EMERGEX® Leaders in Emergency Management

SUPPLEMENT TO

HAZARD, RISK AND VULNERABILITY ANALYSIS FOR THE SUNSHINE COAST REGIONAL DISTRICT

GAMBIER ISLAND AND KEATS ISLAND HAZARD, RISK AND VULNERABILITY ANALYSIS

2005

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EXECUTIVE SUMMARY

The intent of this Hazard, Risk and Vulnerability Analysis (HRVA) is to supplement the existing Hazard, Risk and Vulnerability Analysis for the Sunshine Coast Regional District (SCRD) conducted in August of 2005 by EmergeX Planning Inc. (EmergeX). This analysis summarizes the main hazards, risks and vulnerabilities for the communities of Gambier Island and Keats Island. However, some have widespread effects and will impact all communities in the SCRD. These kinds of hazards are not included in this supplement to the SCRD HRVA but should still be considered as potential hazards for the communities of Gambier Island and Keats Island. Refer to SCRD HRVA for an inclusive list of high and very high risk hazards.

This HRVA uses both quantitative and qualitative methods to determine a risk rating for each hazard. Based on the information discovered through the course of this HRVA, EmergeX has assigned each hazard a rating of '*very high*', '*high*', *'moderate'* or *'low'*.

The communities of Gambier Island and Keats Island have developed and implemented a number of measures to prepare for and respond effectively to a number of disasters. The following strengths were identified for these communities:

- Gambier Island and Keats Island address development on hazardous lands in their Official Community Plans (2001) and municipal policies.

- The communities of Gambier and Keats Island have developed some fire suppression capability through equipment and training cooperatives. This decreases their vulnerability to structural fires and wildland interface fires as they are not supported by a local fire department.

- Gambier and Keats Island's climate is one of the mildest in Canada. Droughts, heat waves, ice formation, and the majority of extreme weather events are rare occurrences in these communities.

However, the following hazards were identified as having a high risk to the communities of Gambier Island and Keats Island:

- Response capability is of primary concern to the communities of Gambier and Keats Island. Response time is limited by the geographic isolation of these communities, potentially increasing risk when a life threatening situation occurs. Response to most events requires the coordinated effort of a variety of organizations from surrounding communities. This coordination may be impeded when entire regions are facing similar response needs.

- Gambier and Keats Island are situated over an active subduction zone that makes it one of the most seismically active regions in Canada. The likelihood of a structurally damaging earthquake (MMI VII) occurring within the next 50 years

has been estimated at 11%. Within these areas, there is the potential for liquefaction along banks and creek-sides which may cause extensive structural damage and impact transportation routes or wharves. Gas supplies, water sources, electricity and telephone service could all potentially be affected in such an event.

- The Sunshine Coast is an active area for vessel traffic. This traffic includes private boaters and transport barges. In this context, Gambier and Keats Island could potentially be impacted by pollution resulting from spillage or vessel collision. Oil spills, depending on their size and area, could have serious impacts on these communities in an economic and environmental sense. Response to such events is limited, especially considering that the closest hazardous materials response teams would be deployed from Surrey, British Columbia.

- Wildland fires have the potential to spread quickly to residential areas in the communities of Gambier and Keats Island. Interface fires can easily overwhelm the limited capacity of local response and the severity of the event can escalate quickly as a result of weather.

This supplement to the SCRD HRVA, considers total of 18 hazards for communities of Gambier Island and Keats Island. It is important to note that some hazards, such as blizzards and snowstorms have widespread effects and will impact all communities in the SCRD. See Appendix A of the SCRD HRVA for an inclusive list of high and very high risk hazards.

Hazards considered in this supplement to the SCRD HRVA are listed alphabetically in Table A along with their associated risk. In selecting these events for consideration, EmergeX acknowledges the potential that other hazards might occur. However, the following hazards are most likely to occur and are suggested by the Provincial Emergency Program for consideration within an HRVA. These hazards may result in significant consequences for the communities of Gambier Island and Keats Island.

Table A Summary of Risk Ratings

HAZARD	RISK RATING			
	Low	*Moderate*	*High*	*Very High*
Aircraft Accident		✓		
Debris Flows	✓			
Earthquake			✓	
Landslides		✓		
Lightning		✓		
Local Flooding		✓		
Local Marine Tsunamis		✓		
Local Terrestrial Tsunamis		✓		
Pandemics			✓	
Marine Accidents			✓	
Motor Vehicle Accidents	✓			
Rain & Wind Storms		✓		
Structural Collapse		✓		
Structural Fires			✓	
Telegenic Tsunamis	✓			
Water Contamination		✓		
West Nile Virus	✓			
Wildland Interface Fires				✓

1.0 INTRODUCTION

This document is intended to supplement the existing Hazard, Risk and Vulnerability Analysis (HRVA) for the Sunshine Coast Regional District (SCRD) conducted in August of 2005 by EmergeX Planning Inc. (EmergeX). The objective of this analysis is to determine the main hazards, risks and vulnerabilities to the communities of Gambier Island and Keats Island.

1.1 Hazards

The foundation of emergency response planning requires identification of the potential hazards that might affect Gambier Island and Keats Island. A hazard is a category of event which threatens the life and safety of people or the things they value (Pearce, 1993).

Factors considered in developing a list of hazards for Gambier Island and Keats Island include:

- Demographics
- Geography and Geology
- Industries and Other Technologies
- Transportation Modes and Routes
- Weather and Climate

EmergeX has identified a select number of hazards that could affect Gambier Island and Keats Island. In considering these hazards, EmergeX acknowledges the potential that other hazards might occur. However, the following hazards are most likely to impact Gambier Island and Keats Island and are outlined in Provincial Emergency Program HRVA Toolkit.

1.2 Risks

A risk is the probability that an incident involving a hazard will lead to an adverse consequence. Historical occurrences, changing circumstances, outside influences and similar occurrences happening elsewhere are examined when analyzing risks.

1.3 Impacts

Different hazards have different potential consequences. These impacts can be categorized as follow:

Geographic	Widespread (will affect most of the region) Localized (will affect a few city blocks) Specific (will affect one or two buildings or locations)
Economic	Jobs Structural Damage Non-structural Damage Infrastructure Damage Economic Survival Transportation
Political	Perception of Blame Credibility or lack thereof
Social	Death Injury Housing Education Family Life
Environmental	Vegetation Wildlife Water Air Soil

1.4 Capability

Gambier Island and Keats Island have plans and resources to respond to some of the hazards that present a threat to these communities. However, almost all incidents require the coordinated efforts of a variety of people and agencies.

