MOBILIZING RESILIENCE
A Disaster Resilience of Place Approach to Integrated Flood Hazard Management Planning in Squamish, British Columbia

Christopher J. Carter

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A DISASTER RESILIENCE OF PLACE APPROACH TO INTEGRATED FLOOD HAZARD MANAGEMENT PLANNING IN SQUAMISH BRITISH COLUMBIA

By

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Executive Summary

The District Municipality of Squamish faces severe coastal flood risk. However, not all of the 7,477 residents living in the floodplain are created equal in the exposure to these floodwaters. In creating an Integrated Flood Hazard Management Plan (IFHMP) it is critical to address both hazard and vulnerability components of risk. While the strength of floods cannot be controlled, reducing existing vulnerability and maintaining natural services that provide protection provides for long-term risk reduction in flood hazard management.

Today, the District Municipality of Squamish retains valuable natural flood management assets -- such as the Skwelwil'em Squamish Estuary -- that delivers an estimated $284 million in flood disturbance regulation services to the District yearly. Meanwhile, the most vulnerable people in Squamish live adjacent to the estuary in the downtown core - the most exposed area to coastal flood events and sea level rise. While the strength of flooding (Hazard) cannot be reduced, the everyday conditions of people and the environment (Vulnerability) can be addressed in local risk-based land use planning and community development.

Reducing vulnerability has many co-benefits, including all hazards planning, poverty reduction, social equity, economic development, ecosystem-based adaptation and integrated resource management. This is the first step to disaster risk reduction and risk-based planning in coastal British Columbia. Failing to address these conditions will result in unchanged or increased vulnerability and sensitivity to flood risk.

Using the Disaster Resilience of Place approach, this report contains 3 major analyses and illustrates how the local government -- in collaboration with the Squamish First Nation and citizens -- can effectively build a more flood resilient community and innovate in IFHMP practice. Tools to assist in quantifying vulnerability and resilience and to improve the performance of public engagement are also offered in the Appendix section of this report. Flood Management and Official Community Plans are identified as key platforms to reduce vulnerability with strong ties to local level emergency management planning and long-term climate adaptation to coastal flood hazard. These are the primary policy and environmental management pathways identified for implementing a DROP approach in Squamish. The following table presents key findings by major analysis area:
Key Findings

Risk Assessment

• The highest concentrations of social vulnerability and greatest exposure to coastal flood hazard (surge and sea level rise) are located in the downtown area – notably Dissemination Areas 59310202 and 59310201.
• Waters during a 200-year coastal flood event may reach 0.5m to 3m across the flood plain in a current diking or future dike failure scenario.
• At least 2% of District’s land is subject to 1 meter of sea level rise.
• Future upland extent of the Squamish estuary, a major ecosystem flood management service, must be considered in land use planning.

OCP and Existing Flood Management Plan Evaluation

• The existing flood hazard management plan from 1994 was never legislated and it is unclear how much was implemented ad hoc in the past 20 years.
• The current Official Community Plan met 63% of evaluation protocol for coastal risk planning – successfully identifying governance arrangements and coordination, social participation and legal requirements.
• The biggest area for improvement in OCP revision is goal setting for coastal hazards risk-reduction and strengthening policy linkages between hazard lands, resource management, community and social development around poverty and vulnerability reduction.

Public Participation

• It remains unclear how this the $2.95 million CAD earmarked by the District Municipality for flood risk management activities will be used to reduce vulnerability and how citizens will meaningfully participate in hazard management and risk-reduction planning.
• Areas of high social vulnerability and low engagement, notably the downtown area neighborhoods, Punjabi community and non-official language speakers, should be the focus of participatory engagement in flood hazard and emergency management planning.
• A citizen seat on the IFHMP steering committee and the creation of an IFHMP implementation committee with strong community organization representation is recommended immediately.
• Participatory and deliberative activities including allocating up to $100,000 for “resilience activities” are recommended to improve IFHMP implementation and vulnerability reduction efforts.
Image 1: The Squamish Yacht Club at 2.15 Meter total water level during a surge event by Christopher J. Carter (LightHawk Conservation Flying | Resilient Coasts UBC), 2015
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2.0 Terms Used

Where not noted, major terms used in this report are from the Intergovernmental Panel on Climate Change (IPCC). However, a few terms are grounded in academic literature, international best practices and Canadian Federal and Provincial law.

**Biodiversity** is the variability among living organisms from all sources including, inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems.

**Dissemination Area** is the smallest level of census data collection in Canada at 400-700 people each and remains stable over time. These areas follow roads, railways, waterways and other major human made boundary. While not exactly aligned with neighborhood and social relations they are the most detailed unit of analysis using Canadian census data and have been used for this report as the level of analysis (Census Canada, 2015).

**Ecosystem services** are the conditions and processes through which natural ecosystems, and the species that make them up, sustain and fulfill human life. Ecosystem goods (such as food) and services (such as waste assimilation) represent the benefits human populations derive, directly or indirectly, from ecosystem functions, most notably, regulating services including water regulating, erosion control and water purification ecosystem services that provide flood hazard mitigation services. (Costanza et al. 1997:253). These are the basis for ecosystem-based adaptation.

**Empowerment** an iterative process involving popular participation of individuals in decision-making that affect community development outcomes such as like poverty eradication, social integration and livelihoods and risk reduction (Wisner, 2006).

**Floodplain** is relatively flat lowland that borders a river, usually dry but subject to flooding and built upon river sediment and past flood deposits.

**Hazard** is the potential occurrence of a natural or human-induced physical event that may cause loss of life, injury, or other health impacts, as well as damage and loss to property, infrastructure, livelihoods, service provision, and environmental resources (UNISDR, 2009).

**Integrated Flood Risk Management Plan (IFHMP):** integrates watershed level planning, disaster management, community development through a multi-stakeholder approach towards sustainable hazard mitigation (Green, 2003).

**Natural Boundary** Any formation or product of nature which may serve to define and fix one or more of the
lines inclosing an estate or piece of property, such as a watercourse or coast. This is determined by a mean high water mark not affected by construction activities such as a dam or diking structure (BC Ministry of Forests and Lands, 1987).

**Neighborhood** is a place-based social construction that reflects social and familial and environmental relations, networks and residential areas and housing systems - often expressed as a familiar place name (i.e. Dentville, Brackendale etc.)

**Official Community Plan (OCP)** is a statement of objectives and policies that guide decisions on growth, planning, land use, and provision of municipal services in the community. The document is reviewed annually and completely revised every 5 to 10 years. As an official bylaw it regulates property development such as through zoning and designated permit areas. All other bylaws must remain consistent with the aims set forth in an OCP. (Local Government Act, 2009)

**Participatory Budgeting (PB)** will be defined as a democratic process in which community members directly decide how to spend part of a public budget. It enables taxpayers to work with government to make the budget decisions that affect their lives (Dias, 2014). This activity will be referred to in proposed “Resilience Activities”.

**Proper Functioning Condition (PFC)** is a method to better understand the health of estuaries and riparian areas that provide flood mitigation services. PFC provides a practical way of classifying the condition of these riparian and intertidal ecosystem services. This is based on studying the physical function of riparian-and coastal wetland areas -- accounting for hydrology, vegetation, and soil/landform attributes. This provides an assessment for prioritizing reclamation actions and monitoring the long-term condition of local ecosystems at the watershed scale (U.S. Department of the Interior - BLM, 1998).

**Recurrence Rate** is the probability of the occurrence of a given flooding event. The recurrence interval is based on the probability that the given event will be equaled or exceeded in any given year. In this case intermittent riverine flooding and coastal surge events. Also known as a return rate (Ministry of the Environment, 2011).

**Resilience** is defined as the ability of a socio-ecological system and its component parts to anticipate, absorb, accommodate, or recover from the effects of a potentially hazardous event in a timely and efficient manner, including the preservation, restoration, or improvement of its essential basic structures and functions (UNISDR, 2009).
**Resilience Activities** are small infrastructure, programs and ecosystem improvements that improve the overall disaster resilience of the community, integrating risk reduction efforts with community development and environmental planning.

