquake hazard, their level of concern would not have increased in the past year because it was already heightened.

Thus, the respondents of Burkeville could have been more active in community preparedness plans because they were motivated by their awareness of the hazard risk.

It is impossible to discern how much of household and individual awareness in Burkeville is a reflection of an 'island mentality'. They do live on an island and have isolation concerns that are unique to island residents. These concerns could encompass a variety of areas, for example, power outages, service outages, bridge failure, total lack of stores in the community to

provide groceries and water in a isolation event.

A concern for many families would be the separation of family members in a crisis. Most of the adults and children commute away from the island to accomplish their daily work and school activities. What family member will be left at home alone in the next power outage, or, during the next snow storm? These are very real concerns for island residents.

One cannot prove or disprove this hypothesis. There are mixed indications in both communities of hazard salience. On the whole, a larger number of Burkeville respondents appear to have translated their awareness into mitigation actions.

**H 4**

*The awareness of mitigative options available to individual households will be greater among residents of Burkeville than among residents of Bridgeview.*

The awareness of mitigative options was statistically different between the two populations in only seven of the twenty three options presented to the respondents in the questionnaire.

Of these seven, the residents of Burkeville appeared to be more aware of the importance of: *Having a working battery operated radio.; Storing of drinking water.; Participating in community preparedness plans.; Attending neighborhood meetings.; Making emergency procedures within the household.; Making family plans for reunion after an earthquake.; Knowing how to notify rescuers if they do or do not need assistance.*

It can be concluded that the respondents of Burkeville are more aware of the mitigative options available to them than are the respondents of Bridgeview.

**H 5**

*The number of mitigative actions undertaken in individual households will be greater in Burkeville than in Bridgeview.*

Again, as in H4, only seven of the twenty three mitigative options presented display significantly different patterns between the two communities.

65% of the Burkeville respondents have a working battery operated radio and in Bridgeview only 40% of the respondents have one for any reason. When the responses are broken into action taken only for the earthquake hazard these percentages are reduced considerably: 17% in Burkeville and 6% in Bridgeview.

In Burkeville, 34% of the respondents had stored drinking water and in Bridgeview only 20% of the respondents had stored drinking water for any reason. The response rate is 23% in Burkeville and 6% in Bridgeview when the responses are separated to include only the storage of water for earthquake preparedness.

In Burkeville, 30% of the respondents had participated in community preparedness plans due to concern for the earthquake hazard. In Bridgeview only 2% of the respondents indicated that they had done so.

37% of the respondents of Burkeville indicated that they had attended neighborhood meetings over concern for the earthquake hazard. In Bridgeview no one had, nor were there such meetings offered.

28% of Bridgeview respondents had made general plans for emergency procedures within the household; 50% of the Burkeville respondents had done so. When the respondents are identified as having done so only for the earthquake hazard the percentages are 29% in Burkeville and 9% in Bridgeview.

In Burkeville, 47% of the population have made family plans for reunion after a disaster; in Bridgeview 11% of the population had done so. When the family reunion question is applied only to the earthquake hazard, the numbers

change to 33% in Burkeville and none in Bridgeview.

30% of the respondents in Burkeville knew how to notify rescuers regarding their need for assistance; in Bridgeview, only 2% of the respondents knew what to do.

One is left to conclude that H5 is partly supported. The two populations were similar in terms of mitigative action undertaken at the household level. In the seven areas in which there is a statistically significant difference between the two populations, the participation rate was considerably higher in Burkeville.

**H 6**

*The number of mitigative options planned in individual households in Burkeville will be greater than those planned in Bridgeview.*

Again, the two populations are similar in response to mitigative options except in the seven areas mentioned in the discussion of H4 and H5.

In Burkeville 11% of the respondents planned to have a working battery operated radio. In Bridgeview, 32% planned to do so.

The storing of drinking water is planned by 43% of the sample population in Burkeville and 33% of the population in Bridgeview.

In Burkeville 29% of the sample population planned to participate in community preparedness plans, compared to 24% of the population in Bridgeview.

23% of the respondents in Burkeville and 29% of those in Bridgeview planned to attend neighborhood meetings.

In Burkeville 38% of the respondents planned to make emergency procedures in the household and in Bridgeview this represented 42% of the sample claimed such plans.

43% of the respondents planned to make arrangements for a family

reunion after an earthquake in Burkeville; this segment of respondents in Bridgeview is 50%.

In Burkeville, 31% of the respondents planned to learn how to notify rescuers if they did or did not need assistance. In Bridgeview this represented 38% of the respondents.

It is interesting to note that out of five of the seven mitigative options addressed in this section, Bridgeview respondents had chosen more 'plans to do' as an option than had the Burkeville residents. This difference amounts to a reversal of response patterns between the two communities.

It could be due to a number of reasons.

Firstly, more respondents had already participated in mitigative options in Burkeville and 'planning to do' was not an option for them.

Secondly, perhaps the questionnaire had succeeded in raising hazard awareness in Bridgeview and some respondents were prepared to actively seek out both information on community preparedness and were preparing to initiate mitigative options in their homes.

Thirdly, the Bridgeview 'plans' may reflect nothing more than a wish to appear concerned for the the researcher.

Again, a word of caution, 'planning to do' something does not necessarily translate into action on the part of the respondent. Intentions are to be applauded, but action is necessary to give the intention validity.

This hypothesis has not been proven. There is evidence that more respondents in Bridgeview planned to undertake mitigative actions than respondents in Burkeville.

**H 7**

*Increased hazard awareness will be manifested in increased mitigation action in individual households in both communities.*

When all factors are considered it appears that the respondents in Burkeville are more aware of the hazards that may affect them and their community and are more willing to be active participants in making both their community and their households safer.

To date, the respondents in Bridgeview, although expressing concern about the hazard had not taken as many actions to mitigate the hazard at either household or community level.

Thus, awareness does lead to action, although it does not do so in any consistent and uniform fashion.

# 6.0 Conclusion

This study has attempted to assess the relative effectiveness of the "bottom-up" Burkeville disaster planning process and the "top-down" disaster planning process used in Bridgeview.

The respondents in both Burkeville and Bridgeview were aware of the earthquake hazard in terms of past events and how an earthquake would effect their respective communities. The only difference between the two populations were concerns that were site specific - dike failure in Burkeville, and slope failure in Bridgeview.

The level of concern about the effects of a damaging earthquake striking the area was significantly different between the respondents of the two communities. Information regarding twenty three mitigative options was requested from the respondents; the samples were similar in all but seven options. For these seven variables Burkeville respondents had actually instituted more mitigative options but more Bridgeview respondents claimed 'plans to do so'.

The two populations were demographically similar in all areas except for the number of adults in the household, and the number of years in the community.

The comments provided by the respondents shed some additional light on their concerns. Seven respondents in Burkeville were aware of and/or involved in B.E.R.T. There was no evidence of community involvement in earthquake preparedness in Bridgeview, although some respondents stated that Bridgeview should have a community preparedness information session.

The lack of community involvement in Bridgeview appeared to leave the population both more apathetic about the earthquake hazard, and uncertain as

to what to do to make their households and family members safer.

It appears that the "bottom-up" planning process has achieved its goal of transferring responsibility for disaster preparedness onto the community and its residents. Three years after the pilot project was initiated in Burkeville there is a lasting legacy of individual, household, and community preparedness.

In Bridgeview, it was evident that the "top-down" approach had left the community with no preparedness plan and individual households with a knowledge deficit in terms of how to protect themselves and their families.

In order to evaluate the long term effects of the "bottom-up" planning process it would be necessary to reexamine the residents of the community of Burkeville periodically over a number of years. In addition, researchers would need to evaluate activity at the community level in terms of preparedness.

Recent changes in provincial legislation have transferred responsibility for emergency preparedness to the local municipal level. There is a need to evaluate emergency preparedness at the household, community and municipal level over the next decades in order to ascertain if programs yet to be implemented are effective.

Finally, responses obtained in this research indicate that even the "bottom-up" process used in Burkeville might be made more effective. Future research might usefully examine ways of improving this process.

# Appendix A: Earthquake Measurement Scales

**Richter Magnitude Scale (M):** The Magnitude Scale is measured on the logarithmic Richter Scale. Each one point (1.0) increase represents a 10 fold increase in the amount of ground shaking and a 32 fold increase in the amount of energy released (Munich).

**Modified Mercalli Intensity Scale (MM):** The effect of an earthquake, as opposed to its Magnitude, is measured with the help of the Modified Mercalli Scale.

I Not felt except by very few under especially favorable circumstances.

II Felt only by a few persons at rest, especially on upper floors of buildings. Delicately suspended objects may swing.

III Felt quite noticeably indoors, especially on upper floors of buildings, but many people do not recognize it as an earthquake. Standing motor cars may rock slightly. Vibration-like passing of truck. Duration estimated.

IV During the day felt indoors by many, outdoors by few. At night some awakened. Dishes, windows, doors disturbed; walls make creaking sound. Sensation like heavy truck striking building. Standing motor cars rocked noticeably.

V Felt by nearly everyone; many awakened. Some dishes, windows, etc., broken; a few instances of cracked plaster; unstable objects overturned. Disturbance of trees, poles and other tall objects sometimes noticed. Pendulum clocks may stop.

VI Felt by all; many frightened and run outdoors. Some heavy furniture moved; a few instances of fallen plaster or damaged chimneys. Damage slight.

VII Everybody runs outdoors. damage negligible in buildings of good design and construction: slight to moderate in well-built ordinary structures: considerable in poorly built or badly designed structures; some chimneys broken. Noticed by persons driving motor cars.

VIII Damage slight in specially designed structures; considerable in ordinary substantial buildings with partial collapse; great in poorly built structures. Panel walls thrown out of frame structures. Fall of

chimneys, factory stacks, columns, monuments, walls. Heavy furniture overturned. Sand and mud ejected in small amounts. Changes in well water. Persons driving motor cars disturbed.