Response time is a key concern for these communities. The geographic isolation that attracts residents to Gambier and Keats may potentially put them at risk when a life threatening situation occurs. Services located directly on these islands are limited, but their proximity to other communities in the SCRD and Vancouver dictates greater support capability.

Gambier and Keats Island are supported by the Canadian Coast Guard, BC Ambulance Service (BCAS), Royal Canadian Mounted Police (RCMP) and Search and Rescue (SAR). Both Gambier and Keats Island have communal fire equipment. However, no official fire firefighting team is stationed on either island.

Gambier and Keats Island rely heavily on coordinated efforts as illustrated by an event in 2002. An elderly woman was found with respiratory difficulty by a yacht crew in a vessel at Centre Bay on Gambier Island. Canadian Coast Guard Auxiliary (CCGA) and the

BCAS Advance Care Paramedic (ACP) crew responded to the incident. The Coast Guard Auxiliary then transported the woman and the ACP crew to Fisherman's Cove (Canadian Coast Guard Auxiliary, 2002). This highlights the amount of coordination and time required to respond to an emergency situation affecting these communities. An objective addressed by the Gambier Island's Official Community Plan is to enhance response capability with the development of helicopter landing pads (2001).

1.5 Background

Gambier Island and Keats Island are members of Sunshine Coast Regional District (SCRD) and Islands Trust. Islands Trust is primarily responsible for the land use and planning associated with these unique communities; SCRD maintains a role in problem resolution and the coordination of services for Gambier and Keats Islands. The Island Trust undertakes the development of official community plans (OCP), zoning and other land use bylaws for the islands. These islands can be reached by water taxi, personal watercraft and BC Ferries. Service provided by BC Ferries is passenger only and operates between 7:00 am and 7:00 pm daily. Core service levels for the Langdale – Keats – Gambier Island route is 10 roundtrips during the peak season and 11 during off peak (BC Ferries, 2005).

Figure 1-1 Geographic Setting

(BC Ferries, 2005)

Gambier Island

Gambier Island is the largest of the Howe Sound Islands and is located approximately 10 km from Lions Bay, 15 km from Horseshoe Bay and 40 km from Vancouver (Figure 1-1). The island hosts 120 full time residents with a growing summer population of approximately 600 (Gambier OCP, 2001). Halkett Bay Provincial Park is located on the southeastern shore of Gambier Island and is frequented by visitors seeking opportunities for hiking, swimming, canoeing, kayaking and fishing (BC Parks, 2005).

Keats Island

Keats Island is also located in Howe Sound (Figure 1-1). The island spans 6 km^2, consisting of a sloped landscape and several coastal bluffs along the southern and eastern border. The only public access to Keats Island is by boat which can dock at one of two wharves on opposite ends of the island. However, there are many private docks accessible by homeowners. Telephone service is available. However, not all dwellings have a phone. Dwellings include 359 developed properties, of which around 20 are occupied full time with the remaining 339 being used seasonally or on a weekend basis. There are between 50 to 80 full time (year round) residents. However, the number of people on the island can fluctuate from less than 50 to more than 1300, depending on the season (Keats OCP, 2001).

2.0 NATURAL HAZARDS AND RISKS

Natural hazards are commonly referred to as acts of God. They are natural incidents that have the potential to cause damage and hardship to people, communities, the environment and the economy.

2.1 ATMOSPHERIC

According to historical weather statistics collected by Environment Canada, summer temperatures in this region have not measured over 33 degrees Celsius in the last 21 years, and hot spells have not typically lasted more than 4 or 5 days. Average annual rainfall is typically 150 cm (Environment Canada, 2005).

Gambier Island and Keats Island are characterized by a relatively moderate climate. Therefore, the risk of events such as ice fogs, blizzards, snowstorms and extreme heat waves is low.

2.1.1 Lightning

Lightning is caused by the union of three contingent factors: moisture laden air, the instability of existing weather systems and a triggering agent which causes air near the ground to ascend. A lightning strike can damage transmission lines, affect aircraft, disrupt communication systems, damage or destroy structures, and cause forest fires. Lightning strikes can also cause severe or fatal injuries to people.

Survey data collected by EmergeX indicates that lighting hazard could potentially affect Gambier Island and Keats Island, though the risk is generally considered to be moderate to low. The extent of damage caused by lightning will depend on what is hit and how quickly response agencies can recover from ensuing problems. Due to the limited response capabilities of each island, especially to threats posed by fire, the overall risk is considered to be ***moderate***.

2.2 GEOLOGICAL

2.2.1 Landslides

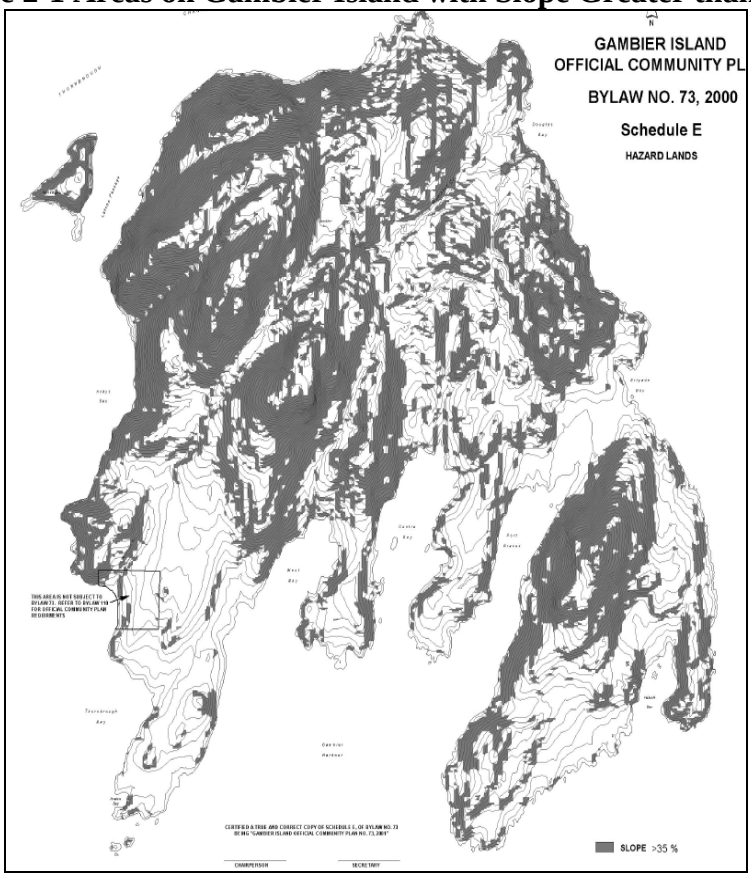
Landslides and rockslides are the result of downward and outward movements of slope materials reacting to the force of gravity and cover a wide variety of landforms and processes. Slide material may be composed of natural rock, soils, artificial landfills or combinations of these components.