**Risk** is the ‘combination of the probability of an event, existing conditions and its consequences.’

**Vulnerability** is a region’s total exposure to hazard (including people, economy and environment) and its existing sensitivities, while taking into consideration its capacity to adapt.

**Social Vulnerability** is a concept that helps to identify indicators, characteristics and experiences of communities (and individuals) that enable them to respond to and recover from environmental hazards.

**Social Vulnerability Index (SoVI)** a collection of quantitative measures, or indicators, that assist in understanding existing social conditions spatially and over time (Cutter, S. L., L. Barnes, M. Berry, & C. Burton, E. Evans, E. Tate, and J. Webb, 2008).

**Total Water Level** is the sum of storm surge, tide level, wave action and fresh water inputs in a specific coastal location (NOAA, 2012).
3.0 Introduction and Problem Statement

First peoples, residents, business owners and the local government of Squamish, British Columbia face serious exposure to coastal and upland flood hazard. As the population of this coastal community is expected to double over the next twenty years, local planning must accommodate urban development while managing risk with citizens. Currently, the District, the Squamish First Nation, Provincial Agencies and community members are creating an Integrated Flood Hazard Management Plan (IFHMP) to meet these challenges. This plan will account for coastal flood risk for the first time in that community, identifying structural upgrades and non-structural approaches to guide safe development of human settlement on the river delta.

Under provincial Bill 27, local governments in British Columbia are mandated to do climate change mitigation planning through GHG target setting but coastal municipalities lag behind in adaptation planning.

Connecting sound climate science with land use policy is difficult. Today it is unclear if local planning institutions operate using evidence-based policy making.

The District of Squamish is a coastal community with unique geography and extensive flood hazard. Located at the head of a fjord in the North Salish Sea of British Columbia, human settlement also rests at the foot of 6 mountain river systems. To date, the District has been equipped with an aging flood management plan, limited dyke infrastructure, little legislated risk-based land use guidelines and a lack of focus on the social and ecological determinants of flood risk vulnerability. To plan for disaster resilience, the District alongside the Squamish First Nation, civil society and businesses must meet risk complexity and new climate realities with innovative and collaborative solutions that effectively mitigate, prepare, respond to and recover from flood events.

In beginning othis research, the following hypotheses were made to critically guide analysis:

A. Certain people in Squamish BC are disproportionately vulnerable to coastal flooding events.
B. The District of Squamish accounts for current and future coastal flood hazards in its planning.
C. The District of Squamish protects ecosystem services that provide coastal flood protection.
D. The District of Squamish engages in evidence-based planning to reduce exposure of vulnerable people and lands.
E. The District of Squamish has created inclusive and participative processes to engage vulnerable populations and industries in adaptation planning.
To investigate these hypotheses, the following analyses were conducted:

1) An analysis of social vulnerability to coastal flood risk spatially using a suite of vulnerability indicators and coastal flood modeling.

2) Plan evaluation of the current official community and flood management plans.

3) Evaluation of public participation in the creation and implementation of an IFHMP.

Recommendations are synthesized at the end of each finding section. These include actions to reduce vulnerability through land use planning, community development policy and participatory planning approaches. Lastly, tools are offered in the Appendix to support the District Municipality in reducing vulnerability and building resilience to coastal flood risk.

This case study offers a timely illustration of how planners, risk managers, engineers and community organizers in British Columbia can better create and Implement an Integrated Flood Hazard Management Plan (IFHMP) through robust vulnerability assessment, land use policy instruments and public participation. However, relevant IFHMP planning must begin with a robust understanding of the planning context.
4.0 The Squamish Context

Many historical and place-based factors influence the capacity of the Squamish environment, local government and residents to face coastal risk and disaster resilience. This section offers an overview of the Squamish setting including historically relevant flood information, environmental observation, social, geographic and institutional conditions which interact to produce vulnerability.

The main sections include:

1. Indigenous Territories
2. Social and Economic Conditions
3. Ecological Condition
4. Planning Institutions
5. Physical Geography and Flooding Hazard

These factors -- belonging to major human, earth and constructed systems -- present relevant historical and societal conditions. These inform the translation of knowledge into action in flood hazard planning. As these systems interact during hazard events, each system plays a unique role in increasing or reducing human loss and damage to property (Mileti, 1999). By understanding each aspect individually, their interaction and complex relationship can be understood and addressed strategically.

For the creation of flood hazard management plans, these details inform the creation of plans that are socio-culturally and environmentally relevant.

Figure 1: Squamish and The Strait of Georgia Region
4.1 Indigenous Territories

The District of Squamish is located within the unceded traditional territory of the Skwxwú7mesh Úxwumixw (Squamish Nation). Since time immemorial that nation made extensive use of the flood plain and coastal areas for subsistence, ceremonial and settlement uses -- often shifting locations with changing flood profiles (Skwxwú7mesh Úxwumixw, 2013)(Kerr Wood Leidal, 2015a).

Today, ten Squamish Nation reserves are located throughout the Squamish Valley and river delta and the nation has a registered population of 3,500 including those living off settlement lands (Muckle, 2014). These lands, a small fraction of the traditional territory, are illustrated in Figure 2. These areas are adjacent to District dissemination areas and share coastlines on the coast and Squamish River. Today the First Nation is engaged in joint planning with the District Municipality in for land use, economic development, and infrastructure and community development initiatives is guided by the 2008 protocol agreement.

Shared exposure to coastal flooding creates further shared value in flood management between the District of Squamish and the Squamish Nation. Plan creation and implementation of the District’s IFHMP follows the 2008 protocol agreement and will be a joint planning initiative with the First Nation participating as an equal party member.

The Squamish Nation government has been recognized federally under the Indian Act with a chief and council system structured using the Indian and Northern Affairs Canada model. Today as a planning institution retain their own land use planning and GIS departments and actively engage traditional forms of governance including siyam (matriarchs and patriarchs) are engaged in core community events, community decision-making and resource management activities (Muckle, 2014) (Dodds, Williams, & Bleck, 2013).

It is important to note that the First Nation, like many in the Province, are seeking long outstanding claim to their traditional territories. This is done through a formal treaty negotiations and currently the nation is at stage 3 of 6 in negotiations British Columbia Treaty Commission (Skwxwú7mesh Úxwumixw, 2013).

The valley name, “Sko-mish” translates “strong wind” or “birthplace of the winds” in the sqʷχʷuʔməʃ sniʔim (Skwomesh) Language. Traditional Ecological Knowledge of a changing land and environment by these first peoples provide critical insight into the nature and history of coastal flood risk - most notably major wind (aiyum-spaiyum) and flood events beyond data record, natural boundaries, of water courses and socio-culturally relevant adaptation and risk management of coastal flood hazard in the
Squamish valley. Much of this knowledge is held and transferred in oral tradition and origin stories.

The legend “The Great Flood” -- an event that came when people stopped listening to elders and lost touch with traditional ways – is a fundamental flood history which predates newcomer settlement on the river valley. A traditional story told by an Skwxwú7mesh Ûxwumíxw elder to Canadian writer E. Pauline Johnson-Tekahionwake in 1911 recounts the intergenerational story:

For, one time, there was no land here at all; everywhere there was just water. It was after a long, long time of this - this rain. It rained for weeks and weeks, while the mountain-torrents roared thunderingly down, and the sea crept silently up. The level lands were first to float in seawater, then to disappear. The slopes were next to slip into the sea. The world was slowly being flooded. Hurriedly the Indian tribes gathered in one spot, a place of safety far above the reach of the on-creeping sea.

A giant tree was felled, and day and night the men toiled over its construction into the most stupendous canoe the world has ever known. Not an hour, not a moment, but many worked, while the toil-wearied ones slept, only to awake to renewed toil. Meanwhile, the women also worked at a cable - the largest, the longest, and the strongest that Indian hands and teeth had ever made. Scores of them gathered and prepared the cedar-fibre; scores of them plaited, rolled, and seasoned it; scores of them chewed upon it inch by inch to make it pliable; scores of them oiled and worked, oiled and worked, oiled and worked it into a sea-resisting fabric.