IX Damage considerable in specially designed structures; well designed frame structures thrown out of plumb; great in substantial buildings, with partial collapse. Buildings shifted off foundations. Ground cracked conspicuously. Underground pipes broken.

X Some well-built wooden structures destroyed; most masonry and frame structures destroyed with foundations, ground badly cracked. Rails bent. Landslides considerable from river banks and steep slopes. Shifted sand and mud. Water splashed (slopped) over banks.

XI Few, if any (masonry), structures remain standing. Bridges destroyed. Broad fissures in ground. Underground pipelines completely out of service. Earth slumps and land slips in soft ground. Rails bent greatly.

XII Damage total. Waves seen on ground surfaces. Lines of sight and level distorted. Objects thrown upward into air.

(Whitham et al, 1970)

# Appendix B: Cover Letters

## Cover Letter Delivered With Questionnaires

July 27, 1993

Dear Householder:

I am a graduate student at Simon Fraser University doing field research into the perception of the local population toward earthquakes.

Attached is a questionnaire I have assembled. With the results from this questionnaire I hope to gain information into how the population perceives this hazard as potentially affecting them, and what steps, if any, that they have taken or intend to take to offset the consequences of any future earthquake events.

I ask that an adult over 18, who is a resident member of your household complete the questionnaire within the next seven days and forward it to the university in the stamped envelope that is provided.

The results of this survey will be sent to your local Emergency Social Services representative, to further facilitate their effort at emergency preparedness within your community. If you would like to personally see the results, please contact me at the university through the Geography Department in January of 1994.

I would like to assure you that this survey will be conducted in such a manner as to guarantee complete anonymity for all participants and their households.

I would like to take this opportunity to thank you for your cooperation in participating in this research.

Sincerely,

C.L. Carnrite
Geography Department
Simon Fraser University

**Reminder Letter Sent to Those Homes That Failed to Respond To The Questionnaire**

August 12, 1993

Dear Householder:

On July 27 a number of questionnaires dealing with the perception of residents towards the local earthquake hazard were delivered at random to households in your community. Your household was one of those chosen to participate in this survey. To date we have not received a response from you. Would you please complete the questionnaire as soon as possible and return it to the university if you have not already done so. If you have misplaced the questionnaire but are willing to complete one, I will forward another copy to you. Please telephone me at home at 936-8336 and leave your address; and I will forward another questionnaire to your household.

If enough households respond to the questionnaire, I hope to: evaluate the effectiveness of Emergency Preparedness Programs, and, to recommend improvements in this programs for the future.

The results of this survey will be sent to your local Emergency Social Services representative. If you would like to personally see the results, please contact me at the university through the Geography Department in January of 1994.

I would like to assure you that this survey will be conducted to guarantee complete anonymity for all participants and their households.

I would like to take this opportunity to thank you for your cooperation in participating in this research.

Sincerely,

C.L. Carnrite
Geography Department
Simon Fraser University

# Appendix C: Sample Questionnaire

Please answer all questions by circling the most appropriate number.

1. To your knowledge has an earthquake occurred in the last 100 years close enough to your community to cause damage?

    1. Yes
    2. No
    3. Uncertain

2. How seriously do you take the prediction of a major earthquake within your lifetime affecting this area?

    1. Very seriously
    2. Seriously
    3. Not very seriously
    4. Don't believe it will occur

3. If a major earthquake happened in this area, how would your property be affected?

    1. No effect
    2. Little effect
    3. Serious effect
    4. Very serious effect
    5. Don't know

4. Would your community be affected by these factors in a major earthquake?

| | Definitely | Probably | Don't Know | Probably Not | Definitely Not |
|---|---|---|---|---|---|
| Flooding | 1 | 2 | 3 | 4 | 5 |
| Violent Shaking | 1 | 2 | 3 | 4 | 5 |
| Dike Failure | 1 | 2 | 3 | 4 | 5 |
| Fire | 1 | 2 | 3 | 4 | 5 |
| Tsunami (Tidal Wave) | 1 | 2 | 3 | 4 | 5 |
| Slope Failure | 1 | 2 | 3 | 4 | 5 |
| Liquefaction (Unstable Soils) | 1 | 2 | 3 | 4 | 5 |

5. During the past year, would you say your concern about a damaging earthquake striking this area, has:

   1. Increased
   2. Decreased
   3. Remained the same

   If your level of concern has changed, please give a brief description of why:

   _____

   _____

6. Below is a list of preparation suggestions that have been made by various agencies and groups that are concerned with earthquake preparedness. Please indicate which answers apply to your household:

| | Have Done For Earthquake | Have Done For Other Reasons | Plan To Do | Don't Plan To Do |
|---|---|---|---|---|
| Have a working flashlight | 1 | 2 | 3 | 4 |
| Have a working battery operated radio | 1 | 2 | 3 | 4 |
| Have a first aid kit | 1 | 2 | 3 | 4 |
| Emergency food stored | 1 | 2 | 3 | 4 |
| Drinking water stored | 1 | 2 | 3 | 4 |
| Secured cupboard latches | 1 | 2 | 3 | 4 |
| Rearranged cupboard contents | 1 | 2 | 3 | 4 |
| Contacted neighbors for information | 1 | 2 | 3 | 4 |
| Participated in community preparedness plans | 1 | 2 | 3 | 4 |
| Attended neighborhood meetings | 1 | 2 | 3 | 4 |
| Inquired about earthquake insurance | 1 | 2 | 3 | 4 |
| Purchased earthquake insurance | 1 | 2 | 3 | 4 |
| Structurally reinforced home | 1 | 2 | 3 | 4 |
| Secured water heater | 1 | 2 | 3 | 4 |
| Secured heavy furniture and and appliances | 1 | 2 | 3 | 4 |

| | Have Done For Earthquake | Have Done For Other Reasons | Plan To Do | Don't Plan To Do |
|---|---|---|---|---|
| Instructed household members on what to do in an earthquake | 1 | 2 | 3 | 4 |
| Made emergency procedures within the household | 1 | 2 | 3 | 4 |
| Made family plans for reunion after an earthquake | 1 | 2 | 3 | 4 |
| Know when to shut off utilities going into your house | 1 | 2 | 3 | 4 |
| Know how to shut off utilities going into your house | 1 | 2 | 3 | 4 |
| Have taken a basic First Aid course | 1 | 2 | 3 | 4 |
| Know how to notify rescuers if you do or do not need assistance | 1 | 2 | 3 | 4 |
| If you have children, know the emergency provisions in place at their school(s) | 1 | 2 | 3 | 4 |

I would like to take this opportunity to thank you for taking the time to complete this questionnaire.

If you have any comments to make about the earthquake hazard in your community, I would appreciate hearing them. Please write them down in the space provided below.

Thank you.

_____

_____

_____

_____

_____

In order to give the data collected some meaning, I need to know a little about you, the respondent and about your household. I would like to assure you that all questionnaires will remain anonymous. Please circle the appropriate response.

1. Gender:

    1. Male
    2. Female

2. Age:

   1. 18-24
   2. 25-34
   3. 35-44
   4. 45-54
   5. 55-64
   6. 65+

3. Number of adults (18 and over) living in your household: _____

   Number of children (under 18) living in your household: _____

4. Income per household per year:

   1. Under $10,000.00
   2. $10,000.00 - $19,999.00
   3. $20,000.00 - $29,999.00
   4. $30,000.00 - $39,999.00
   5. $40,000.00 - $49,999.00
   6. $50,000.00 and over

5. Highest education level you have achieved:

   1. Secondary school or less
   2. Trade certificate or diploma
   3. Other non-university education
   4. Some university
   5. University with a degree granted
   6. Graduate degree

6. How many years have you lived in this community? _____ years

7. What type of structure is your place of residence?

   1. Single family house
   2. Duplex
   3. Apartment
   4. Other, please specify: _____

8. Do you rent or own your residence?

   1. Rent
   2. Own

9. What type of construction is your place of residence?

   1. Wood frame
   2. Concrete masonry
   3. Other, please specify _____

## Appendix D: Comments Written on Questionnaires

DURING THE PAST YEAR, WOULD YOU SAY YOUR CONCERN ABOUT A DAMAGING EARTHQUAKE STRIKING THIS AREA, HAS:

1. INCREASED
2. DECREASED
3. REMAINED THE SAME

BRIDGEVIEW - SURREY

2 - 1. As older people, we are not nimble anymore. Previously we owned a home on high ground in Burnaby.

30 - 1. Happenings in the world and Frisco quake.

34 - 1. I read in the newspaper that an earthquake is supposed to strike this area.

39 - 1. We are on a fault. Recent San Francisco earthquake. Media reports " the big one coming" within the next 500 years.

43 - 1. We've moved from a townhouse to a house that backs on a ravine.

66 - 1. TV programs and info about the San Francisco 1989 quake.

76 - 3. Can't tell what will happen with the weather the way it is.

91 - 1. Because of the shifting of the plates and predictions from experts in the field saying that within the period of approximately 300 years there will be a major earthquake. Note: And the knowledge that the lower mainland is not prepared for such a event.

96- 1. Previous history.

115- 1. With more quakes happening around the world, we hear more people telling us to be prepared.

139- 1. Media talk of anticipation, also activity recently seen in lower Andreas Fault (CA) and Pacific Rim.

159- 1. I get more and more scared hearing all these other places being destroyed.

163- 1. Other natural disasters elsewhere and because of the nature of our grounds in the river estuary.

174- 1. Just moved to B.C. about one year ago. Hadn't really thought about earthquake much up to that point.

182- 1. The weather pattern has altered in B.C. The disasters happening all over the world. The end of the world is happening.

209- 1. Media attention to this factor, plus various earthquakes around the world.

BURKEVILLE - RICHMOND

15 - 3. At age 76 my years are numbered.

30 - 3. Due for one. Other areas have had them, U.S. States and up North.