In January 2005, landslides caused by the interface of heavy rain and soft soils affected one household in the SCRD and forced the evacuation of its owners. The descent of sand, logs and rock caused localized damage and could easily have caused septic overflow and gas leakage, creating a larger problem for a number of homes nearby.

This is a particular concern where lots or locations having steep or unstable slopes interface with areas zoned as residential or contain infrastructure necessary for the continued function of essential services. Large-scale landslides can also occur when heavy rainfall, especially in areas that have steep pitch and are unprotected by vegetation, trees and root mat systems. Logged slope sides, creek or river ravines, and steep areas below large, rapidly melting snow packs can pose a serious hazard for landslide activity.

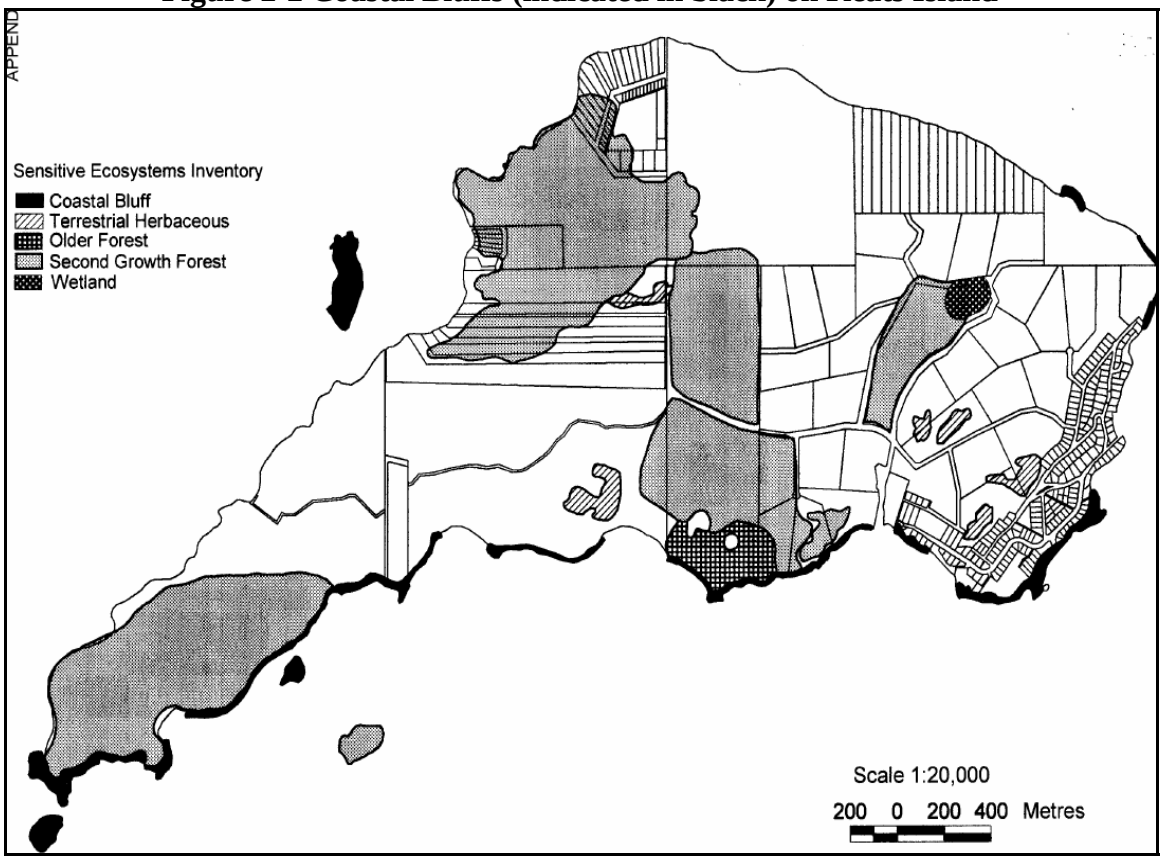
Gambier Island has a significant amount of area with slope angles greater than 35% (Figure 2-1). Most of the development on Gambier and Keats is not located within areas of steep slope (Keats OCP, Gambier OCP, 2001). However, recreational users may frequent such areas. Dwellings located along the southeastern coastline of Keats Island, where high bluffs are found (Figure 2-2), may be in an area of greater risk.

Figure 2-1 Areas on Gambier Island with Slope Greater than 35%



(Gambier OCP, 2001)

Figure 2-2 Coastal Bluffs (indicated in black) on Keats Island



(Keats OCP, 2002)

To ensure that risk to community members is minimized Gambier Island has limited land use and development in areas of hazardous conditions such as steep slopes at least until further studies are completed. For Gambier Island, buildings must be no closer than 15 m from the natural boundary of the sea, lake, water course or wetland (Gambier OCP, 2001). Keats Island possesses a similar regulation whereby structures cannot be within 7.5 m from the sea boundary, with the exception of utility houses, stairs or walkway to access the foreshore (Keats OCP, 2002).

Based on an assessment of land use and development, geological reviews and observations, landslide activity poses a ***moderate*** risk to communities of Gambier Island and Keats Island.

2.2.2 Debris Flows

Debris flows are a form of rapid mass movement in which loose soils, rocks and organic matter, combined with air and water, form a slurry that flows down-slope. Because debris flows are often a result of heavy rain, flooding commonly occurs at the same time which can make response and recovery operations more troublesome.

A number of areas throughout the SCRD are identified as having high potential for debris flow, mostly where creeks and ravine valleys exist. Destructive debris flows occurred in

November of 1983 in Roberts Creek, which originated in a clear-cut area along Clough Creek during a period of heavy rain. The debris and water ran beneath Orange Road causing severe property damage to houses in the immediate area. This hazard is widespread throughout the SCRD and poses a significant risk to infrastructure and property where designated in OCPs. However, EmergeX has not discovered any evidence to suggest that there is a debris flow risk for the Islands. Therefore, the risk rating for this hazard on Gambier and Keats Island is ***low***.