And still the seas crept up, and up, and up. It was the last day; hope of life for the tribes, of land for the world, was doomed. Then, with the bravest hearts that ever beat, noble hands lifted every child of the tribes into this vast canoe; not one single baby was overlooked. For days and days there was no land - just the rush of swirling, snarling sea; but the canoe rode safely at anchor in to the top of Nch’kay (Mt. Garibaldi).

But one morning at sunrise, far to the south, a speck floated on the breast of the waters; at midday it was larger; at evening it was yet larger. The moon arose, and in its magic light the man at the stern saw it was a patch of land. All night he watched it grow, and at daybreak looked with glad eyes upon the summit of Mount Baker. He cut the cable, grasped his paddle in his strong young hands, and steered for the south.

When they landed, the waters were sunken half down the mountainside. The children were lifted out; the beautiful young mother, the stalwart young brave, turned to each other, clasped hands, looked into each other’s eyes - and smiled.

When the waters receded, the people who survived came to their senses and listened to their elders. Then the game and the fish and the berries returned in abundance.
Managing flood risk today must deal with climate uncertainties and must work with local level data and knowledge to guide successful adaptation and risk reduction. As downscaled climate modeling is incomplete and hydrographic data records a mere past thirty years of the Squamish watershed comprehensively, traditional knowledge of successful adaptation, land and water systems can reveal a more comprehensive understanding of life and risk management on the coastal flood plain. As partners in Integrated Flood Hazard Management Planning and in other joint planning initiatives, there are significant opportunities to privilege indigenous knowledge of the Squamish watershed -- engaging elders and traditional knowledge holders in policy creation, resource managers in environmental monitoring and collaboration to reduce vulnerability for present and future coastal flood risk.

Figure 2: Indigenous Land Reserves and Flood Infrastructure in the Squamish Valley
4.2 Social and Economic

Historically the territory of Skwxwú7mesh Úxwumíxw (Squamish Nation), the population size and composition have changed significantly over the past hundred years of settler migration into the Squamish Valley. The District Municipality of Squamish reported a population of 17,674 people (incorporating census undercount) in the 2011 Census and has grown to an estimated 19,294 since1. (Statistics Canada, 2015)(BC Stats, 2015).

The rate of change in the area in the past few years has been unprecedented with a reported 14% growth rate since 2006 -- 2.7% alone in 2014. This makes Squamish one of the fastest growing coastal communities in the Straight of Georgia and higher than the rest of the Squamish Lillooet Regional District (13% growth) in the past decade. Over the next 20 yrs the community is expected to double in size. At the provincial level it is the 7th fastest growing municipalities in the province (BC Stats, 2015) (Statistics Canada, 2015).

The median household income in Squamish in 2011 was $69,171. According to the Census designation for a semi-urban community the size of Squamish, families earning less than $44,340 after taxes for a family of 4 would be considered of Low Income Cut-Off (LICO) status. Given this definition, over 2,500 households in Squamish are low-income households and 195 households live in extreme poverty -- earning less than $5,000 a year after taxes.

Squamish residents find a majority of employment in the public sector (18%) while Tourism (11%) and Construction (10%) remain other dominant sectors. Squamish is predominately young, with a median age 36.8 years old with a majority of the population in the 25-44-age cohort. However, over the past decade, the proportion of the population under 24 has shrunk while those above 45 and 65 years old have grown, becoming a larger portion of the population. Looking forward to 2031 the trend of population cohorts is set to increase in the size of the population aged 55-64 and over 65 years old (Statistics Canada, 2011).

1 Province of British Columbia generalized estimations

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**Source:** 2011 NHS Census Data (Statistics Canada, 2015)

**Mobilizing Resilience:** A Disaster Resilience of Place Approach to IFHMP in Squamish British Columbia
Figure 4: Household Income Distribution

Source: 2011 NHS Census Data (Statistics Canada, 2015)
A majority of Squamish residents own their homes. However, 42% of Squamish residents rent. Of these, 54.3% of them spend more than 30% of their household income on housing. Affordable housing in British Columbia is defined as “rent costing no more than 30% of a household’s total gross monthly income, subject to a minimum rent that tenants will be asked to pay based on the number of persons living in the home” (BC Housing, 2015).

In 2014, Squamish reported a 0.3% rental vacancy rate (Canada Mortgage and Housing Corporation, 2014). Low vacancy rates have been shown to correlate with a difficulty for communities to recover from floods and other natural disaster events as the availability of temporary and permanent housing generally is limited by their pre-impact supply in and near the impact area of a disaster flood event (National Research Council, 2006). Such problems may be more prevalent in lower-income groups that have few alternative resources and when most members of an extended family live in the same affected community (Sen, 1981) (National Research Council, 2006). Squamish is currently experiencing a near zero percent vacancy rate and there was no recorded increase in housing rental stock between 2013 and 2014 (Canada Mortgage and Housing Corporation, 2014). This data is collected at the municipal scale rather than Dissemination Area level, but has implications for those impacted and displaced by a flood hazard event. This is a key factor to monitor mitigation and recovery in disaster resilience and emergency planning. Table 1 illustrates Squamish vacancy rates by housing type in relation to provincial averages.
Table 1. Housing Vacancy Rate Trends for Private Townhouses and Apartments

<table>
<thead>
<tr>
<th>Housing Type</th>
<th>Vacancy Rates (%) in 2013</th>
<th>Vacancy Rates (%) in 2014</th>
</tr>
</thead>
<tbody>
<tr>
<td>Squamish</td>
<td>5.6</td>
<td>0.3</td>
</tr>
<tr>
<td>British Columbia</td>
<td>3.5</td>
<td>2.5</td>
</tr>
<tr>
<td>Average</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(Canada Mortgage and Housing Corporation, 2014)

While rental housing can be difficult to secure, some Squamish residents remain without any housing arrangements, living in undeveloped plots of land near watercourses, on boats and in vehicles (Carter, 2015). Local NGO Squamish Helping Hands Society reported more than 200 homeless persons during an annual count in 2014 - 1.13% of the total population.

Squamish is an increasingly diverse society. While original settlers came from Europe during westward expansion, newcomers today are increasingly from other world regions with diverse linguistic and cultural backgrounds. While internal migration from other regions of Canada to is also common, over the past decade 1,000 migrants have arrived to the valley from overseas -- most notably South Asia. A majority of this migration has occurred in the past 5 years. Communication, integration and social connectivity of these new residents -- in an area of predominately English and French speakers -- may prove difficult, especially for the 147 people (8% of the population) who do not speak an official Canadian language at home (Statistics Canada, 2015). This has real implications in flood risk management and emergency management communications.

Ethnic backgrounds and religious affiliations provide an unique understanding of household worldviews of natural hazards, environmental management and climatic change (Norris, Stevens, Pfefferbaum, Wyche, & Pfefferbaum, 2008) (Oliver-Smith & Hoffman, 2002). Figures 6 and 7 offer a composition of these elements. While the European ethnic descent remains dominant, recent trends in South Asian populations (Punjab Region of India and the Philippines) must be noted. Further, a significant number of Squamish residents do not subscribe to a major religion while Christian and Sikh retain the two largest groups of religious followers. These social, cultural, religious and linguistic characteristics are critical to recognize and address in plan creation, public engagement and implementation that meets resident values perception and worldview of risk and flood hazard management.
Figure 6: Ethnic Origins

Figure 7: Religious Affiliation

Source: Assembled from 2011 NHS Census Data (Statistics Canada, 2015)

Mobilizing Resilience: A Disaster Resilience of Place Approach to IFHMP in Squamish British Columbia
4.3 Ecological Condition

Estuaries in the Howe sound region are key green infrastructure assets -- providing up to $84,000 CAD per hectare yearly \(^2\) in disturbance regulation to flood events (Molnar, 2015). The 935-acre Skwelwil’em Squamish Estuary and Management Area provides critical riverine and coastal flood disturbance services. As a largely intact estuarine salt marsh and forest is the primary existing ecosystem service to coastal flooding for the District of Squamish. Containing aquatic, estuarine and terrestrial environs it accounts for 96 per cent of estuarine habitat in the Howe sound area -- providing spawning habitat and food for the migrating anadromous (fresh water spawning) fish populations and is the biodiversity “hot spot” in the District (BC Ministry of Environment, 2007) (Molnar, 2015).