33 - 1. The frequency of earthquakes around the world seems to be increasing.

38 - 1. Participated in beginning of Burkeville Disaster Planning. Earthquake approximately 3 years ago.

40 - 2. Earthquake study here is still preliminary. New information indicates uncertainty of previous conventional thought.

59 - 1. News media stressing the inevitability of an earthquake.

60 - 1. We're below sea level here. (On Sea Island)

61 - 2. Media has changed. Program in area decreased.

75 - 1. My husband talking about it.

87 - 1. Exposure to local E.R.T. and worldwide media attention re: natural disasters.

92 - ?. Recent earthquakes in California and Northern Japan. Where will the next one strike? One also in Alaska in '63.

96 - 1. Hearing more on radio, TV, etc.

122- 1. I am a member of B.E.R.T. (Burkeville Emergency Response Team) and I am attempting to raise awareness here by doing a similar survey of homes.

124- 1. San Franciso.

125- 1. Our community has developed an emergency earthquake preparedness plan.

136- 1. More awareness has been given to me to cause me to feel more concerned.

**********

IF YOU HAVE ANY COMMENTS TO MAKE ABOUT THE EARTHQUAKE HAZARD IN YOUR COMMUNITY, I WOULD APPRECIATE HEARING THEM.

BRIDGEVIEW - SURREY

2. My husband is in a wheelchair, I have trouble walking and I want to leave this area for higher ground as soon as possible. What can we do? I have water, extra food, battery radio. Bridgeview is below river level.

66. A series of Info seminars held at local library and/or community centers on what to do and how to do it re: earthquakes. Also written info sent to every household.

113. Your questionnaire has made me wonder:
What are the odds?
and
Where, and how do I shut off the utilities?
In future I would appreciate answers to these questions.

115. Where do I find out info on what areas in the lower mainland are most likely to be hit the hardest in an earthquake. A big hazard, I feel is people like myself - aren't sure if we should be seriously prepared for an earthquake as it "seems" so unlikely to happen. (?)

123. I would like to know if there is a community preparedness center in any area, if so, where are they located. Also, it will be handy to organize a community preparedness meeting in our community.

174. While I have heard mention of earthquake education sessions, etc. the profile seems to be fairly low. I realize the risk does exist but find it difficult to take it seriously. It certainly isn't a preoccupation of mine. Perhaps if I didn't have to seek out info and it was more readily available I may feel differently.

175. To be able to purchase Earthquake Survival Kit. Thanks.

182. Being close to the river I would like to have sand bags available to Phillip's Mobile Home Park on the King George Highway as soon as possible, or a storage place made ready for residents.

209. I was happy to answer your questionnaire. However I was far from happy with questions #4 and #5 on this sheet I feel you will get more responses if you omit these questions. They are too personal and I feel, far from relevant. I was tempted to tear this up instead of mailing to you. I suggest you pass my views to your superiors as I feel it is important.

220. No new buildings on unstable land - especially residential!

BURKEVILLE - RICHMOND

8. Bridges from Richmond to rest of mainland may not be able to withstand a heavy quake. I have been led to understand that Sea Island area wouldn't liquefy as badly as areas east of #4 Road.

20. We will have not too many problems (I hope) but our neighbour will have our fireplace in his living room.

30. I missed the last earthquake meeting.

36. About skyscraper structures in Vancouver, I fear that they are fabricated only by thin round iron wires not by steels of heavy H character's style. Are they safe on structural studies?

38. Have some knowledge as per above, participated in original door to door convassing.

61. I'm struggling to survive. I don't have to be reminded of unpredictable possibilities.

71. Every household in our community has been contacted by the Disaster Emergency Response Team - some apathy, but a working group has been in place for about three years. (Red Cross training, First Aid, etc. Enquiry and Registration practice, all nurses and doctors living in our community listed.) We work in cooperation with Richmond Disaster team - close liaison. This government group has been working and investigating for several years.

75. Living on Sea Island - we wish there was more advertised seminars going on....

87. Your questionnaire prompted some discussion about our household plans re: earthquake event and we have made some changes. Thanks and sorry about being so late in finishing your questionnaire.

92. Living on Sea Island we are surrounded by water. Hoping the bridges are not affected so there can be some hope to escape in case of tidal wave that engulfed Nanaimo in 1963.

104. I feel that perhaps the best way to get pertinent earthquake information to the people in the Richmond area is to prepare a very readable and informative report for the local Richmond paper to publish.

122. Possible isolation of Sea Island due to bridge failure or tidal wave. Possible flooding hazard on Sea Island if dikes fail at high tide - combined with possible aviation fuel spill - dispersed by flood water - large fire threat? Very large population of air travellers trapped on Sea Island. suggestions to aid recovery: If available the large vacuum tank trucks could be used to assist in debris/slurry removal to rescue victims trapped in mud etc. Jet skis would be excellent transportation in shallow flooding on low lands.

125. I know we have a program in place in our community but sometimes I wonder how much concern I should actually have. I am more aware now that we have a small child and will plan to do more.

135. I don't think it will happen, but if it did, there's not much we could do because Sea Island is so low and flat, we would probably all get washed away by a tsunami anyway.

136. How do we notify rescue workers if I do or don't need assistance?

## Appendix E: Statistical Results

1. To your knowledge has an earthquake occurred in the last 100 years close enough to your community to cause damage?

| Burkeville | Bridgeview | |
|---|---|---|
| 16 | 13 | 1. Yes |
| 30 | 23 | 2. No |
| 12 | 16 | 3. Uncertain |

Chi-Square = 1.483
P = 0.4763

2. How seriously do you take the prediction of a major earthquake within your lifetime affecting this area?

| Burkeville | Bridgeview | |
|---|---|---|
| 13 | 10 | 1. Very seriously |
| 33 | 25 | 2. Seriously |
| 12 | 17 | 3. Not very seriously/Don't believe it will occur |

Chi Square = 2.036
P = 0.3614

3. If a major earthquake happened in this area, how would your property be effected?

| Burkeville | Bridgeview | |
|---|---|---|
| 3 | 8 | 1. No effect/Little effect |
| 25 | 18 | 2. Serious effect |
| 20 | 15 | 3. Very serious effect |

Chi Square = 3.598
P = 0.1654

**4. Would your community be affected by these factors in a major earthquake?**

A. Flooding

| Burkeville | Bridgeview | |
|---|---|---|
| 31 | 20 | 1. Definitely |
| 19 | 20 | 2. Probably |
| 4 | 8 | 3. Probably not/Definitely not |

Chi Square = 3.606
P = 0.4619

B. Violent Shaking

| Burkeville | Bridgeview | |
|---|---|---|
| 25 | 23 | 1. Definitely |
| 26 | 21 | 2. Probably |

Chi Square = 0.1
P = 0.7518

**C. Dike Failure**

| **Burkeville** | **Bridgeview** | |
|---|---|---|
| **22** | **8** | **1. Definitely** |
| **20** | **10** | **2. Probably** |
| **6** | **16** | **3. Probably Not/Definitely Not** |

**Chi-Square = 12.383**
**P = 0.002**

D. Fire

| Burkeville | Bridgeview | |
|---|---|---|
| 5 | 10 | 1. Definitely |
| 25 | 24 | 2. Probably |
| 9 | 6 | 3. Probably not/Definitely not |

Chi Square = 2.275
P = 0.3207

E. Tsunami (Tidal Wave)

| Burkeville | Bridgeview | |
|---|---|---|
| 10 | 4 | 1. Definitely |
| 12 | 9 | 2. Probably |
| 19 | 23 | 3. Probably not/Definitely not |

Chi Square = 3.069
P = 0.2155

**F. Slope Failure**

| **Burkeville** | **Bridgeview** | |
|---|---|---|
| **4** | **11** | **1. Definitely** |
| **5** | **11** | **2. Probably** |
| **18** | **7** | **3. Probably Not** |
| **12** | **7** | **4. Definitely Not** |

**Chi-Square = 11.571**
**P = 0.009**

G. Liquefaction

| Burkeville | Bridgeview | |
|---|---|---|
| 25 | 27 | 1. Definitely |
| 23 | 10 | 2. Probably |

Chi Square = 3.839
P = 0.0501

5. During the past year, would you say your concern about a damaging earthquake striking this area, has:

| Burkeville | Bridgeview | |
|---|---|---|
| 12 | 20 | 1. Increased |
| 42 | 32 | 2. Remained the same |

Chi Square = 3.315
P = 0.0687

**********

**6. Below is a list of preparation suggestions that have been made by various agencies and groups that are concerned with earthquake preparedness. Please indicate which answers apply to your household:**

A. Have a working flashlight

| Burkeville | Bridgeview | |
|---|---|---|
| 11 | 4 | 1. Have Done For Earthquake |
| 38 | 38 | 2. Have Done For Other Reasons |

Chi-Square = 2.744
P = 0.0976

**B. Have a working battery operated radio**

| **Burkeville** | **Bridgeview** | |
|---|---|---|
| **35** | **19** | **1. Have Done For Earthquake/ Other Reasons** |
| **6** | **15** | **2. Plan To Do** |
| **13** | **13** | **3. Don't Plan To Do** |

**Chi-Square = 8.152**
**P = 0.017**

C. Have a first aid kit

| Burkeville | Bridgeview | |
|---|---|---|
| 34 | 31 | 1. Have Done For Earthquake/Other Reasons |
| 12 | 14 | 2. Plan To Do |

Chi Square = 0.281
P = 0.5958

D. Emergency food saved

| Burkeville | Bridgeview | |
|---|---|---|
| 28 | 17 | 1. Have Done For Earthquake/Other Reasons |
| 15 | 14 | 2. Plan To Do |
| 13 | 18 | 3. Don't Plan To Do |