2.3 HYDROLOGICAL

2.3.1 Local Flooding

This type of flooding may be associated with an extreme hydrologic event, but it is most often caused by blocked or impaired drainage. In some cases, it is an annual event, which occurs on agricultural land and has no major consequences. In other cases it can cause severe hardship in residential or developed areas. Septic fields may run over; houses and buildings may suffer water damage. Creeks may swell and avulse, basins may overflow and discharge, doubling the flood risk to downstream areas. As roads are generally not paved, they may wash out, making transportation, access and evacuation difficult. Overall, risk of flood on both islands is ***moderate***.

2.3.2 Rain Storms

The basic cause of most river or creek floods is excessive rainfall, which causes significant elevations in river level and ultimately the inundation of low-lying floodplain areas. Rain storms themselves cause damage by overwhelming drainage capacities, causing saturation-induced landslides, snow melt, ground slumping, erosion and debris flow, and where large snow deposits accumulate, may cause avalanches.

Rain storms are not uncommon on Gambier and Keats Island and at times, can last for several days. The wettest time of year is typically from October to February, with November averaging close to 300 mm of rainfall (Environment Canada, 2005). Overall, rainstorms pose a ***moderate*** risk to Gambier Island and Keats Island.

2.4 SEISMIC

According to the National Building Code of Canada (NBC) 1990, the SCRD is located in a region that has been designated as Seismic Zone 4, of 6 possible zones (Zone 6 assuming the greatest risk of seismic activity). These Zones reflect horizontal velocity as a percentage of gravity force, and take into account historical earthquake intensities as well as frequency of occurrence (Table 2-1)

Table 2-1 Seismic Zones and Horizontal Velocity

NBC Seismic Zone	Horizontal Velocity
0	.00g
1	.05g
2	.10g
3	.15g
4	**.20g**
5	.30g
6	.40g

(PEP, 1990).

Three types of damaging earthquakes are known to occur in coastal British Columbia and could potentially affect the Gambier Island and Keats Island:

1) Shallow or Crustal Earthquakes
2) Juan de Fuca Plate or Sub-Crustal Earthquakes
3) Plate Boundary or Subduction Earthquakes

2.4.1 Shallow or Crustal Earthquakes

Crustal earthquakes are the most common type of quake and typically occur along faults at an average depth of 10-20 km. Though the magnitude of these quakes tends to be lower than sub-crustal or subduction quakes, they can and have caused significant damage due to their proximity to land surface. The impact of a crustal earthquake on human settlements and infrastructure depends on a number of factors such as: its magnitude or size; lateral distance from the earthquake focus or source; depth; type of faulting affected; local soil composition; and frequency of ground motion. This type of event is usually followed by a large number of aftershocks that can be just as damaging as the initial shake. Due to the frequency with which these quakes occur and their potential to cause damage to dwellings and infrastructure as well as overwhelm response capabilities over a large area, this risk is considered ***high***.

2.4.2 Juan de Fuca Plate or Sub-Crustal Earthquakes

At average depths of 30 – 70 km beneath Georgia and Puget Sounds, these quakes occur less frequently but are more typically more destructive than sub-crustal earthquakes. Southwestern British Columbia and Northern Washington have experienced some very large sub-crustal quakes in the past, the largest occurring in Seattle in 1945 (M5.5) and again in 1965 (M6.5). As these quakes have fairly frequent recurrence intervals, they pose a significant threat to Gambier and Keats Island; however their impact is often tempered by focus depths. Overall, this is also a ***high*** risk.

2.4.3 Subduction Earthquakes

Subduction earthquakes occur when a massive shift takes place at the junction of multiple tectonic plates. These quakes are by far the most devastating and release a tremendous amount of energy over a very wide area. Fortunately, these quakes are very infrequent, with an average recurrence interval of 500 years +/- 150 years (Onur & Seeman, 2004). Southwestern British Columbia vulnerable to this threat however, as it is located in an area known as the Cascadia Subduction Zone, near the intersection of the Juan de Fuca, North America and Pacific plates. Research indicates that these plates are currently locked and are accumulating strain which will ultimately be released in one or more large earthquakes, similar to the one which occurred off the coast of North America, 305 years ago (M9) and in the Indian Ocean, December 26, 2004 (M9).

Depending on where the rupture occurs and the length of the rupture area along the fault line, Gambier Island and Keats Island (along with the remainder of southwestern British Columbia) could experience a subduction earthquake. However, given that the likelihood of this event occurring within the next 50 years has been estimated at 11%, the risk factor is considered to be ***moderate***.

2.4.4 Earthquake Risk for Gambier Island and Keats Island

Based on probabilistic seismic hazard models developed by the Geological Survey of Canada, statistical estimates for the occurrence of 'structurally' damaging ground shaking due to crustal or sub-crustal earthquakes have been determined for various regions throughout British Columbia (Onur & Seeman, 2004). While Gambier Island and Keats Island themselves have not been assessed for seismic probability, Vancouver BC has been evaluated and is proximate enough to provide a 'best guess' as to the likelihood of a significant earthquake affecting these communities. Using the Modified Mercalli Intensity Scale (MMI) as a description of earthquake effects at a given intensity level (expressed in Roman numerals), Onur & Seeman (2004) provide a percentage probability of three earthquake intensities being exceeded over a period of 10, 50, and 100 years. Results for the Vancouver area are as follows:

MMI	Description of Effects	Probability of Being Exceeded in	
V	Felt indoors by practically all, outdoors by many or most. Buildings tremble throughout. Broken dishes, glassware to some extent. Hanging objects, doors swing generally. Pictures knocked against walls or swung out of place.	10 years	26%
		50 years	77%
		100 years	95%
VI	Felt by all, indoors and outdoors. General excitement, some alarm. Damage slight in poorly build buildings. Fall of plaster, cracks in plaster and fine cracks in chimneys in some instances. Broken dishes, glassware in considerable quantity, as well as some windows. Overturned furniture in many instances.	10 years	8.6%
		50 years	36%
		100 years	60%
VII	General alarm, all run outdoors. Some or many find it difficult to stand. Damage negligible in buildings of good design, slight to moderate in ordinary buildings, and considerable in poorly built or badly designed buildings. Cracked chimneys to considerable extent and walls to some extent. Fall of plaster in considerable to large amounts. Dislodged brick and stone. Overturned heavy furniture.	10 years	2.5%
		50 years	12%
		100 years	22%

2.4.5 Effects on Electrical Power

Overhead towers and lines, except where they cross waterways, are generally expected to survive a moderate earthquake. The impact of seismic shaking on underground lines however is not well understood. BC Hydro expects loses in substations of both ceramic damage and anchorage failure. Power failures are typical in post-earthquake environments and interruptions to service may last days or weeks. This can cause serious problems for buildings that require a continuous power source such as hospitals, communication and response facilities. In these instances, back-up power sources and generators are essential. Restoration of power will depend largely on the extent of the damage sustained and will likely be in priority sequence – critical infrastructure and essential services will be restored first, followed by residential and commercial areas. Consideration should be given to the time of year and weather, as prolonged power outages can also affect heating and air conditioning units leaving particularly vulnerable populations such as the elderly, disabled or very young at higher risk of exposure.