Half of the extent of the Skwelwil’em Squamish Estuary is protected from development as part of a wildlife management planning area. Land use in this area is restricted to preserving habitat and biodiversity and recreational uses. Land use is guided by a 2007 plan and is co-implemented between the District of Squamish and the Squamish First Nation (BC Ministry of Environment, 2007). Outside of this area, urban settlement, industrial development, deforestation has reduced the extent of

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\(^2\) A benefit transfer valuation approach was used using avoided cost, replacement cost and hedonic pricing methods.

the forest, altering the form, function and protection that the estuary provides the downtown area.

Estuaries and bays, coastal wetlands, headlands, seagrass beds, rock reefs and kelp forests provide protection from storms, storm surges, tsunamis and other disturbances. These ecosystems are able to absorb and store large amounts of rainwater or flood runoff during a storm event. Further, in studies of estuary function in flood events, the debris and salt marsh canopies has been observed to reduce wave height of up to 50% over the first 10–20 m (Möller, 2006). Estuarine ecosystems with intact vegetation -- as in much of the Squamish estuary -- are also important for absorbing floodwaters during storm surge and are especially important in smaller more frequent flood events (L.A. Leonard & Reed, 2012).

Estuarine environments play a key role in protecting the most vulnerable populations in local society. Across the north American continent, intact coastal ecosystems adjacent to socially vulnerable neighborhoods have been found to reduce the exposure of populations by up to 50% (Arkema, 2013). Using these regional estimations for ecosystem services that regulate flood disturbance and its current extent, the Skwelwil’em Squamish Estuary Management Area delivers up to $284 million in disturbance regulation services to the District yearly.

The Skwelwil’em Squamish estuary management area includes all major coastal and intertidal ecosystems. However, estuary, salt marsh wetlands and estuarine forest are dominant.
Figure 8. Coastal Ecosystem Benefits Valuation in the Howe Sound By Land/Water Feature

<table>
<thead>
<tr>
<th>Land/water cover type</th>
<th>Total value/year ($/yr)</th>
<th>Value per hectare per year ($/ha/yr)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Low</td>
<td>High</td>
</tr>
<tr>
<td>Beach</td>
<td>$100,457</td>
<td>$32,640,226</td>
</tr>
<tr>
<td>Estuary</td>
<td>$179,370</td>
<td>$462,600</td>
</tr>
<tr>
<td>Forest</td>
<td>$682,526,262</td>
<td>$1,599,254,118</td>
</tr>
<tr>
<td>Lakes and Rivers</td>
<td>$3,271,323</td>
<td>$117,643,415</td>
</tr>
<tr>
<td>Marine</td>
<td>$102,005,609</td>
<td>$2,811,105,944</td>
</tr>
<tr>
<td>Riparian Buffer</td>
<td>$3,979,334</td>
<td>$156,128,608</td>
</tr>
<tr>
<td>Wetlands</td>
<td>$329,165</td>
<td>$22,482,905</td>
</tr>
<tr>
<td>Total</td>
<td>$792,544,295</td>
<td>$4,740,284,637</td>
</tr>
</tbody>
</table>

A complete table of ecosystem benefits in the Howe Sound by coastal asset area and monetary valuation is offered in Figure 8. Knowing the market value of natural assets provides a useful in asserting accurate values of ecosystem function in flood hazard mitigation, ecosystem-based adaptation and in making transparent decisions and tradeoffs in urban development.

The Skwelwil’em Squamish Estuary contains a number of human alterations that have changed its function over time. An intact coastal estuary system -- with adequate vegetation, forest and large woody debris -- reduces coastal energy associated with surge, higher sea levels and intertidal flooding during mountain freshets from the Squamish River, reduces erosion and serve as buffer from storm surge from the Southern waters of Howe Sound.

To date a detailed inventory of land/water cover at the hectare level and an ecosystem function assessment has not been completed for the estuary. This has been posited as a core monitoring and evaluation activity in the 2007 Skwelwil’em Squamish Estuary management area plan.

Source: Reprinted unmodified under the permission of the David Suzuki Foundation (David Suzuki Foundation, 2015)

3 Amounts are in Canadian Dollars for the year 2014 calculated using replacement values.
While a complete inventory, ecological function assessment or its equivalent has not been completed, a few observations can be made using Proper Functioning Condition methodology and criteria developed by the US Department of Interior of the United States for riparian and intertidal watercourses. This offers a quantitative approach to gauge the quality of estuary function and can inform a more comprehensive analysis and inventory.

Given the major reduction in the total area and notable industrial use and alteration historically the Skwelwil’em Squamish Estuary and surrounding unprotected areas contain some “at risk” areas in ecosystem function including areas of historical pollution, impediment and ongoing remediation (BC Ministry of Environment, 2007). These are further outlines in Figure 9.
Sites:
1) Former garbage dump adjacent to Site A;
2) Mercury contamination site:
   a) Southeast portion of the WMA;
   b) Site A;
3) Old Dredge spoils pile in the Central Delta;
4) Log sort tenure in the Central Channel;
5) Squamish River training dyke.

Figure 9: Environmental Remediation Sites in the Skwelwil’em Squamish Estuary Management

Mobilizing Resilience: A Disaster Resilience of Place Approach to IFHMP in Squamish British Columbia
Image 1: Aerial of Skwelwil'em Squamish Estuary and the Downtown Area Looking South

Photo: Christopher J. Carter - LightHawk Conservation Flying | Resilient Coasts UBC
Given the largest population and the highest population growth in the regional district and Howe Sound, the pressures of urbanization and industrial development on these ecosystem services is and will remain palpable. However, the long-term value and irreplaceable nature of estuary areas will become more critical given expected increases in coastal flood events in Squamish (Kerr Wood Leidal, 2015a).

As the estuary has seen a recovery from the industrial activities of the early 20th century, with schools of herring and the re-opening of the commercial salmon fishery, the estuary remains only 50 percent of its original habitat extent (Molnar, 2015). Looking forward there is opportunity to complete estuary reclamation using “Living shoreline” restorations or artificial structures that reduce erosion, promote native species and ecosystem functions that reduce flood impacts. This can compliment traditional grey infrastructure flood mitigation approaches and which has demonstrated lower environmental impacts, lifecycle costs and improved ecosystem services in global studies (United Nations Environment Programme, 2014). Preserving and improving the condition of these estuarine systems, which have evolved with the human settlement, will build socio-ecological resilience to coastal flood risk in Squamish.
4.4 Geography of Coastal Flood Risk

The total land area of the District of Squamish is 11,730 hectares (29,000 acres). At the head of Howe Sound, a steep fjord, Squamish is at sea level and terrain within the District boundaries rises to elevations of over 900 meters. At the confluence of major 6 mountain river systems (the Squamish, Mamquam, Cheakamus, Elaho, Ashlu and Stawamus), the Squamish Valley watershed is largest watershed originating in the Straight of Georgia region. As the IFHMP process must create both riverine and coastal flood risk management solutions -- illustrated in Figure 10 -- This analysis will focus solely on coastal flooding.

As human settlement in Squamish is prone to riverine flooding, coastal flooding, earthquakes, tsunami, liquefaction, landslide and debris flows, Squamish is often referred to as the “natural hazard capital” of Canada. The interaction between this geography of hazard and human exposure is tangible. In 2003, Squamish experienced riverine and intertidal flooding that cost approximately $40 million ($70 million in 2014 dollars) to properties and displacing 800 people, no fatalities were reported (Gardner, 2011).

**Figure 10: Flood Risks In the Squamish Valley**

Source: Reprinted unmodified with permission of the District Municipality of Squamish (District of Squamish, 2014)
The District faces probable and consequential coastal flood hazards. As 200-year flood events are the baseline for flood risk management planning and infrastructure design, recent KWL modeling of 1:50 year flood show considerable inundation (up to 3 m) to the largely unprotected downtown. In December 2014, recordings of tidal gates noted that coastal waters were 0.1 meters of topping Loggers Lane during a storm surge (Kerr Wood Leidal, 2015b).