Chi Square = 3.077
P = 0.2147

**E. Drinking water stored**

| **Burkeville** | **Bridgeview** | |
|---|---|---|
| **19** | **9** | **1. Have Done For Earthquake/ Other Reasons** |
| **24** | **15** | **2. Plan To Do** |
| **13** | **22** | **3. Don't Plan To Do** |

**Chi-Square = 7.05**
**P = 0.0295**

F. Secured cupboard contents

| Burkeville | Bridgeview | |
|---|---|---|
| 5 | 5 | 1. Have Done For Other Reasons |
| 11 | 10 | 2. Plan To Do |
| 36 | 33 | 3. Don't Plan To Do |

Chi-Square = 0.018
P = 0.991

G. Rearranged cupboard contents

| Burkeville | Bridgeview | |
|---|---|---|
| 9 | 15 | 1. Plan To Do |
| 39 | 28 | 2. Don't Plan To Do |

Chi-Square = 3.04
P = 0.0812

H. Contacted neighbors for information

| Burkeville | Bridgeview | |
|---|---|---|
| 8 | 3 | 1. Have Done For Earthquake |
| 4 | 8 | 2. Plan To Do |
| 36 | 32 | 3. Don't Plan To Do |

Chi-Square = 3.577
P = 0.1672

**I. Participated in community preparedness plans**

| **Burkeville** | **Bridgeview** | |
|---|---|---|
| **19** | **1** | **1. Have Done For Earthquake** |
| **15** | **11** | **2. Plan To Do** |
| **18** | **33** | **3. Don't Plan To Do** |

**Chi-Square = 20.83**
**P = 0.0001**

**J. Attended neighborhood meetings**

| **Burkeville** | **Bridgeview** | |
|---|---|---|
| **30** | **12** | **1. Have Done For Earthquake/ Plan To Do** |
| **22** | **30** | **2. Don't Plan To Do** |

**Chi-Square = 7.971**
**P = 0.0048**

K. Inquired about earthquake insurance

| Burkeville | Bridgeview | |
|---|---|---|
| 26 | 18 | 1. Have Done For Earthquake |
| 11 | 9 | 2. Plan To Do |
| 15 | 18 | 3. Don't Plan To Do |

Chi-Square = 1.43
P = 0.4893

L. Purchased earthquake insurance

| Burkeville | Bridgeview | |
|---|---|---|
| 22 | 16 | 1. Have Done For Earthquake |
| 10 | 8 | 2. Plan To Do |
| 20 | 20 | 3. Don't Plan To Do |

Chi-Square = 0.506
P = 0.7763

M. Structurally reinforced home

| Burkeville | Bridgeview | |
|---|---|---|
| 8 | 3 | 1. Have Done For Other Reasons |
| 8 | 11 | 2. Plan To Do |
| 36 | 28 | 3. Don't Plan To Do |

Chi-Square = 2.713
P = 0.2575

N. Secured water heater

| Burkeville | Bridgeview | |
|---|---|---|
| 4 | 6 | 1. Have Done For Earthquake |
| 19 | 9 | 2. Plan To Do |
| 26 | 26 | 3. Don't Plan To Do |

Chi-Square = 3.286
P = 0.1934

O. Secured heavy furniture and appliances

| Burkeville | Bridgeview | |
|---|---|---|
| 9 | 10 | 1. Plan To Do |
| 40 | 31 | 2. Don't Plan To Do |

Chi-Square = 0.486
P = 0.4856

P. Instructed household members on what to do in an earthquake

| Burkeville | Bridgeview | |
|---|---|---|
| 28 | 16 | 1. Have Done For Earthquake/Other Reasons |
| 16 | 16 | 2. Plan To Do |
| 5 | 12 | 3. Don't Plan To Do |

Chi-Square = 5.903
P = 0.0523

**Q. Made emergency procedures within the household**

| **Burkeville** | **Bridgeview** | |
|---|---|---|
| **24** | **12** | **1. Have Done For Earthquake/ Other Reasons** |
| **24** | **31** | **2. Plan To Do/Don't Plan To Do** |

**Chi-Square = 5.16**
**P = 0.023**

**R. Made family plans for reunion after an earthquake**

| Burkeville | Bridgeview | |
|---|---|---|
| **23** | **5** | **1. Have Done For Earthquake/ Other Reasons** |
| **16** | **22** | **2. Plan To Do** |
| **10** | **17** | **3. Don't Plan To Do** |

**Chi-Square = 14.106**
**P = 0.0009**

S. Know when to shut off utilities going into your house

| Burkeville | Bridgeview | |
|---|---|---|
| 38 | 42 | 1. Have Done For Earthquake/Other Reasons |
| 12 | 11 | 2. Plan To Do |

Chi-Square = 0.156
P = 0.6926

T. Know how to shut off utilities going into your house

| Burkeville | Bridgeview | |
|---|---|---|
| 22 | 31 | 1. Have Done For Earthquake/Other Reasons |
| 19 | 16 | 2. Plan To Do |

Chi-Square = 1.383
P = 0.2396

U. Have taken a basic First Aid course

| Burkeville | Bridgeview | |
|---|---|---|
| 32 | 24 | 1. Have Done For Other Reasons |
| 3 | 9 | 2. Plan To Do |
| 11 | 12 | 3. Don't Plan To Do |

Chi-Square = 74.176
P = 0.1239

**V. Know how to notify rescuers if you do or do not need assistance**

| Burkeville | Bridgeview | |
|---|---|---|
| **16** | **1** | **1. Have Done For Earthquake** |
| **13** | **19** | **2. Have Done For Other Reasons** |
| **25** | **25** | **3. Plan To Do/Don't Plan To Do** |

**Chi-Square = 13.655**
**P = 0.0011**

W. If you have children, know the emergency provisions in place at their school(s)

| Burkeville | Bridgeview | |
|---|---|---|
| 7 | 3 | 1. Have Done For Earthquake |
| 7 | 11 | 2. Plan To Do |
| 1 | 2 | 3. Don't Plan To Do |

Chi-Square = 2.793
P = 0.2475

**********

## Demographic Information

1. Gender

| Burkeville | Bridgeview | |
|---|---|---|
| 24 | 21 | 1. Male |
| 29 | 26 | 2. Female |

Chi-Square = 0.004
P = 0.9518

2. Age

| Burkeville | Bridgeview | |
|---|---|---|
| 2 | 6 | 1. 18 - 24 Years |
| 19 | 15 | 2. 25 - 34 Years |
| 16 | 13 | 3. 35 - 44 Years |
| 7 | 8 | 4. 45 - 54 Years |
| 14 | 8 | 5. 55 Years And Over |

Chi-Square = 3.913
P = 0.4179

**3a. Number of adults (18 and over) living in your household: ____**

| **Burkeville** | **Bridgeview** | |
|---|---|---|
| **8** | **10** | **1. One Person Per Household** |
| **47** | **31** | **2. Two Persons Per Household** |
| **2** | **8** | **3. Three Or More Persons Per Household** |

**Chi-Square = 6.538**
**P = 0.038**

3b. Number of children (under 18) living in your household: _____

| Burkeville | Bridgeview | |
|---|---|---|
| 38 | 33 | 1. No Children |
| 7 | 7 | 2. One Child |
| 13 | 12 | 3. Two Or More Children |

Chi-Square = 0.065
P = 0.968

4. Income per household per year:

| Burkeville | Bridgeview | |
|---|---|---|
| 5 | 8 | 1. Under $19,999 |
| 10 | 4 | 2. $20,000 to $29,999 |
| 10 | 9 | 3. $30,000 to $39,999 |
| 7 | 15 | 4. $40,000 to $49,999 |
| 19 | 9 | 5. $50,000 Or More |

Chi-Square = 9.459
P = 0.0506

5. Highest education level you have achieved:

| Burkeville | Bridgeview | |
|---|---|---|
| 9 | 11 | 1. Secondary school or less |
| 13 | 11 | 2. Trade certificate or diploma |
| 15 | 9 | 3. Other non-university education |
| 11 | 5 | 4. Some university |
| 2 | 10 | 5. University with a degree granted |
| 5 | 2 | 6. Graduate degree |

Chi-Square = 10.308
P = 0.067

**6. How many years have you lived in this community? ___ years**

| **Burkeville** | **Bridgeview** | |
|---|---|---|
| **26** | **35** | **1. One To Five Years** |
| **31** | **13** | **2. More Than Five Years** |

**Chi-Square = 7.98**
**P = 0.0047**

7. What type of structure is your place of residence?

| Burkeville | Bridgeview | |
|---|---|---|
| 56 | 45 | 1. Single family house |
| 2 | 6 | 2. Other |

Chi-Square = 2.76
P = 0.0967

8. Do you rent or own your residence?

| Burkeville | Bridgeview | |
|---|---|---|
| 7 | 11 | 1. Rent |
| 51 | 40 | 2. Own |

Chi-Square = 1.776
P = 0.1826

9. What type of construction is your place of residence?

| Burkeville | Bridgeview | |
|---|---|---|
| 56 | 42 | 1.Wood frame |
| 1 | 4 | 2. Other |

Chi-Square = 2.656
P = 0.1032

# Bibliography

Adams, J. 1990. Paleoseismicity of the Cascadia Subduction Zone: Evidence from Turbidities Off the Oregon-Washington Margin. Tectonics 9:4:569-583.

Adams, J. 1984. Active Deformation of the Pacific Northwest Continental Margin. Tectonics 3:4:449-472.

Agnos, A. 1990. First Word. Omni 12:8.

Anderson, I. and M. Cross. 1988. World faces growing quake threat. Science 120:3-4.

Anderson, P., N. Edelson, B. Hansen, R. Harding, K. Huhtala and L. Laughy. 1990. Hazard Management Planning in British Columbia: Issues and Challenges. Emergency Preparedness Planning Series. UBC Center for Human Settlements, Vancouver, B.C.

Ando, A. and E.I. Balazs. 1979. Geodetic Evidence for Aseismic Subduction of the Juan de Fuca Plate. Journal of Geophysical Research 84:B6:3023-3028.