2.4.6 Effects on Gas and Water Supply

Gas storage tanks are particularly vulnerable in the event of an earthquake and can result in substantial secondary damage. Depending on the magnitude of the tremor, tanks can become dislodged allowing leakage of contaminants into soil or groundwater and release of toxic fumes into the air. Injury or death can result from explosion, fire or inhalation of the toxins. Fire following earthquake is very common in post-disaster environments. The additional strain that this places on first responders and local resources (human and material) may be significant. With increased chance of fire, there is a concern for suppression resources. The majority of dwellings are situated along the coast and firefighting techniques include pumping of sea water; shortage of water for fire control is of most concern to residents of the interior of these islands.

Keats Island maintains a water tower, which in the event of an earthquake, may be impacted. Commonly on both Keats and Gambier Island, wells supply drinking water to residents. An earthquake can potentially shift wells, resulting in drainage of wells. Less obvious is the potential for water and fuel to combine due to leakage, which can complicate response by causing fire spread. Downed power lines and live wiring is hazardous when introduced to pooling water, which can endanger the lives of both victims and first responders. In an effort to create 'disaster resilient communities' local residents should be advised to maintain a fresh, three day supply of drinking water in their homes. Individual lots are required to provide septic fields, which are to be set back from springs, wells and lakes in accordance with health regulations (Gambier OCP, 2001); however an earthquake can cause leakage of blackwater and human waste resulting in soil and groundwater contamination. Gone undetected, contamination can lead to adverse health effects.

2.4.7 Effects on Roads

It is difficult to predict what damage will occur to roads on the islands. Slumping and cracking are not uncommon during an earthquake, nor are rockfalls, landslides, liquefaction or subsidence. Areas identified to be at risk of these events should be considered, particularly where their occurrence might impede access or evacuation. Roads are generally not paved and all terrain vehicles are potentially a major means of transportation after an earthquake. Many homes are accessible by boat, therefore, road access may be less of a concern than in other communities.

2.4.8 Effects on Telephone Service

Telus's main concern is the integrity and effective operation of its communications network. Controls and network management procedures are in place, which allow telephone service to be re-routed around affected areas. As such, Telus is confident that it can respond effectively to any disaster that might affect their infrastructure. System overload by customers is likely to be a primary cause of interruption for both land lines and cellular service. Essential Line Treatment (ELT), or Priority Access Dialing (PAD), is one method that can be used to mitigate this risk. All essential City phones and the

EOC should be put on ELT/PAD through the Provincial Emergency Program (PEP). Local residents should be informed of the problems caused by system overload and encouraged to utilize an 'Out-of-Area Contact' system.

2.5 TSUNAMIS

Tsunamis are large wave events generated by large surface impacts, or when the floor of a water body moves suddenly, displacing the water on top of it (Clague, 2001; Anderson & Gow, 2004). Although usually associated with earthquakes, tsunamis also can be triggered by many other types of phenomena, including submarine or terrestrial slides, submarine and terrestrial volcanic eruptions, explosions and even bolide (e.g. asteroid, meteor, comet) impacts (Clague, 2001; Paine, 1999 in Anderson & Gow, 2004). Tsunami hazards along the Lower Mainland of British Columbia generally fall into three categories:

1) Telegenic or distant, earthquake-induced tsunamis
2) Local tsunami (marine)
3) Local tsunami (terrestrial)

Several years ago the Canadian Hydrographic Service initiated an upgrading of all tide gauges and tsunami stations on the coast of British Columbia in order to address shortcomings of outdated systems (Rabinovich & Stephenson, 2004). Three of the new stations (Tofino, Winter Harbour, and Langara) revealed two weak tsunamis: one on June 23, 2001 generated by the Peru Earthquake, and a local tsunami of October 12, 2001 induced by the Queen Charlotte Earthquake (Rabinovich & Stephenson, 2004).

2.5.1 Telegenic Tsunamis

Telegenic tsunamis have distant origins and are typically generated as a result of an earthquake along a subduction zone. Depending on the size of the fault rupture, these tsunamis can be very large or very small. In 1964, a 9.2 subduction quake in Prince William Sound, Alaska, generated the largest and most destructive tsunami to affect coastal British Columbia in the last 100 years. Townships on the northern and western shores of Vancouver Island were affected, but the eastern side of Vancouver Island and exposed communities on the mainland were not impacted (Anderson & Gow, 2004). However, waves traveling northward through the Strait of Georgia could potentially breach on shore lines of the Lower Mainland, particularly if they are a result of a subduction quake originating off the coast of northern Washington.

The impact of a telegenic tsunami on Gambier or Keats Island will depend on a number of factors including (but not limited to): location of earthquake focus and direction of wave travel, magnitude of quake and corresponding wave size. Because the islands are somewhat sheltered by Vancouver Island, telegenic tsunamis originating in the Cascadia Subduction Zone (southwest of Vancouver Island), the Kamchatka Subduction Zone (southeast of Russia's Kamchatka Peninsula), or the Aleutian Subduction Zone (south of the Aleutian Islands) are not likely to cause serious damage to its member communities.

Subduction earthquakes, though serious, are considered rare. Furthermore, because the Sunshine Coast is sheltered from open-ocean by Vancouver Island, telegenic tsunamis are considered to be a ***low*** risk for Gambier Island and Keats Island.

2.5.2 Local Marine Tsunamis

Local marine tsunamis are caused by submarine slides or slumping in local waters. In 1975 a large submarine slide at the head of Douglas Channel triggered a local tsunami which caused approximately $600,000 in damage to boats, docks and other property in Kitimat Harbour (Clague, 2001). Though infrequent and often times difficult to detect, these events give residents little warning time due to their proximity to the focus or site of initiation. They can be caused by earthquakes (in which case the earthquake is the warning), but more frequently are triggered by non-seismic events such as abnormally low tides, coastal construction activity, heavy rainfall, strong winds, atmospheric pressure changes and sudden soil deposition (especially in deltaic areas) during flooding (Rabinovich et. al., 2003, p. 1276).