A majority of human settlement today sits on the valley on a river delta, an area subject to freshet flood events fed by heavy rain, mountain runoff and glaciers. While settlement in flood prone areas has decreased over the past 15 years, 7,440 residents today remain living on the flood plain, exposed to riverine and coastal flood hazard (Ebbwater, 2015; Journeay, M. J., 2011). Smaller, lower-elevation watersheds create precipitation-based floods, while snowmelt and glacial runoff plays a more significant role for the larger, higher-elevation watersheds.

All historical coastal inundation events to date have occurred during September to December period when some of the largest storm surges and when temperatures are warm enough that precipitation falls as rain throughout the elevation in the five watersheds. The Cheakamus and Mamquam rivers, mostly fed by snowmelt runoff are the largest of the 5 rivers draining an area 3700 km2.

The Squamish river system reaches a maximum discharge of 760 m3/s in the early summer. Figure 11 illustrates hydrographs of the three gauged rivers (Squamish, Stawamus and Cheakamus) individually and median high water levels observed at Point Atkinson. The highest recorded peak flows in this watershed were 2100 m3/s.

During these events river freshets due to early thaws have interacted with high tides to create major intertidal flood events, inundating the downtown area with 1.5 meters of water about every 16 years. Figure 12 provides an overview of historic flooding and flood planning events. Driven by these major river flows from the Squamish watershed, the Howe Sound has an “estuarine-type” surface circulation, first creating an eddy at the mouth of Squamish river before making a major push south towards the Straight of Georgia, their rate greatly impacted by local diurnal and inlet wind currents (Department of Fisheries and Oceans, 2014).
Figure 11: Monthly Average River Flows and Tidal Level in Squamish 1991-2012

Source: Assembled from Department of Fisheries and Oceans hydrographic and tidal monitoring data.\(^4\)

\(^4\) 1991 to 2012 timeframe reflects data availability of all sources for a shared timeframe
Figure 12: Timeline of Coastal and Intertidal Flooding Events

December 1932  Howe Sound coastal flooding overtops the sea dike flooding Downtown Squamish

October 1940  Squamish River floods causing evacuations in Brackendale and Downtown

December 1951  Overtopping of the sea dike in Downtown

December 1967  Sea dike was overtopped and Downtown Squamish Floods

August 1991  Flooding of Squamish Cheamamus and Cheekye Rivers flood 15 houses on Cheamamus I.R. No.11 and wash out access road to Paradise Valley

October 1994  Flood Hazard Management Plan Written but not legislated

October 2003  50 year flood in the Cheamamus (369 mm in 4 days) cause district evacuations and damage BC rail line. Dikes were not overtopped.

September 2014  Integrated Flood Hazard Management Planning begins
Industrial, commercial and residential development has taken place largely on the valley floor and it has been estimated that historically, 75% of the population has lived in flood hazard prone areas (District of Squamish, 1994). While settlement in these areas has decreased in the past 40 years, to upland areas such as Garibaldi heights and Valleycliffe, in 2011 an estimated 7,477 people remain living in the floodplain (Journeay, M. J., 2011) (Ebbwater, 2015).

Two-thirds of the world’s coastal disasters every year are associated with extreme weather events, such as storms and flooding. Given climate modeling synthesized in 5 IPCC reports we understand that coastal hazard and disasters will become more pervasive due to anthropogenic shifts in Earth’s climate and sea level rise (Adger, Hughes, Folke, Carpenter, & Rockström, 2005). Historical accounts of natural hazards in the Squamish Valley reveal that the most frequent threats are those triggered by severe weather events most notably four coastal flood events caused by high wind and storm surge from the Howe sound which led to inundation of the downtown area. Situated at the mouth these five rivers delta, river sediments advance the Squamish River Delta into the head of the fjord -- advancing as much as front as much as 7 meters yearly. This creates a steep bottom slope seaward into the steep fjord which may effect wave height run up in storm surge or tsunami events(Department of Fisheries and Oceans, 2013).

Due to its location at the head of Howe sound, strong winds or “Squamishes” can interact with coastal flooding, lasting for 3 - 5 days with wind speeds frequently reaching 15-30 m/s (30 to 60 knots). This effect can amplify wave action and total water level during coastal flooding. Further, Squamish experiences some of the strongest diurnal winds in the Georgia Strait, most often during high-pressure systems. This is dominated half the time by a powerful southern sea breezes blowing up the Squamish Valley. This is caused by the heating of the land and water during the day with wind speeds recorded 20 m/s. Less powerful land breezes occur from the north during the night as mountain land masses cool (Department of Fisheries and Oceans, 2013.)

Given a warming of global temperatures and relative rise in seas, the Strait of Georgia is already experiencing a 1.7mm rise yearly (Fisheries and Oceans Canada, 2008). As local effects such as land subsidence effect the local effects of mean Sea Level Rise, Squamish is expected to experience between a rise of .38 to .59m in High High Water Levels by 2100 depending on global climate scenarios (James et al., 2014). This is illustrated at the human scale in Figure 13. Further, flooding regimes will experience a shift towards higher water levels and sharper peak flows during storms and earlier spring freshet events, storm surge events traditionally experienced during the winter months are expected to intensify (The Arlington Group, 2010). The tides in Squamish are very similar in size and timing to the Vancouver area with mean range of 3.2 m and the large tide range of 4.9m (Department of Fisheries and Oceans, 2015).
Figure 13. Squamish Sea Level Rise Estimations and the Human Scale
4.5 Institutional

Given the risk management, public safety and land use impact of a flood management plan, Federal and Provincial legislation including the Local Government Act, Community Charter, Land Title Act, Dike Maintenance Act and Emergency Management Act apply.

It is important to recognize that the District Municipality has been handed down the statutory obligation to consider appeals to any flood-proofing requirement. As such the District is responsible with the preparation of plans and strategies to meet complex hazards in the Squamish Valley. How local planning and political institutions deal with the complexity and social context of flood risk is a critical capacity consideration in risk management and must be accounted for in IFHMP creation (Kasperson & Kasperson, 1996).

Currently the existing flood risk plan, written in 1994, is being updated as part of the district’s Integrated Flood Hazard Management Plan (IFHMP) process. Much as the 1994 plan chose to “protect” human settlement to river and coastal flooding, the current IFHMP continues to pursue this same paradigm of coastal adaptation, especially in the downtown area. Accommodation of sea-level rise has been considered and certain core services (including city hall) have been recommended to be moved upland, given coastal flood concerns (Kerr Wood Leidal, 2015b).

The current Squamish OCP and IFHMP planning process aims to manage water resources at the watershed scale in partnership with indigenous and other regional districts and municipalities guided by protocol agreements and regional planning principles. Figure 14 illustrates the extent of the Squamish Valley watershed in relation to political boundaries. To date there has not been a sea level rise strategy, or climate adaptation plan completed. However a Hazard Vulnerability Risk Assessment (HVRA) and Comprehensive Community Emergency Plan are underway.

While the 1994 flood hazard management plan in the following analyses presents non-structural provisions such as restrictive covenants and zoning provisions the plan itself was not ratified and Flood Construction Levels (FCL) are out of date (District of Squamish, 2014). Further, the 2031 Official Community Plan lacks natural hazards or adaptation strategies for coastal flood risks(District Municipality of Squamish, 2009).
Figure 14: The Squamish Watershed and Institutional Boundaries
Integrated Flood Hazard Management Planning:

IFHMP manages risk and engages multiple stakeholders at watershed level. In line with international definitions of IFHMP best practice the District Municipality of Squamish should:

1) Cooperate and coordinate across disciplinary and jurisdictional boundaries.
2) Focus on participatory and transparent approaches to decision-making;
3) Manage water and land across the catchment as a whole and;
4) Capture the range of perturbation including cycle, trend and unexplained variation.

(Green, 2003; Rasch, Ipsen, Malmgren-Hansen, & Mogensen, 2005).