Armstrong, J.E. 1956. Surficial Geology of Vancouver Area British Columbia. Geological Survey of Canada Paper 55-40, Ottawa, Ontario.

Association of Professional Engineers of the Province of British Columbia. 1988. Seismic Risk in British Columbia. Brief to the British Columbia Government.

Atwater, B.F. 1987. Evidence for Great Holocene Earthquakes Along the Outer Coast of Washington State. Science 236:942-944.

Basham, P.W. 1983. New Seismic Zoning Maps of Canada. Geos 12:3:10-12.

Barnard, W.D. 1978. The Washington Continental Slope: Quaternary Tectonics and Sedimentation. Marine Geology 27:79-114.

Beatley, T. 1988. Ethical Dilemmas in Hazard Management. Natural Hazards Observer XII:5:1-3.

Bernknopf, R.L. 1990. An Economic Evaluation of Changes in Risk Perceptions. Journal of Environment, Economy and Management 18:35-49.

Bilham, R. 1988. Earthquakes and urban growth. Nature 336:625-626.

Blackwell, D.D., R.G. Bowen, D.A. Hull, J. Riccio and J.L. Steele. 1982. Heat Flow, Arc Volcanism, and Subduction in Northern Oregon. Journal of Geophysical Research 67:810:8735-8754.

Blunden, R.H. 1973. Urban Geology of Richmond, British Columbia. Report No. 15, Department of Geological Sciences, UBC, Vancouver, B. C.

Bolt, B.A. 1991. Balance of Risks and Benefits in Preparation for Earthquakes. Science 251:169-174.

British Columbia Professional Fire Fighters Association. 1991. Emergency Preparedness Manual. Stuart-Bradley Productions Inc., Canada.

British Columbia Emergency Program Act (1993), A Guide to. 1995. Emergency Preparedness Information Exchange. Center for Policy Research on Science and Technology, Simon Fraser University, [http://hoshi.cic.sfu.ca/epix].

Brookshire, D.S., M.A. Thayer, J. Tschirhart and W.D. Schulze. 1985. A Test of the Expected Utility Model: Evidence from Earthquake Risks. Journal of Political Economy 93:2:369-389.

Burkeville Emergency Response Plan. 1991.

Burton, I. 1989. The Criterion of "Reasonableness" in the Communication of Risk Information. In: "Prospects and Problems in Risk Communication". W. Leiss (ed.). University of Waterloo Press, Waterloo. pp 211-216.

Burton, I. 1970. The Social Role of Attitude and Perception Studies. In: "Perceptions and Attitudes in Resources Management". W.R.D. Sewell and I. Burton (ed.). Resource Paper No. 2, Policy Research and Coordination Branch, Department of Energy, Mines and Resources, Ottawa, Canada. pp 1-6.

Burton, I. and R.W. Kates. 1964. The Perception of Natural Hazards in Resource Management. Natural Resources Journal 3:412-441.

Burton, I., R.W. Kates and G.F. White. 1978. The Environment As Hazard. Oxford University Press, London.

Byrne, P.M. 1976. The Earthquake Hazard in the Fraser Delta. Department of Civil Engineering, UBC, Vancouver, B.C.

Byrne, P.M. and D.L. Anderson. 1987. Earthquake Design in Richmond, B.C. Department of Civil Engineering, UBC, Vancouver, B.C.

Byrne, P.M., J.J. Clague, J. Luternauer and E. Naesgaard. 1992. Technical Tour No. 3: Fraser River Delta. In Technical Tours Guidebook, May 7, 1992. BiTech Publishers Ltd., Vancouver, B.C. pp 101-119.

Byrne, P.M. and T. Srithar. 1992. Assessment of Foundation Treatment for Liquefaction. In Proceedings of the Symposium of Geotechnique and Natural Hazards, BiTech Publishers Ltd., Vancouver, B.C. pp 263-271.

Calvert, A.J. and R.M. Clowes. 1991. Seismic evidence for the migration of fluids within the accretionary complex of western Canada. Canadian Journal of Earth Sciences 28:542-556.

Campbell, D.D. and J.L. Rotzien. 1992 Deterministic Basis for Seismic Design in B.C. In Proceedings of the Symposium of Geotechnique and Natural Hazards, BiTech Publishers Ltd., Vancouver, B.C. pp 71-80.

Cave, P.W. 1992. Natural Hazards, Risk assessment and land use planning in British Columbia: Progress and Problems. In Proceedings of the Symposium of Geotechnique and Natural Hazards, BiTech Publishers Ltd., Vancouver, B.C. pp 1-11.

Charlwood, R.G. and G.M. Atkinson. 1983. Earthquake Hazards in British Columbia. The BC Professional Engineer December:14-16.

Clague, J.J., J.L. Luternauer and R.F. Hebda. 1983. Sedimentary environments and postglacial history of the Fraser Delta and lower Fraser Valley, British Columbia. Canadian Journal of Earth Science 20:1314-1326.

Clague, J.J., E. Naesgaard and A. Sy. 1992. Liquefaction features on the Fraser delta: evidence for prehistoric earthquakes? Canadian Journal of Earth Science 28:8:1734-1745.

Clary, B.B. 1985. The Evolution and Structure of Natural Hazard Policies. Public Administration Review 45:20-28.

Cluff, L.S. 1992. Politics of seismic safety decision making. In Proceedings of the Symposium of Geotechnique and Natural Hazards, BiTech Publishers Ltd., Vancouver, B.C. pp 13-30.

Comfort, L.K. 1985. Integrating Organizational Action in Emergency Management; Strategies for Change. Public Administration Review 45:155-164.

Cooper, F.D. 1988. Canada. In Proceedings of the Western States Seismic Policy Council, The State of Hawaii and the Federal Emergency Management Agency:148-150.

Cooper, F.D. 1986. The Prediction No one Wants to Hear: The Great 'Quake. Emergency Preparedness Digest July/September.

Covello, V.T. 1989. Informing People About Risks from Chemicals, Radiation, and Other Toxic Substances: A Review of Obstacles to Public Understanding and Effective Risk Communication. In: "Prospects and Problems in Risk Communication". W. Leiss (ed.). University of Waterloo Press, Waterloo. pp 1-49.

Covello, V.T. 1987. Introduction - Case Studies of Risk Communication. In: "Risk Communication". J.C. Davies, V.T. Covello and F.W. Allen (eds.). The Conservation Foundation, Washington, D.C. pp 63-65.

Covello, V.T., D. von Winterfeldt and P. Slovic. 1987. Communicating Scientific Information about Health and Environmental Risks: Problems and Opportunities from a Social and Behavioral Perspective. In: "Prospects and Problems in Risk Communication". W. Leiss (ed.). University of Waterloo Press, Waterloo. pp 109-134.

Davies, J.C., V.T Covello and F.W. Allen (eds.). 1987. Risk Communication. The Conservation Foundation, Washington, D.C.

Davis, E.E., R.G. Currie, R.P. Riddihough and B.S. Sawyer. 1985. A New Look at the Juan de Fuca Ridge. Geos 2:10-15.

Davis, E.E. and R.P. Riddihough. 1982. The Winona Basin: structure and tectonics. Canadian Journal of Earth Sciences 19:767-788.

Dehler, S.A. and R.M. Clowes. 1988. The Queen Charlotte Island refraction project. Part I. The Queen Charlotte Fault Zone. Canadian Journal of Earth Sciences 25:1857-1870.

Drabek, T.E. 1985. Managing the Emergency Response. Public Administration Review 45:85-90.

Dragert, H. 1987. The fall (and rise) of central Vancouver Island: 1930-1985. Canadian Journal of Earth Sciences 24:689-697.

Dragert, H. and G.C. Rogers. 1988. Could a megathrust earthquake strike southwestern British Columbia? Geos 17:3:5-8.

Dynes, R.R. 1970. Organized Behavior in Disaster. Heath Lexington Books, Lexington, Mass.

Ellson, R.W., J.W. Milliman and R.B. Roberts. 1984. Measuring the Regional Economic Effects of Earthquakes and Earthquake Predictions. Journal of Regional Science 24:4:559-579.

Emergency Preparedness Canada. 1989. Canadians Polled on Emergency Preparedness. Emergency Preparedness Digest 16:2:37.

Faupel, C.E. and S.P. Styles. 1993. Disaster Education, Household Preparedness, and Stress Responses Following Hurricane Hugo. Environment and Behavior 25:2:228-249.

Federal Emergency Preparedness in Canada, A Summary. 1995. Emergency Preparedness Information Exchange. Center for Policy Research on Science and Technology, Simon Fraser University, [http://hoshi.cic.sfu.ca/epix].

Feitelson, E. 1991. The Potential of Mail Surveys in Geography: Some Empirical Evidence. Professional Geographer 43:2:190-205.

Fifield, R. 1990. The calm that comes before the quake. Science 126:36.

Fisher, J.D., P.A. Bell and A. Baum. 1984. Environmental Psychology, 2nd Ed. Holt Rinehart and Winston, New York.

Foster, H.D. 1987. Disaster Mitigation: A Geomorphological Contribution. Emergency Planning Digest October/December:2-9.

Foster, J.D. and N.E. Hardy. 1989. B.C. Ministry of Health Carves New Path in Emergency Preparedness. Emergency Preparedness Digest 16:2:18-20.

Frankel, J. 1988. From continental drift to plate tectonics. Nature 335:127-130.

Godschalk, D.R. and D.J. Brower. 1985. Mitigation Strategies and Integrated Emergency Management. Public Administration Review 45:64-71.

Government of Canada. 1989. Earthquakes in Canada. Geofacts, Energy, Mines and Resources Canada.

Gronbeck-Jones, D. 1989. British Columbia Report. In: Anticipating Earthquakes: Risk Reduction Policies and Practices in the Puget Sound and Portland Areas. In Proceedings on the Western States Seismic Policy Council, XII Annual Meeting, Bureau of Disaster Services in cooperation with Idaho Geological Survey.