A 2003 report by Rabinovich et. al., examined the potential for a slide induced tsunami in the Strait of Georgia. Using numerical modeling techniques, it was estimated that a hypothetical underwater slope failure of a 1,250,000 m^3 sediment lobe (one of two lobes, the second one is larger but is not considered in the study) located along the eastern shore of Texada Island would likely cause waves with a trough-to-crest height up to 2 m (Rabinovich et. al., 2003). If evacuation was necessary, the main route off either Keats or Gambier Island is by boat/ferry which a tsunami could impede.

The probability of such an event happening is not particularly high, though the proximity of Gambier and Keats Island to the source area means that the time interval between the event and the impact would be negligible. Rabinovich et. al.(2003), estimate a leading wave transiting Malaspina Strait and arriving at Cape Cockburn area about 132 seconds after the inception of the slide (Rabinovich et. al, 2003). The authors acknowledge that landslide generated tsunamis are an emerging issue in geophysical and disaster research and as such, caution against using their 2003 study as a platform for hazard assessments. In the interest of situational awareness and proactive planning however, it is wise to consider the potential risk associated with sediment slide activity off neighboring islands. Until further research can confirm the extent of slide-generated tsunami hazard to Gambier and Keats Island, this threat should be considered ***moderate***.

2.5.3 Local Terrestrial Tsunamis

These events are caused by land slides and can occur in both oceanic and fresh water regions of British Columbia (Anderson & Gow, 2004). In 1880, 27 acres of farmland, located on the north side of the Fraser River in Haney (now Maple Ridge), slid into the Fraser River, causing a displacement 12 m high (Anderson & Gow, 2004). Local terrestrial tsunamis are most often caused by slope failure though on rare occasion, can be caused by an earthquake-induced landslide. The likelihood of such an occurrence causing

loss of life and property within either Gambier or Keats Island is low, though some areas may be more prone than others, especially considering the proximity of these communities to water. Overall, this risk is rated as ***moderate***.

3.0 HUMAN CAUSED HAZARDS AND RISKS

Human caused hazards are also referred to as technological hazards. They are hazards caused by human beings via an act, omission or commission.

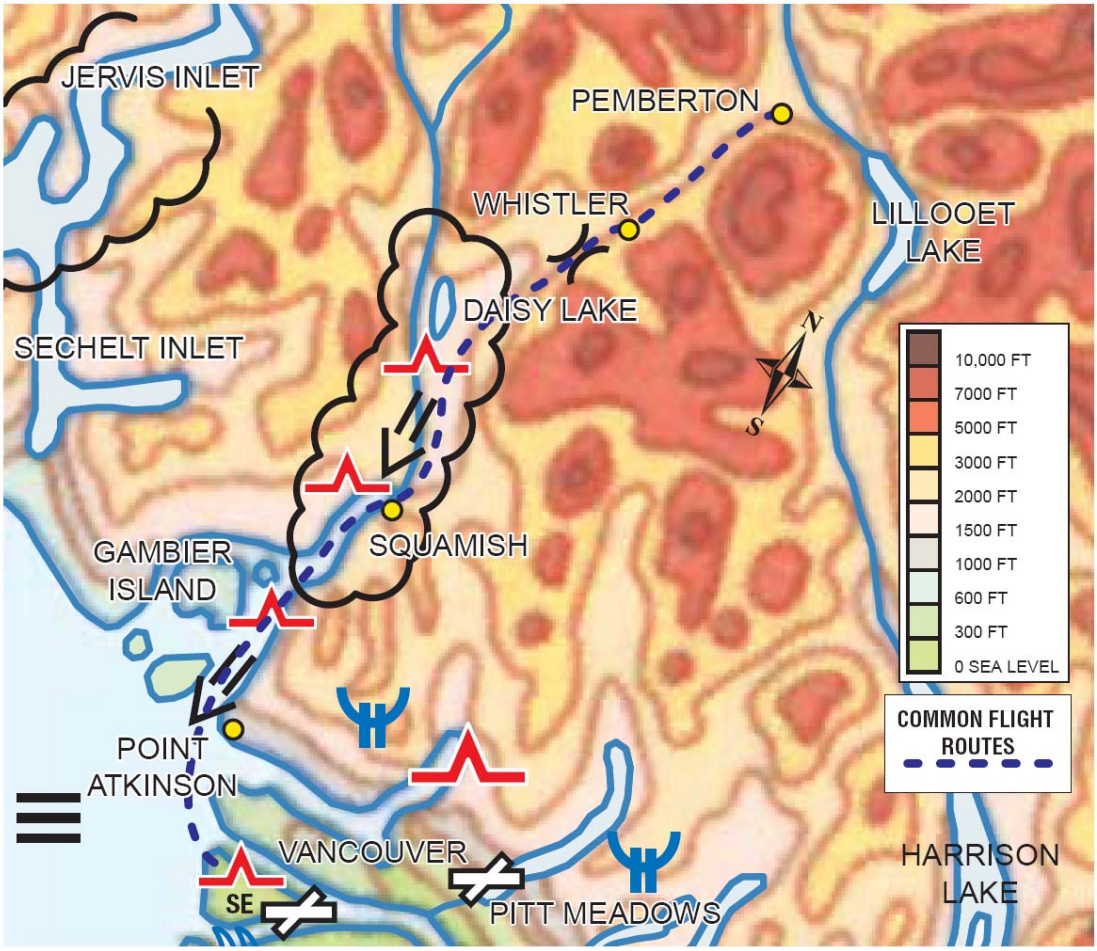
3.1 ACCIDENTS

An accident is considered to be an event occurring by chance or arising from an unknown cause. It is unexpected and causes loss or injury.

3.1.1 Aircraft Crashes

The possibility of an aircraft accident affecting Gambier Island or Keats Island is remote, but possible. Float planes facilities exist in various locations throughout the SCRD. Charter and scheduled services are provided by Sechelt Gibsons Air, Tofino Air, Pacific Wings, Coast Western Airlines and Glacier Air. Gambier and Keats are also in a flight path often used as an alternative route to the Interior (Fig.4). The potential for aircraft accidents is thus increased due to a considerable amount of air traffic in the region. A crash-landing or other such incident can easily overwhelm the already limited response capability of these islands, particularly if a mass-casualty incident transpires. Corollary issues include fire, structural damage, and hazardous materials spills. Objective 9.15 of Gambier Island's Official Community Plan addresses traffic concerns by striving to limit air transportation service to emergency helicopter service and private float planes (2001). As there is very little Gambier Island and Keats Island can do to prevent or mitigate such an incident and both have limited capacity to, therefore this risk is considered to be ***moderate***.