Today, the District Municipality of Squamish does not have a floodplain bylaw or stand alone Development Permit Area designation for areas prone to coastal flooding (District Municipality of Squamish, 2009). Zoning setbacks from rivers and sensitive areas have been implemented but are not consistent across properties. Flood hazard management activities of the district have been exclusively structural.

Since 1994, the District Municipality has completed upgrades on all dikes, including construction/upgrade of sea dikes and drainage infrastructure and currently maintains 19km of dikes with a dike volume of 670,000 cubic meters, 4 pump stations, 9 flood boxes and 50 gates (Public Works Asset Management Plan, 2010). Current dyke infrastructure, mostly for riverine events, was built for a 1 in 200-year event (Kerr Wood Leidal, 2015a).

IFHMPs are typically updated every 15 years in the province of British Columbia. Their project scope includes a public engagement framework, intensive technical work program for river and coastal floods, technical working group workshops, presentations to District council, and three public open houses. A website [http://www.squamish.ca/yourgovernment/ projects-and-initiatives/floodhazard/] is available as an electronic clearinghouse of storyboards, event records and current analyses (District of Squamish, 2014c).
Figure 15: IFHMP Planning Timeline

(District of Squamish, 2014)
New flood infrastructure protection under the current "protect" strategy will mean major capital investments including dike upgrading, additional coastal dike alignments and operational costing to cover maintenance. These provisions address the likelihood but not consequences of flood hazard events. To reduce risk, structural hazard mitigation must be accompanied by reducing vulnerability of populations living behind said protective coastal infrastructure. This is based on an understanding that flood protection engineering is an inexact science that cannot completely eliminate the risk of structural failure and is dependent on continual inspection, performance monitoring in advance of and during large flow events (Ministry of the Environment, 2011). Examples of dyke infrastructure failure during Hurricane Katrina in the US and previously unseen storm strength during Typhoon Haiyan in the Philippines further support planning institutions to address both hazard mitigation and vulnerability reduction in natural hazard mitigation planning.

Flood mitigation activities in the past 5 years include:

- **Squamish River dike raising downstream of BC Rail bridge**
- **Stability assessment of the Squamish River dike**
- **Upper Squamish River Dike Erosion protection works**
- **Sediment management at Cheekye River and Mamquam River**
- **Repair of Squamish River dike sinkhole**

Today the District of Squamish finances and manages the infrastructure that must be considered in coastal flood hazard planning. In urbanizing coastal areas, flood loss and damage from dyke failure is amplified due to the accumulated value of adjacent property and the density of human settlement (Ramesh, 2012). While providing efficient protection against low magnitude flooding, river and coastal dykes may fail under extreme water levels and long floods, future climatic change in precipitation, in mountain river peak flows and sea-level rise (Ramesh, 2012). **Figure 16** below illustrates current flood infrastructure inventory while **Figure 17** notes flood related infrastructure and land use designations in the District as of 2015.
Figure 16: District Municipality of Squamish Infrastructure Inventory

<table>
<thead>
<tr>
<th>Water</th>
<th>Sanitary</th>
<th>Waste Water Treatment</th>
<th>Roads</th>
<th>Drainage</th>
<th>Flood</th>
<th>Parks</th>
</tr>
</thead>
<tbody>
<tr>
<td>122 km water mains</td>
<td>105 km sewer mains</td>
<td>21 Million liters/day capacity</td>
<td>137 km paved road</td>
<td>31 km of storm sewer</td>
<td>19 km dykes</td>
<td>244 ha parkland</td>
</tr>
<tr>
<td>24 million/liters/day capacity</td>
<td>18 lift stations</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Source:* Public Works Asset Management Plan, 2010
Figure 17: Waterways, Flood Infrastructure and Management in Squamish in 2015
5.0 Approach
5.1 Building a Disaster Resilience of Place

A Disaster Resilience of Place (DROP) is grounded in the core concept that social systems, the built environment and natural systems interact to create current conditions of vulnerability and resilience (Cutter, S., Boruff, & Shirley, 2003; Mileti, 1999).

The DROP concept has emerged in the work of vulnerability scholar Susan Cutter and other resilience planning practitioners -- informed by a shift in international disaster risk reduction away from response and towards reducing existing vulnerability (United Nations, 2005) (Cutter, S. et al 2008). To reduce risk in Squamish, this analysis adopts the view that disaster resilience of place begins not only by addressing hazard events but also their interaction with social vulnerability -- existing conditions -- and how well local government is engaged with reducing total risk.

Core concepts of DROP include:

- Watershed scale planning
- Ecosystem Service recognition
- A Focus on Social Capital Focused
- Transparent risk reduction
- Institutional Networks and Social Learning
- Diversified and Equitable Economies
- Community Competence
- Infrastructure Status

Root causes of vulnerability interact with dynamic forces (i.e. decentralized risk management, urban development pressure etc.) and unsafe conditions (i.e. poverty and/or exposed old residential housing etc.) to produce community vulnerability. These vulnerabilities converge with flood hazard events to produce total risk, loss and damage across the disaster cycle (Figure 18).

The dynamic of progressive vulnerability and its interaction with coastal flood hazard is illustrated in detail as a Pressure and Release Model located in Appendix Item 12.3. If the end goal is to build DROP, it is critical to address the underlying causes of vulnerability rather than allowing vulnerability to increase -- relying solely on proposed future flood protection works.

To illustrate areas where Disaster Resilience of Place to coastal flood hazards can be built in Squamish, this report:

1) Accounts for current social vulnerability spatially
2) Examines the interaction of social vulnerability with coastal flood events

3) Examines the interaction of environmental buffers, human settlement and sea level rise;

4) Evaluates the strength of current plans

5) Illustrates how society can be better engaged in flood hazard planning and management.

In choosing DROP is a desired outcome for flood hazard management and risk-based planning, the District of Squamish must address the root conditions of vulnerability to hazard -- focusing on reducing vulnerability across the disaster cycle (Figure 18).

**Figure 18. The Disaster Risk Cycle**
5.2 Social Vulnerability

Not all citizens or neighborhoods are created equal in exposure to coastal flood risk. This is strongly connected to existing and historical inequity, access to resources and other forms of social capital which alter the level of exposure to hazard (Cutter, S. et al., 2003). With this understanding, this analysis will define and assess vulnerability in Squamish as a condition actively produced and refined by socio-political processes – which interact with flood hazard to produce risk.

A social vulnerability approach often does not always account for physical flood risks but aims at addressing the root causes of inequity in exposure and propensity for loss. This approach recognizes power disparity, aims for citizen empowerment and is a valuable tool for the District of Squamish to involve citizen expertise, creativity and empowerment to make strategic decisions and more successfully implement flood plans (Burby, 1999). Ultimately, reducing vulnerability will reduce loss and damage -- especially for those most exposed to coastal flooding. For the purpose of this assessment, social vulnerability was assessed as a linchpin to reducing loss across the disaster cycle. As Bolin (1993a: 13) observes, the household and neighborhood scale is productive unit of analysis:

Disasters can have a multiplicity of effects on a household, including physical losses to property, injury and/or death, loss of job or livelihood, disruption of social and personal relations, relocation of some or all members of a family, physical disruption or transformation of community and neighborhood, and increased household indebtedness.

Approaches to measures of Social Vulnerability offer repeatable and long-term observation of risk reduction. This can improve planning effectiveness and increase transparency in the governance of risk. For this analysis a suite of statistical indicators at the Dissemination Areas level -- the lowest level of census data collection in Squamish -- were selected to offer spatial understanding of existing vulnerability before a flood event. Social Vulnerability does interact with physical flood hazard and for this analyses the interaction of social vulnerability and a 200-year storm surge are also offered to illustrate total risk and inundation.

Social processes, perception and worldviews of the environmental hazard also produce social vulnerability – most notably influencing individual acceptance of exposure as well as action to warning signals (Oliver-Smith & Hoffman, 2002; Slovic, Kunreuther, & White, 2000)(Gaillard et. al, 2008). The dominant view of
natural hazard frames floods and disasters as external forces, or “acts of god” that originate elsewhere, “out of the blue” and with equitable social impact. Such ideologies of disasters as external sources of destruction -- and a belief that the hazards can be controlled and settlement protected by human intervention-- lead to a perception of safety but often little risk reduction. The devastation experienced in “Natural” hazards often not natural at all, but rather the condition of the community, economy, infrastructure and environment before the event (Mileti, 1999).