Gruntest, E. and C. Huber. 1989. Status Report on Flood Warning Systems in the United States. Environmental Management 13:3:279-286.

Guelke, L. 1985. On the Role of Evidence in Physical and Human Geography. Geoforum 16:2:131-137.

Hamilton, R. 1976. Catastrophe and Communication. Natural Hazards Observer 1:1:1-2.

Hannigan, F.A. and R.M. Kueneman. 1978. Anticipating Flood Emergencies: A Case Study of a Canadian Disaster Subculture. In: "Disasters - Theory and Research:. E.L. Quarantelli (ed.). Sage Publications Ltd., London.

Harris, S.L. 1988. The Pacific Northwest: Due for Giant Earthquakes/ American West 25:42-43.

Harris, S.L. 1984-85. Earthquake Hazards in the West. American West 21:28-36.

Hart, B.S., D.B. Prior, T.S. Hamilton, J.V. Barrie and R.G. Currie. 1992. Patterns and Styles of Sedimentation, Erosion and Failure, Fraser Delta Slope, British Columbia. In Proceedings of the Symposium of Geotechnique and Natural Hazards, BiTech Publishers Ltd., Vancouver, B.C. pp 365-372.

Hartzell, S.H. and T.H. Heaton. 1986. Teleseismic Time Functions for Large, Shallow Subduction Zone Earthquakes. Bulletin of Seismological Society of America 75:965-1004.

Hays, W.W. (Editor). 1989. Proceedings of Conference XLVIII, 3RD Annual Workshop on "Earthquake Hazards in the Puget Sound, Portland Area". United States Department of the Interior Geological Survey, Open-File Report 89-465.

Heaton, T.H. 1990. The calm before the quake? Nature 343:511-512.

Heaton, T.H. and S.H. Hartzell. 1987. Earthquake Hazards on the Cascadia Subduction Zone. Science 236:162-168.

Heaton, T.H. and S.H. Hartzell. 1986. Source Characteristics of Hypothetical Subduction Earthquakes in the Northwestern United States. Bulletin of the Seismological Society of America 76:3:675-708.

Heaton, T.H. and H. Kanamori. 1984. Seismic Potential Associated with Subduction in the Northwestern United States. Bulletin of the Seismological Society of America 74:3:933-941.

Heaton, T.H. and P.D. Snavely, Jr. 1985. Possible Tsunami along the Northwestern Coast of the United States Inferred from Indian Traditions. Bulletin of the Seismological Society of America 76:1455-1460.

Hebenstreit, G.T. and T.S. Murty. 1989. Tsunami Amplitudes from Local Earthquakes in the Pacific Northwest Region of North America, Part 1: The Outer Coast. Marine Geodesy 13:101-146.

Hickson, C.J. 1992. Volcanism in the Canadian Cordillera: Should we worry? In Proceedings of the Symposium of Geotechnique and Natural Hazards, BiTech Publishers Ltd., Vancouver, B.C. pp 31-40.

Hickson, C. 1990. Can It happen Here? Geos 19:1:1-7.

Houston, H. and Q. Williams. 1991. Fast rise times and the physical mechanism of deep earthquakes. Nature 352:520-522.

Hy, R.J. and W.L. Waugh. 1990. The Function of Emergency Management. In: "Handbook of Emergency Management - Programs and Policies Dealing with Major Hazards and Disasters". W.L. Waugh and R.J. Hy (eds.). Greenwood Press, Westport, CT.

Hyndman, R.D. and R.P. Riddihough. 1979. The Nootka Fault Zone - a new plate boundary off western Canada. Geophysical Journal of the Royal Astronomical Society 58:667-683.

Hyndman, R.D. and D.H. Weichert. 1983. Seismicity and rates of relative motion on the plate boundaries of Western North America. Geophysical Journal of the Royal Astronomical Society 72:59-82.

Imrie, A. 1992. Natural Hazards Editorial. Geotechnical News 10:1:34-35.

Jackson, E.L. 1974. Response to Earthquake Hazard: Factors Related to the Adoption of Adjustments by Residents of Three Earthquake Areas of the West Coast of North America. Unpublished Ph.D. Thesis. University of Toronto, Toronto, Ontario.

Jackson, E.L. and T. Mukerjee. 1974. Human adjustment to the earthquake hazard of San Francisco, California. In: "Natural Hazards - Local, National, Global." G.F. White (ed.). Oxford University Press, London. pp 160-166.

Johnson, F.T. 1990. The Lessons of Loma Prieta. Popular Science 236:74-81.

Johnson, K. 1985. Can Hazards Be Reduced in High-Risk Settings? Natural Hazards Observer X:1:1-2.

Kartez, J.D. and M.K. Lindell. 1987. Planning for Uncertainty - The Case of Local Disaster Planning. American Planning Association Journal 53:4:487-498.

Kasperson, R.E. and K.D. Pijawka. 1985. Societal Response to Hazards and Major Hazard Events: Comparing Natural and Technological Hazards. Public Administration Review 45:7-18.

Kates, R.W. 1971. Natural Hazard in Human Ecological Perspective: Hypotheses and Models. Economic Geography 47:438-451.

Kates, R.W. 1970. Human Perception of the Environment. International Social Science Journal 22.

Kates, R.W. 1962. Hazard and Choice Perception in Flood Plain Management. University of Chicago, Chicago.

Kerr, R.A. 1991. Big Squeeze Points to a Big Quake. Science 252:28.

Kerr, R.A. 1989. Take Your Choice: Ice Ages, Quakes, or Impacts. Science 243:479-480.

Kerr, R.A. 1986. Sinking Slabs Puncture Layered Mantle Model. Science 231:548-549.

Khanna, J. and J.W. Gadsby. 1972. Seismic Exposure in Greater Vancouver. Engineering Journal July/August:37-42.

Kockelman, W.J. 1991. Techniques for Reducing Earthquake Hazards - An Introduction. United States Department of the Interior Geological Survey: Open-File Report 91-441-L.

Kockelman, W.J. 1984-85. Reducing Losses From Earthquakes Through Personal Preparedness. Earthquake Information Bulletin 16-17:50-59.

Koppel, T. 1989. Earthquake: Major quake overdue on the West Coast. Canada Geological Survey.

Krimsky, S. and A. Plough. 1988. Environmental Hazards - Communicating Risks as a Social Process. Auburn House Publishing Company, Dover, Mass.

Kuhn, R.G. 1985. A Framework for the Investigation of Environmental Attitudes. In Current Research by Western Canadian Geographers. University of Victoria Papers.

Kunreuther, H. 1985. Insurance Versus Disaster Relief: An Analysis of Interactive Modelling for Disaster Policy Planning. Public Administration Review 45:147-154.

Kunreuther, H. 1974. Economic analysis of natural hazards: an ordered choice approach. In: "Natural Hazards - Local, National, Global." G.F. White (ed.). Oxford University Press, London. pp 206-219.

Kusler, J.A. 1985. Liability as a Dilemma for Local Managers. Public Administration Review 45:118-122.

LaCasse, A.L. 1992. Neighbourhood Disaster Planning. Unpublished M.A. Thesis, UBC, Vancouver, B.C.

Lafond, G. and A. Gosselin. 1986. A Survey on Perceived Risks. Emergency Preparedness Canada, Report No. 86.12.01.

Lamontagne, M., R. du Berger and A.E. Stevens. 1991. Reducing Public Aftershock...A Role for Seismologists. Emergency Preparedness Digest October/December:17-20.

Laska, S. 1988. Retrofitting: The New Kid on the Block. Natural Hazards Observer XII:4:1-2.

Laughy, L. 1990. A Planner's Handbook for Emergency Preparedness. Emergency Preparedness Planning Series. UBC Centre for Human Settlements, Vancouver, B.C.

Lay, T., H. Kanamori and L. Ruff. 1982. The Asperity Model and the Nature of Large Subduction Zone Earthquakes. Earthquake Preparedness Research 1:3-71.

Leiss, W. (ed.). 1989. Prospects and Problems in Risk Communication. University of Waterloo Press, Waterloo.

Leiss, W. and D. Krewski. 1989. Risk Communication: Theory and Practice. In: "Prospects and Problems in Risk Communication". W.Leiss (ed.). pp 89-112.

Lewis, T.J., A.M. Jessop and A.S. Judge. 1985. Heat flux measurements in southwestern British Columbia: the thermal consequences of plate tectonics. Canadian Journal of Earth Sciences 22:1262-1273.

Liston, A.J. 1989. Risk Communication and Health Protection. In: "Prospects and Problems in Risk Communication". W.Leiss (ed.). pp 51-64.

Little, T.E., D.V. Vandine and A.Sutherland-Brown. 1992. An Airphoto Study to Locate Ground Surface Rupture Caused by the 1946 Earthquake on Vancouver Island, British Columbia. In Proceedings of the Symposium of Geotechnique and Natural Hazards, BiTech Publishers Ltd., Vancouver, B.C. pp 183-192.

Lo, R.C. and E.J. Klohn. 1992. Behavior of Embankment Dams in Earthquakes. In Proceedings of the Symposium of Geotechnique and Natural Hazards, BiTech Publishers Ltd., Vancouver, B.C. pp 273-279.

MacDonald, D.N., J.C. Murdoch and H.L. White. 1987. Uncertain Hazards, Insurance, and Consumer Choice: Evidence from Housing Markets. Land Economics 63:4:361-371.

Mackie, D.J., R.M. Clowes, S.A. Dehler and R.M. Ellis. 1989. The Queen Charlotte Islands refraction project. Part II. Structural model for transition from Pacific plate to North American plate. Canadian Journal of Earth Sciences 26:1713-1725.

Marshall, J. 1985. Lithoprobe Maps Subduction Zone. Geos 32:42-45.