Figure 3-1 An example of a flight path that passes the communities of Gambier Island and Keats Island.



(Klock and Mullock, 2001)

3.1.2 Marine Accidents

Marine accidents are shipping events that threaten human life, property and natural resources. Collisions, fires, foundering and dangerous goods spills are examples of marine accidents. Nuclear accidents are also a possibility as nuclear powered ships and submarines occasionally transit through the Strait of Georgia, en route to the Nanoose Bay Range and other proximate areas. Although this type of accident is possible, the probability of a nuclear incident occurring is low. Collisions at sea and marine accidents more generally are a moderate risk.

The Sunshine Coast is a very active area where vessel traffic is concerned. BC Ferries are in operation between Langdale and Horseshoe Bay, Langdale-Keats-Gambier and Earls Cove and Saltery Bay, while private boaters and transport barges frequently transit local waters with a variety of cargo. The summer months see a dramatic increase in boat traffic which may also include recreational paddlers. Dangerous goods used in pulp processing at the Howe Sound Mill (Port Mellon) and the Weyerhaeuser Stillwater mill (Powell

River) are frequently transported via rail barge through the Strait of Georgia, and to a lesser extent, Malaspina Strait. BC Ferries also carry large volumes of diesel fuel and lubricants between Nanaimo and Horseshoe Bay.

In this context, the greatest marine threat to the Gambier Island and Keats Island is pollution caused by spillage or vessel collision. Oil spills, depending on their size and area, could have a serious impact on these communities in an economic and environmental sense. Depending on the substance released, the amount, proximity to inhabited areas, prevailing wind and tidal conditions, spillage of some dangerous goods may require evacuation due to toxic fumes. Given that the closest hazardous materials response teams are deployed from Surrey, BC and that the SCRD has limited capacity to respond independently, this risk for Gambier Island and Keats Island has been identified as ***high***.

Another important consideration is the high use of and dependency on marine travel for the communities of Gambier Island and Keats Island. Summer months may also see an increase in inexperienced travelers and potentially increase the risk of marine accident. An example of this is illustrated on the May long weekend of 2001. The Canadian Coast Guard Auxiliary responded to call from a boat that had been swamped in fairly heavy seas. The vessel arrived safely after being towed to Gambier Island (Canadian Coast Guard Auxiliary, 2001)

3.1.3 Motor Vehicle Accidents

Motor vehicle crashes occur whenever a motor-powered vehicle collides with another vehicle, fixed or moving structure, or loses control and incurs damage. Accidents involving large numbers of people or dangerous goods however, can be very serious.

Gambier and Keats Island are not serviced by ferries which carry vehicles; therefore, summer populations are not equated with large increases in vehicular traffic. Vehicles and golf carts are primarily used for transporting goods from docks to residents' homes and short distance travel on these islands limited road networks. Lower speed limits and population size on both islands generally dictate a low risk. Accidents however, do occur as highlighted in April 2005 when a young resident on Gambier Island was involved in a fatal motor vehicle accident. The reality of limited response capability associated with a semi-isolated community and the unpredictability of serious accidents does however increase this risk. Still, this risk is ***low*** due to the limited vehicular traffic.

3.2 FIRE

3.2.1 Structural Fire

Fires are a reality in any municipality, region or district and have the capacity to spread quickly to adjoining structures such as homes, commercial buildings and other infrastructure. Calculating the frequency of urban fires is difficult as most outbreaks tend

to be random accidents, excepting criminal acts of arson. Estimating a community's ability to respond, based on available resources and the existence of mutual aid agreements, is a much more efficient way of calculating the risk of urban fire.

Both Gambier and Keats Island have communal fire equipment; however, no official fire firefighting team. Keats Island has equipped fire sheds located at Keats Landing Dock, Eastbourne Dock, the Co-op and West Beach, as well as a community siren. Gambier Island established a cooperative in 1980 called the Gambier Fire Equipment Group (GFEG). The group trains individuals in the use of fire suppression equipment, which is acquired through membership money and outside funding. The group states that their aim is self help and is in no position to respond to emergency calls. However, historically, members have been known to help out in times of need. Equipment is not exclusively for the use of members; however they have priority if multiple fires are an issue. Equipment is located at designated sheds as well as a mobile trailer, with prospects for more mobile units.

As with any first response service, speed of delivery is dependent on a variety of extraneous factors, such as weather, traffic, vehicle access and number of concurrent dispatches. With neither island having an established fire fighting organization, appropriate fire suppression techniques may be lacking. Also proper and rapid response may be insufficient as help will often be from direct neighbors and word may spread slower than the fire. Gambier Island is attempting to manage for this with the cooperative initiative and training of members. Considering the response capability and the potential for random accidents the overall risk is ***high***.

3.2.2 Wildland Interface Fire

Abnormally hot, dry weather and excessive fuel loading often make forest areas particularly vulnerable to lightning strikes and human carelessness. Once burning, a wildland fire can spread quickly due to high winds and easily overwhelm the capacity of local response agencies. Aside from the environmental and economic impact, wildland fires become particularly devastating when they encroach upon human settlements and critical infrastructure. When this occurs, they become 'interface' fires and because of their difficulty to manage, can be extremely destructive.

The Firestorm of 2003 made the risk of interface fires abundantly clear to communities across British Columbia. Between July and August, over 2,500 fires burned throughout the interior, causing 344 homes and businesses to be lost, 45,000 people to be evacuated, and 260,000 hectares of forest to be destroyed. The total cost of the Firestorm was estimated to be $700 million, though the greatest loss of all was that of three pilots who died in the line of duty (Filmon, 2003, p. 10).

As a means of hazard identification and risk management, the Sunshine Coast Regional Fire Centre completed interface community fire hazard rating and mapping in 1999 for all populated areas within the SCRD. The numerical rating system considered a number of factors for various points throughout the SCRD, such as:

Fuel load	Forest fire history
Topography	Land use
Weather and climate	Fire protection capability
Existing mutual aid agreements	Fire potential on adjacent lands

Each category was ranked and given a score against a total of 169. The rating scheme was as follows:

Figure 3-2 Interface Community Fire Hazard Rating

0-55	Low	Green
56-70	Moderate	Yellow
71-85	High	Orange
86+	Extreme	Red

The resulting data were then plotted and mapped to provide a visual representation of interface fire hazards within the SCRD. Overall, the areas at extreme risk of wildland interface fire were Keats Island and the southern peninsulas of Gambier Island, due largely to fuel loading and limited fire protection and water coverage in undeveloped areas.