While total risk is widely accepted as a function of hazard and vulnerability, governments worldwide often seek expensive geotechnical solutions to “protect” settlement from hazard while not effectively studying or addressing current vulnerability in natural hazards management planning - institutions failing to do so ignore and exacerbate risk. This is often a ‘root cause’ of social and physical vulnerability (Hewitt, 1983). These beliefs alongside a popular narrative of a settler community battling for “Protection” in a flood prone areas reify hazard focused planning over vulnerability reduction. A complete dynamic model of progressive vulnerability with Squamish institutional and social considerations in is illustrated as a Pressure and Release (PAR) model in Appendix Item 12.3.
In defining this approach, a few key concepts guide evaluation of vulnerability and local planning efforts. Local land use planning can affect -- both positively and negatively -- ecosystem services at the watershed scale that reduce flood disturbance in flood prone communities. (Adger et al., 2005). Societies and the health of ecosystems are interactive, creating a complex and adaptive relationship controlled by local land use planning and environmental management values.

Understanding the preexisting conditions of human settlement, notably social conditions, ecological health and their interaction can prove a productive at reducing total loss and damages, especially for those most vulnerable. This is a founding principle of vulnerability reduction in an era of environmental and climate change. Resilience planning is a response to heightened environmental pressure and new risks given human induced climatic change. Connections climate, risk and socioeconomic pathways are well illustrated by working group II of the IPCC on adaptation offered in Figure 19.
Figure 19: IPCC Illustration of Risk & Climate

(IPCC, 2014)\(^5\)

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6.0 Methodology
6.1 Strategic and Value-Focused Planning

To structure analysis and planning recommendations in this report the *Climate Adaptation Guide for Urban Planners*, developed by EcoPlan international and Compass Resource Management for UNHABITAT was deployed. Taking a value-focused and strategic approach the guide places vulnerability at the core of planning and climate adaptation and is structured around strong stakeholder participation, new information and identifying vulnerable populations and lands. Four core themes guide the approach: Where are we now? Where do we want to go? How do we get there? And have we arrived? Each of the four strategic planning themes is presented with relevant analyses in Figure 20. A complete overview of the strategic and value-focused approach to planning for climate change is presented in Figure 21.

Today, the field of urban planning has evolved to represent more than the designation of land, engineering and efficient delivery of services but rather connecting forms of knowledge with forms of action in the public domain – engaging with an organized civil society and human values at the local and regional level to guide land use and community development beyond (Friedmann, 1993).

Given uncertainties of climate change, limited or poor quality data and often-scarce financial resources in local coastal planning institution, items must be prioritized if they are to be completed. In doing so, complex tradeoffs between alternatives must be faced – individual performances evaluated based on what and where matters the most in relation to coastal flood risk (R Keeney & Raiffa, 1993; Merkhofer & Keeney, 1987). As institutional and community values guide the creation and implementation of plan making, transparent decision-making for coastal risk reduction is an act of good governance. Further, taking a values-based approach allows an understanding why and how people act, offering a broader range of alternatives and more creativity in decision-making. (RL Keeney, 1996)(R Keeney & Raiffa, 1993).
Figure 20: Methodology by Strategic Planning Theme

What is Happening?
Getting Started, Stakeholders and Participation and Vulnerability Assessment

Where do we want to go?
Issues and Objectives

(Findings Area 2)

How do we get there?
Option Identification, Option Assessment and Implementation

Public Participation and IFHMP Implementation
(Findings Area 3)

Have we arrived?
Monitoring and Evaluation, Adjust and Modify

SoVI composite scoring for 2011 Census Reporting
(Findings Area 1)

Descriptive Statistic tables for individual SoVI variables and vulnerability factors for each Dissemination Area.
(Appendix)

Social Vulnerability Indicators and Monitoring Sheet.
(Appendix)

The Squamish Context

Social Vulnerability, Social Vulnerability and AEP 200 Coastal Flood inundation and Sea Level Rise Mapping.
(Findings Area 1)

(Findings Area 2)

Evaluation of public participation in IFHMP creation.
(Findings Area 3)
For each of the three findings areas, a synthesis of policy recommendations is at short, medium and long-term timeframes. These recommendations are meant to implement the DROP approach guided by community values formally articulated in the Official Community Plan. These values, noted in the vision for community development read as follows:

We are a spectacular seaside mountain community where people come to live, learn, work and play in harmony. We are multicultural, compassionate, vibrant and diverse. We are leaders in fostering social integrity, economic development, and environmental sustainability.

- Official Community Plan (2009)

Further, values around risk and prioritization of vulnerable persons in Squamish has been elicited from a sample of Squamish residents during working groups in previous NRCAN studies (see Journey, M. J., 2011). From these studies there is a noted importance in the community that prioritizes elders, the very young and other mobility challenged persons in risk planning.

Given this vision statement, a suite of values that can guide vulnerability reduction policy, evaluation and decision-making at the District were noted:

- Environmental Appreciation and Ethic
- Collaboration and Partnerships
- Social Equity and Inclusion
- Economic Prosperity
- In Pursuit of Sustainable Development
Figure 21: A Strategic Planning Approach to Climate Adaptation

Source: (UNHABITAT, 2014)\(^6\)

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Methodology for each Analysis used international best practices in vulnerability assessment, policy analysis and critical theory.

The following section offers methodology for each of the reports major three areas of analysis. Findings for each of the major areas are available in the following chapter. Methodology use in each analysis include:

- **Risk Assessment**
  - **Social Vulnerability Assessment** using SoVI component score and spatial analysis to isolate social vulnerability.
  - **Social Vulnerability and AEP 200 year coastal flooding** to look at physical hazard of waters and produced risk when interacting with social conditions.
  - **Sea Level Rise** of 1 meter to understand future new natural boundaries on human settlement planning and ecosystem service management.

- **Plan Evaluation**
  - **1994 Flood Hazard Management Plan** using a SWOT approach.
  - **2009 Official Community Plan** using plan content evaluation.

- **Social Participation and Implementation in IFHMP**
  - **Evaluation of current levels of participation**
  - **Recommendations** for more effective participation and IFHMP implementation
6.2 Risk Assessment

6.2.1 Social Vulnerability Assessment

To assess social vulnerability in Squamish a quantitative indicator-based approach was taken. The Social Vulnerability Index (SoVI) offers a transparent and repeatable planning tool that identifies and visualizes local patterns of vulnerability (Cutter, S. L. et al., 2008). This is based on identifying local data that best reflects determinants of risk. The aim is to increase the understanding of local vulnerability to inform bottom-up and vulnerability focused sustained risk-reduction planning (Khan, 2012) (Lee, 2014). In the assessment of social vulnerability assessment high-quality scientific and geotechnical inputs must be balanced with rigorous analysis of social conditions, participatory and ground truthing (Van Aalst et al, 2012) . Baseline conditions captured in SoVI allow for adequate action planning and preparedness to reduce vulnerability.

Further, assessments need to keep the process simple, participatory, and implementable at the local planning scale. The SoVI approach, which tailors indicators to context and maximizes available data offers such a pragmatic approach – offering a beginning step to quantitatively and spatially address who, where is socially vulnerable today prior to a flood hazard event.

In the selection of indicators a review of literature was completed to select variables that reflect determinants of risk given the Squamish context and available data. Cornerstone literature on quantifying vulnerability note the importance of variables that reflect race/ethnicity (Cutter, S. L. et al., 2008), socioeconomic class, age (very old and very young) (McGuire, 2007)(Peek & Stough, 2010), gender (Sen, 1981), migration, and housing tenure (renters and owners), as among the most common social vulnerability characteristics group living facilities, ethnic minorities (by language capacity); recent migrants (including immigrants); tourists and transients; physically or mentally disabled (Wisner, 2006); large households; renters; large concentrations of children and youth; poor households; the homeless and single parent households (Wisner, 1998);. Social vulnerability indices and maps offer the state of vulnerability and while often completed at larger census tract areas are most meaningful at the downscaled neighborhood level (Adger and Kelly, 1999).