Mathews, W.H. 1979. Landslides of Central Vancouver Island and the 1946 Earthquake. Bulletin of the Seismological Society of America 69:2:445-450.

May, P.J. 1991. Addressing Public Risks: Federal Earthquake Policy Design. Journal of Policy Analysis and Management 10:2:263-285.

May, P.J. 1989. Anticipating Earthquakes: Risk Reduction Policies and Practices in the Puget Sound and Portland Areas. In Proceedings on the Western States Seismic Policy Council, XII Annual Meeting, Bureau of Disaster Services in cooperation with Idaho Geological Survey.

May, P.J. 1985. FEMA's Role in Emergency Management: Examining Recent Experience. Public Administration Review 45:40-48.

McLoughlin, D. 1985. A Framework for Integrated Emergency Management. Public Administration Review 45:165-172.

Michaels, S. 1990. The Process and Structures of Earthquake Information Exchange in the Province of British Columbia and the State of Washington. Unpublished Ph.D. thesis, University of Colorado, Colorado.

Mileti, D.S., T.E. Drabek and J.E. Haas. 1975. Human Systems in Extreme Environments: A Sociological Perspective. The University of Colorado, Colorado.

Miller, C.D. 1990. Volcanic Hazards in the Pacific Northwest. Geoscience Canada 17:3:183-187.

Milne, W.G., G.C. Rogers, R.P. Riddihough, G.A. McMechan and R.D. Hyndman. 1978. Seismicity of Western Canada. Canadian Journal of Earth Sciences 15:1170-1193.

Milne, W.G., W.E.T. Smith and G.C. Rogers. 1970. Canadian seismicity and micro earthquake research in Canada. Canadian Journal of Earth Sciences 7:591-601.

Mitchell, J.K. 1974. Natural Hazard Research. In: "Perspectives on Environment". I.R. Manners and M.W. Mikesall (eds.). Publication #13, Association of American Geographers, National Science Foundation. pp 311-341.

Moen, A.D. 1970. Symposium on Tectonism of the Pacific Northwest. In Proceedings at Pacific Northwest Region of American Geophysical Union, Tacoma, Washington 628-645.

Molnar, P. and T. Atwater. 1978. Interarc Spreading and Cordilleran Tectonics as Alternates Related to the Age of Subducted Oceanic Lithosphere. Earth and Planetary Science Letters 41:330-340.

Monastersky, R. 1991. Perils of Prediction. Science News 139:376-379.

Monastersky, R. 1987. The Juan de Fuca Plate: A Sticky Situation. Science News 132:42-43.

Monastersky, R. 1987. Quake prediction: Magnetic signals? Science News 132:167.

Monger, J. 1990. Continent-Ocean Interactions Built Vancouver's Foundations. Geos 4:7-13.

Montz, B.E. 1982. The Effect of Location on the Adoption of Hazard Mitigation. The Professional Geographer 34:4:416-423.

Moseley, C. 1988. Slow Progress in Predicting Earthquakes. Editorial Research Reports 2:2:354-362.

Moss, B. 1989. A Post-Hugo Evaluation. Public Management 71:15-17.

Muller, J.E. 1977. Evolution of the Pacific Margin, Vancouver Island, and adjacent regions. Canadian Journal of Earth Sciences 14:2062-2085.

Munich Reinsurance Company of Canada. 1992. Earthquake: Economic Impact Study. Toronto, Ontario.

Murty, T.S. 1992. Tsunami threat to the British Columbia Coast. In Proceedings of the Symposium of Geotechnique and Natural Hazards, BiTech Publishers Ltd., Vancouver, B.C. pp 81-89.

Naesgaard, E., A. Sy and J.J. Clague. 1992 Liquefaction Sand Dykes at Kwantlen College, Richmond, B.C. In Proceedings of the symposium of Geotechnique and Natural Hazards, BiTech Publishers Ltd., Vancouver, B.C. pp 159-166.

National Building Code of Canada, Supplement to 1985. Commentary J: Effects of Earthquakes. NRCC No. 23178. pp 221-241.

Newton, R. 1993. Personal Conversation on May 25. Research Analyst, Planning Department, City of Richmond.

Ng, M.K.F., P.H. LeBlond and T.S. Murty. 1990. Simulation of Tsunamis from Great Earthquakes on the Cascadia Subduction Zone. Science 250:1248-1251.

Nishenko, S.P. and R. Buland. 1987. A Generic Recurrence Interval Distribution for Earthquake Forecasting. Bulletin of the Seismological Society of America 77:4:1382-1399.

Oxford Dictionary of Earth Sciences. 1991. Oxford University Press, Oxford, New York.

Palm, R.I. 1990. Natural Hazards: An Integrative Framework for Research and Planning. The John Hopkins University Press, Baltimore.

Palm, R.I. 1981. Public Response to Earthquake Hazard Information. The Association of American Geographers 71:3:389-399.

Palm, R. and M. Hodgson. 1992. Earthquake Insurance: Mandated Disclosure and Homeowner Response in California. Annals of the Association of American Geographers 82:2:207-222.

Pearce, L.D. 1989. Canada Report. In: Anticipating Earthquakes: Risk Reduction Policies and Practices in the Puget Sound and Portland Areas. In Proceedings on the Western States Seismic Policy Council, XII Annual Meeting, Bureau of Disaster Services in cooperation with Idaho Geological Survey.

Perry, R.W. and M.R. Green. 1982. The Role of Ethnicity in the Emergency Decision-Making Process. Sociological Inquiry 52:4:306-334.

Perry, R.W. and M.K. Lindell. 1990. Living with Mount St. Helens - Human Adjustment to Volcano Hazards. Washington State University Press, Pullman, Washington.

Perry, R.W. and J.M. Nigg. 1985. Emergency Management Strategies for Communication Hazard Information. Public Administration Review 45:72-77.

Personal Services: Psychosocial Planning for Disasters. 1990. H-84-47/1990E, Minister of National Health and Welfare, Canada.

Petak, W.J. 1985. Emergency Management: A Challenge for Public Administration. Public Administration Review 45:3-7.

Petak, W.J. and A.A. Atkisson. 1982. Natural Hazard Risk Assessment and Public Policy. Springer-Verlag, New York.

Peter, B. 1972. Investigation of Earthquake Loads for Richmond General Hospital. Thompson, Berwick, Pratt & Partners, Vancouver, B.C.

Peterson, I. 1985. Liquid Sand: The liquid-like behavior of soils during major earthquakes causes considerable damage. Science News 128:234-238.

Philipsborn, C. 1987. Private Sector Involvement in Hazard Mitigation. Natural Hazards Observer XI:6:1-3.

Plafker, G. 1965. Tectonic Deformation Associated with the 1964 Alaska Earthquake. Science 148:3678:1675-1687.

Professional Engineers of the Province of British Columbia, Association of 1988. Seismic Risk in B.C. 1988. Brief to the B.C. Government.

Quarantelli, E.L. (e.). 1978. Disasters - Theory and Research. Sage Publications Ltd., Beverly Hills, California.

Quarantelli, E.L. and V. Taylor. 1978. Warning in Disasters. Emergency Planning Digest July/September:13-15.

Rainer, J.H. 1989. The Vancouver Quake of 199?. Emergency Preparedness Digest July/September:5-8.

Raleigh, C.B. 1981. When the Earth Quakes. Technology Review August/September:46-55.

Report to Parliament on the operation of the "Emergency Preparedness Act". April 1, 1989 - March 31, 1990. Minister of Supply and Services, Ottawa.

Report to Parliament on the operation of the "Emergency Preparedness Act". October 1, 1988 - March 31, 1989. Minister of Supply and Services, Ottawa.

Richmond: A Statistical Profile. 1985.

Richmond: Demographic and Selected Social Statistics for Richmond Neighbourhood Planning Areas. Part 2. 1982.

Richmond: Emergency Plan Administrative Structure.

Riddihough, R.P. 1984. Recent Movements of the Juan de Fuca Plate System. Journal of Geophysical Research 89:B8:6980-6994.

Riddihough, R.P. 1983. A Global Detective Story. Geos 12:3:2-5.

Riddihough, R.P. 1982a. Contemporary Movements and Tectonics on Canada's West Coast: A Discussion. Technophysics 86:319-341.

Riddihough, R.P. 1982b. One Hundred Million Years of Plate Tectonics in Western Canada. Geoscience Canada 9:1:28-34.

Riddihough, R.P. 1980. Gorda Plate Motions from Magnetic Anomaly Analysis. Earth and Planetary Science Letters 51:163-170.

Riddihough, R.P. 1979. Gravity and structure of an active margin - British Columbia and Washington. Canadian Journal of Earth Science 16:350-363.

Riddihough, R.P. 1977. A model for recent plate interactions off Canada's west coast. Canadian Journal of Earth Sciences 14:384-396.

Riebsame, W.E. 1988. Reducing Hazards During the 1990's. Natural Hazards Observer XII:1:1-3.

Rogers, A.M. 1986-1987. Living With the Earthquake Risk. Earthquakes and Volcanoes 18-19.

Rogers, A.M., T.J. Walsh, W.J. Kockelman and G.R. Priest. 1991. Earthquake Hazards in the Pacific Northwest: An Overview. United States Department of the Interior Geological Survey. Open-File Report 91-441-0.

Rogers, G.C. 1992. The Earthquake Threat in Southwest British Columbia. In Proceedings of the Symposium of Geotechnique and Natural Hazards, BiTech Publishers Ltd., Vancouver, B.C. pp 63-69.

Rogers, G.C. 1988a. An assessment of the megathrust earthquake potential of the Cascadia subduction zone. Canadian Journal of Earth Science 25:844-852.

Rogers, G.C. 1988b. Seismic potential of the Cascadia subduction zone. Nature 332:17.

Rogers, G.C. 1985. Variation in Cascadia volcanism with margin orientation. Geology July:495-498.