As with structural fires, an understanding of suppression techniques may be limited, as there is no official fire fighting organization on either island. Equipment is made available to the residents; however, supplies may be insufficient to deal with a large scale fire. A further problem arises with the Gambier Fire Equipment Group when dealing with a multiple property wildfire, where members have first claim on their equipment for protecting their own property. In the incident of such a large scale fire, the Forest Fire Service can be contacted to provide additional support.

Overall, Keats Island and Gambier Island have limited response capabilities, a large fuel load, limited fire protection and limited water supply in undeveloped areas. Taking these factors into account along with the rating of interface fire from the SCRD, the risk is rated as ***very high***.

3.3 STRUCTURAL COLLAPSE

Structural collapse occurs when a building or structure collapses due to engineering or construction problems, metal fatigue, changes to the load bearing capacity of the structure, human operating error or other cause such as demolition, earthquake, flood, fire, explosion, snow or ice buildup.

If people are in the building, are on or near the structure when it collapses, injuries and death can potentially be high. When buildings or large structures collapse, they often cause ruptures in existing infrastructure such as gas lines, electrical, water, sewage, and telephone lines. For these reasons, fire is often a corollary hazard that follows structural collapse.

Restrictions on structural dimensions of buildings are in place to maintain standards, such as the maximum height of a principal building on Gambier Island is 10 meters and the maximum height of an accessory building is one storey (7 meters); except for a building for agricultural use which shall not exceed 12 meters or a commercial building which shall not exceed 5 meters (Gambier OCP, 2001). Similarly, Keats Island has a height restriction of 11 meters; but this does not apply to towers for water, fire alarms and bells, as well as silos, antennas and chimney stacks (Keats OCP, 2001).

Of special concern are the fire suppression sheds as well as the water tower on Keats Island. Should they be compromised, a corollary fire could get out of control. Overall, this risk is considered ***moderate***.

4.0 DIESEASES, EPIDEMICS, PANDEMICS

4.1 WATER CONTAMINATION

A variety of events can lead to disease and epidemic among the residents and visitors of Gambier and Keats Island. Drinking contaminated water has affected tens of thousands of North Americans in the last decade. The protozoa parasite Giardia lamblia was the agent most commonly implicated in outbreaks. Many of these outbreaks were associated with ingestion of chlorinated but unfiltered surface water.

Shigella sonnei was the most commonly implicated bacterial pathogen in major water-borne disease events in the last ten years. In outbreaks caused by this pathogen, water supplies were found to be contaminated with human waste.

Cryptosporidium contamination of a chlorinated, filtered public water supply has also caused outbreaks of disease in North America, most recently in North Battleford Saskatchewan.

In May of 2000, the small community of Walkerton, Ontario, was hit by an outbreak of E. coli found in the public water supply. It is believed that approximately eleven persons died from this disease, and more than a thousand people were infected.

Tampering with public water supplies has recently surfaced in BC with incidents reported at Ladysmith and Kaslo.

Residents of Gambier and Keats Island primarily rely on well source water supplies. These are typically located on each property, but some households may draw from a communal well. As the water supply is not located at a single point source, deliberate contamination would be more difficult. However, monitoring of water quality over both space and time presents a challenge to ensure that any potential contamination is avoided. Considering that the protection of the water sources from intentional contamination is virtually impossible to achieve, the risk to these communities is ***moderate***.

4.2 WEST NILE VIRUS

West Nile virus (WNV) is a potentially serious illness spread by mosquitoes primarily of the *Culex* species which feed on infected birds. The virus is transmitted to humans through the bite of an infected mosquito. It is important to note that the West Nile virus (WNV) is expected to arrive in BC in 2005 and migrate to northern BC from the South or Alberta.

According to the British Columbia Centre for Disease Control (BCCDC), there have been no historic cases of humans or birds testing positive for WNV.

Areas of Gambier and Keats Island with standing water are good breeding and resting sites for mosquitoes; thus increasing the threat of WNV. To date, WNV does not pose a great threat to these communities; therefore this risk is considered ***low***.

4.3 PANDEMICS

Yearly epidemics cause serious illness and death, especially among those who have weakened immune systems due to age or underlying medical conditions. A pandemic is an epidemic that affects a very large geographic area and is often global.

Influenza is a common infection that affects large numbers of people annually. Among the general population, influenza is recognized as a very uncomfortable but self-limiting, and ultimately benign, illness. Yet the last 100 years has seen three occasions of worldwide pandemic outbreaks of severe influenza. The worst of these pandemics was the infamous Spanish Flu of 1918 which killed an estimated 20 to 40 million people around the globe – more than the casualties of the First World War. The Spanish Flu of 1918 is considered to be the most devastating pandemic in world history. According to the BC Centre for Disease Control (BCCDC), pandemics occur every 20 to 40 years. With today's global transportation networks, the potential for a pandemic to spread rapidly is high.

The BCCDC estimates that 20 to 50 per cent of the BC population will become infected with the next influenza pandemic, with 15 to 35 per cent becoming clinically ill. The rate of hospitalizations is estimated at 40 to 400 people per 1000 people. These estimates are based on the impacts of the 1957 and 1968 pandemics which were relatively mild when compared to those of the 1918 Spanish Flu. Actual rates of the next pandemic may be significantly higher and it should be noted that disease agents other than influenza, such as SARS, may also be the cause of a pandemic.

During a pandemic, there is an unusually high number of hospitalizations and local health authorities will likely be overwhelmed. Municipalities should work with local health authorities to create contingency plans on how they will handle the surge in patients. In addition, municipalities will need to continue providing essential services and support to residents. As many municipal employees may also become infected and be unable to work, contingency plans should be made to operate with a reduced workforce.

Due to the widespread nature of pandemics, neighbouring communities may not be able to provide assistance. This is especially a concern to the communities of Gambier and Keats Island as emergency response is primarily coordinated with neighbouring communities. However, due to the remoteness of Gambier and Keats Island, the disease may be detected in cities higher up the urban hierarchy (i.e. Vancouver) before it arrives on these islands. This may provide some advanced warning. However, with today's transportation networks and the mobility of today's population this should not be relied upon. The risk to Gambier and Keats Island is considered ***high***.

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