Rogers, G.C. 1980. A documentation of soil failure during the British Columbia earthquake of 23 June 1946. Canadian Geotechnical Journal 17:122-131.

Rogers, G.C. and H.S. Hasegawa. 1978. A Second Look at the British Columbia Earthquake of June 23, 1946. Bulletin of the Seismological Society of America 68:3:653-675.

Rogers, G.C. and J.G. Souther. 1983. Hotspots trace plate movements. Geos 12:2:10-14.

Rosenbaum, D.B. and P. Reina. 1990. Many markets motionless or worse, fire and earthquake rules rumbling. ENR 224:42-44.

Rubin, C.B. and D.G. Barbee. 1985. Disaster Recovery and Hazard Mitigation: Bridging the Intergovernmental Gap. Public Administration Review 45:57-63.

Ruckelshaus, W.D. 1987. Communication about Risk. In: "Risk Communication". J.C.Davies, V.T. Covello and F.W. Allen (eds.). pp 3-9.

Russell, S.O.D. 1992. Engineering Decisions and Natural Hazards. In Proceedings of the Symposium of Geotechnique and Natural Hazards, BiTech Publishers Ltd., Vancouver, B.C. pp 219-224.

Saarinen, T.F. 1974a. Problems in the Use of a Standardized Questionnaire for Cross-cultural Research on Perception of Natural Hazards. In: "Natural Hazards - Local, National, Global." G.F. White (ed.). Oxford University Press, London. pp 180-184.

Saarinen, T.F. 1974b. Environmental Perception. In: "Perspectives on Environment". I.R. Manners and M.W. Mikesall (eds.). Publication #13, Association of American Geographers, National Science Foundation. pp 252-289.

Saarinen, T.F. 1970. Research Approaches and Questionnaire Design. In: "Perceptions and Attitudes in Resources Management". W.R.D. Sewell and I. Burton (ed.). Resource Paper No. 2, Policy Research and Coordination Branch, Department of Energy, Mines and Resources, Ottawa, Canada.

Savage, J.S. and M. Lisowski. 1991. Strain Measurements and the Potential for a Great Subduction Earthquake Off the Coast of Washington. Science 252:101-103.

Savigny, W., A. Imrie, I. Bruce, J. Locat and J. Chagnon. 1992. Natural Hazards - A Canadian Perspective. Geotechnical News 10:1:36-42.

Schafer, E. 1991. Predicting earthquake risks. Nature 350.

Schiff, M.R. 1970. The Definition of Perceptions and Attitudes. In: "Perceptions and Attitudes in Resources Management". W.R.D. Sewell and I. Burton (ed.). Resource Paper No. 2, Policy Research and Coordination Branch, Department of Energy, Mines and Resources, Ottawa, Canada. pp 7-12.

Scott, W.E. 1990. Patterns of Volcanism in the Cascadia Arc During the Past 15,000 Years. Geoscience Canada 17:3:179-187.

Settle, A.K. 1985. Financing Disaster Mitigation, Preparedness, Response, and Recovery. Public Administration Review 45:101-106.

Sewell, W.R.D. 1971. Environmental Perceptions and Attitudes of Engineers and Public Health Officials. Environment and Behavior 3:1:23-59.

Seyffert, J.S. 1988. Comprehensive Risk Management. Natural Hazards Observer XII:6:1-2.

Shook, M. and D. Steger. 1989. How to Handle a Disaster: A Study in Teamwork. Public Management 71:10-14.

Siegel, G.B. 1985. Human Resource Development for Emergency Management. Public Administration Review 45:107-117.

Sims, J.H. and D.D. Baumann. 1983. Educational Programs and Human Response to Natural Hazards. Environment and Behavior 15:2:165-189.

Slovic, P., H. Kunreuther and G. F. White. 1974. Decision Processes, Rationality, and Adjustment to Natural Hazards. In: "Natural Hazards - Local, National, Global." G.F. White (ed.). Oxford University Press, London. pp 187-205.

Souther, J.G. 1970. Volcanism and its relationship to recent crustal movements in the Canadian Cordillera. Canadian Journal of Earth Sciences 2:2:553-568.

Spall, H. 1990. On Shaky Ground. New Scientist 126:56-57.

Spall, H. 1976-83. Gilbert White Talks About Natural Hazards. Earthquake Information Bulletin 8-15:16-19.

Stallings, R.A. and E.L. Quarantelli. 1985. Emergent Citizen Groups and Emergency Management. Public Administration Review 45:91-100.

Stein, R.S. and R.S. Yeats. 1989. Hidden Earthquakes. Scientific American June:48-57.

Stewart, M.C. 1989. Emergency Preparedness in B.C. - A Time of Necessary Change. Emergency Preparedness Digest 16:2:2-5.

Surrey: A Community Profile. July 1986.

Surrey Stats: 1986 Census Information by Community

Stix, G. 1991. Future Shock. Scientific American January:111-112.

Szalay, L.B., A. Inn, S.K. Vilov and J.B. Strohl. 1986. Regional and Demographic Variations in Public Perceptions Related to Emergency Preparedness. Federal Emergency Management Agency.

Taber, J.J. and S.W. Smith. 1985. Seismicity and Focal Mechanisms Associated with the Subduction on the Juan de Fuca Plate Beneath the Olympic Peninsula, Washington. Bulletin for the Seismological Society of America 75:1:237-249.

Technical Tours Guidebook. 1992. BiTech Publishers Ltd., Vancouver, B.C.

Thatcher, W. 1989. Earthquake recurrence and risk assessment in circum-Pacific seismic gaps. Nature 341:432-434.

Tobin, D.G. and L.R. Sykes. 1968. Seismicity and Tectonics of the Northeast Pacific Ocean. Journal of Geophysical Research 73:12:3821-3845.

Tranter, R.A.F. 1989. Some Lessons from the October 17 Quake. Public Management 71:2-17.

Tuchmen, J. L. 1989. U.S. preparedness inches forward. ENR 223:17-18.

Turner, R.H., J.M. Nigg and D.H. Paz. 1986. Waiting for Disaster, Earthquake Watch in California. University of California Press, Berkeley, CA.

UNESCO. 1978. The Assessment and Mitigation of Earthquake Risk.

Uyeda, S. 1979. Back-Arc Opening and the Mode of Subduction. Journal of Geophysical Research 34:B3:1049-1061.

Vancouver, City of: Seismic Report. 1991.

Visader, H. and I. Burton. 1974. Natural hazards and hazard policy in Canada and the United States. In: "Natural Hazards - Local, National, Global." G.F. White (ed.). Oxford University Press, London. pp 219-231.

Wallace, W.A. and F. DeBalogh. 1985. Decision Support Systems for Disaster Management. Public Administration Review 45:134-146.

Walter, S.R. 1986. Intermediate-Focus Earthquakes Associated with Gorda Plate Subduction in Northern California. Bulletin of the Seismological Society of America 76:2:583-588.

Watts, B.D., W.C. Seyers and R.A. Stewart. 1992. Liquefaction susceptibility of greater Vancouver area soils. In Proceedings of the Symposium of Geotechnique and Natural Hazards, BiTech Publishers Ltd., Vancouver, B.C. pp 145-157.

Waugh, W.L. and R.J. Hy (eds.). 1990. Handbook of Emergency Management - Programs and Policies Dealing with Major Hazards and Disasters. Greenwood Press, Westport, CT.

Weaver, C.S. and S.W. Smith. 1983. Regional Tectonic and Earthquake Hazard Implications of a Crustal Fault Zone in Southwestern Washington. Journal of Geophysical Research 88:B12:10,371-10,383.

Weinstein, N.D. 1989a. Optimistic Biases About Personal Risks. Science 246:1232.

Weinstein, N.D. 1989b. Effects of Personal Experience on Self-Protective Behavior. Psychological Bulletin 105:1:31-50.

Weinstein, N.D. 1987. Taking Care - Understanding And Encouraging Self Protective Behavior. Cambridge University Press, Cambridge.

Weisbone, B. 1985. Quake potential in Pacific Northwest. Science News 127:270.

Wesnousky, S.g. 1988. Seismological and structural evolution of strike-slip faults. Nature 335:22:340-343.

Wesson, R. 1988. The Earthquake Hazard in the Pacific Northwest. In Proceedings of the Western States Seismic Policy Council, State of Hawaii and Federal Emergency Management Agency:12-20.

West, D.O. and D.R. McCrumb. 1988. Coastline uplift in Oregon and Washington and the nature of Cascadia Subduction-zone tectonics. Geology 16: 169-172.

White, G.F. 1974. Natural Hazards Research: Concepts, Methods and Policy Implications. In: "Natural Hazards - Local, National, Global." G.F. White (ed.). Oxford University Press, London. pp 3-16.

White, G.F. (ed.). 1974. Natural Hazards - Local, National, Global. Oxford University Press, London.

White, S.N. 1986. Thirty Years of Emergency Planning. Emergency Planning Digest July/August:7-15.

Whitehead, J. and M. Sadkowski. 1989. Predicting Earthquakes. Emergency Preparedness Digest 16:3:26-29.

Whitham, K., W.G. Milne and W.E.T. Smith. 1970. Geophysics: The New Seismic Zoning Map for Canada, 1970 Edition. Earth Physics Branch, Department of Mines, Energy and Resources, Ottawa, Canada.

Wijkman, A. and L. Timberlake 1984-85. Tempting the Fury of Nature. Inter Wildlife 14/15:16-19.

Wilson, D.S. 1986. A Kinematic Model for the Gorda Deformation Zone as a Diffuse Southern Boundary of the Juan de Fuca Plate. Journal of Geophysical Research 91:B10:10,259-10,269.

Wyss, M. 1990. Seismic cycle not so simple. Nature 345:290.

Wyss, M. 1978. Estimating maximum expectable magnitude of earthquakes from fault dimensions. Geology 7:336-340.