In Canada the smallest level of data collection is at the Dissemination Area scale – this is the level of analyses that was chosen for this social vulnerability assessment using 2011 NHS census data. It is important to note that this was a voluntary rather than compulsory social data collection and its quality reflected by a lower response rate and level of population representativeness.

A set of variables used in a 2011 NRCAN pathways study in Squamish -- the first application of SoVI in Canada -- informed the development of a suite of indicators and was ultimately matched for continuity. These original indicators were based off of values elicited from the Squamish community groups and available census statistics. As that study used 2006 Census data to riverine flood risk was adopted (Journeay, M. J., 2011) using these indicators allows for longitudinal
To date the district has identified the following populations as vulnerable in emergency planning. These include the following:

- People living with disabilities, The seriously ill
- Those less then 5 years of age
- Seniors living alone
- Single parent-families
- First Nation communities,
- Low Income families
- English as a second language speaking families

However, the District Municipality has not completed a spatial analyses or public engagement to engage vulnerable populations meaningfully in planning. The United Nations Hyogo Framework for Action (HFA) for the period 2005-2015 notes how critical it is to develop high quality vulnerability indicators in order to enable decision-makers to assess the impact of disasters (UN, 2005). The Hyogo framework underlines that impact of disasters on (1) social, (2) economic, and (3) environmental conditions should be examined through necessary indicators. As per the strategies adopted by the Hyogo framework, respective countries need to develop vulnerability indicators that capture local level risk as a key activity. Canada is a participating country in the Hyogo framework, delivering a National Platform for disaster risk reduction.

Given the value of having quantitative and repeatable study of vulnerability in Canadian coastal communities a

Social Vulnerability Index statistical calculation methodology, developed by the Hazards and Vulnerability Research Institute at the University of South Carolina, was utilized. For a local level data set at the lowest possible scale, Dissemination Area, the 2011 Canadian Census National Household Survey data was used for the District Municipality of Squamish to create a map of social vulnerability (SoVI).

The following are steps taken to create a SoVI composite score and spatial visualization.

1. Selection of social vulnerability variables. This was preceded by a literature review of quantitative and qualitative studies from coastal British Columbia.

2. Indicators were given equal weight and non-percentage indicators were normalized

3. Dataset accuracy was reviewed using descriptive statistics.

4. Any missing values, notably in the Average Rent Variable, were replaced by substituting the variable’s mean value for each enumeration unit. Census Dissemination Area 59310194 was omitted due to major incomplete population data sets.
5. Input variables were standardized using a z-score standardization based on a standard deviation and is as follows:

\[ Z = \frac{\chi - \mu}{\sigma} \]

Where:

- \( z \) is a standardized unadjusted score
- \( \chi \) is the social variable value (expressed as % or $)
- \( \mu \) is mean of variable set
- \( \sigma \) is the standard deviation

This generated variables across the data set with a mean of 0 and standard deviation of 1.5.

6. A principal components analysis (PCA) was completed in SPSS software using the dimension reduction factor analysis. Correlation was analyzed using coefficients, reproduced, Anti-image and KMO & Bartlett’s test of sphericity. Principle components were extracted based on eigenvalues greater than 1 with 25 maximum iterations for convergence. A varimax rotation and Kaiser criterion were used for component selection.

7. The amount that the individual variables had on the total data, or factors, was noted and adjustments were made.

8. An average of each attribute was used to create a composite standard deviation score.

9. This score was prepared as an attribute table and assigned to Dissemination Area polygon shapes and mapped in ArcGIS.

Population and demographic variables were selected on the basis of their capacity to describe patterns of social disadvantage at a local scale (Cutter et al., 2003; Andrey and Jones, 2008) and to be assessed at the neighborhood level (census dissemination areas). Sparsely populated neighborhoods were excluded from the analysis, as Statistics Canada does not distribute community profile data for dissemination areas in which there are fewer than 40 people to ensure individual privacy rights. Figure 22 summarizes selected socio-economic variables for use in vulnerability assessment.

Limitations

While the SoVI approach offers a quantitative assessment of vulnerability there are limitations. First the extent and quality of analysis is directly related to local data availability. Also, the quantitative approach, -- while repeatable -- captures the amount and location of vulnerable populations rather than why and how the conditions came about. With these limitations on mind SoVI and its interactive with physical hazard models offer a baseline in vulnerability reduction and a resource for participatory planning – making inequity in exposure tangible at the community level and on the land.
Figure 22: Selected Variables of Social Vulnerability in Squamish

<table>
<thead>
<tr>
<th>Variable Number</th>
<th>Variable Label</th>
<th>Description</th>
<th>Justification</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>P_SEN_ALON</td>
<td>% of population that lives alone</td>
<td>Low social support systems cohesiveness and poor pathways to communication</td>
</tr>
<tr>
<td>2.</td>
<td>P_MIG_E</td>
<td>% of population that has migrated from elsewhere in Canada</td>
<td>Low level of social cohesion with broader community</td>
</tr>
<tr>
<td>3.</td>
<td>IN_NO_VE H</td>
<td>% population without access to a vehicle</td>
<td>Lack of access to livelihoods and broader community (in a semi-rural community with limited transit).</td>
</tr>
<tr>
<td>4.</td>
<td>P_AGE_GT_65</td>
<td>% of population greater than 65 years old</td>
<td>A locally determined prioritized vulnerable population.</td>
</tr>
<tr>
<td>5.</td>
<td>P_MOB_LT 1</td>
<td>% Population that has moved within the last year</td>
<td>Low social connectivity and trust to greater community and participation in planning</td>
</tr>
</tbody>
</table>

Mobilizing Resilience: A Disaster Resilience of Place Approach to IFHMP in Squamish British Columbia
<table>
<thead>
<tr>
<th>Variable Number</th>
<th>Variable Label</th>
<th>Description</th>
<th>Justification</th>
</tr>
</thead>
<tbody>
<tr>
<td>6.</td>
<td>P_MOB_LT5</td>
<td>% Population that has moved within the last 5 year</td>
<td>Medium-low social connectivity and trust to greater community and participation in planning. Low level of knowledge about risk mitigation measures, evacuation, and low social connectivity in recovery.</td>
</tr>
<tr>
<td>7.</td>
<td>P_LFP</td>
<td>% lone female parent households</td>
<td>Lower financial resources, children may be left alone more frequently. Difficulty in coordinating flood risk planning engagement and evacuation during flood events.</td>
</tr>
<tr>
<td>8.</td>
<td>P_ABORIGINAL</td>
<td>% Aboriginal community</td>
<td>Historic dispossession from land. Historic socio-cultural trauma from boarding schools and settler occupation with associated psychosocial and physical health impacts. Lack of flood insurance due to land tenure restrictions under the Indian Act. Statistically lower access to transportation for evacuation.</td>
</tr>
<tr>
<td>Variable Number</td>
<td>Variable Label</td>
<td>Description</td>
<td>Justification</td>
</tr>
<tr>
<td>-----------------</td>
<td>----------------</td>
<td>-------------</td>
<td>---------------</td>
</tr>
<tr>
<td>9.</td>
<td>P_L_INC_F</td>
<td>% low-income families</td>
<td>Lack of access to financial resources in mitigation and recovery. Lower cost residential areas tend to be more subject to natural hazards globally.</td>
</tr>
<tr>
<td>10.</td>
<td>P_SEN_GT10</td>
<td>% Families spending &gt; 10 hrs. of unpaid care to seniors</td>
<td>Caregivers shoulder the costs of care but provide valuable support. Higher connectivity to support systems in flood hazard preparedness and transportation in evacuation.</td>
</tr>
<tr>
<td>11.</td>
<td>P_TEN_GT30</td>
<td>% Tenant occupied households spending &gt; 30% on shelter</td>
<td>Low residual income beyond core housing needs. High cost housing systems leave fewer funds available for mitigation. Coupled with District low vacancy rates recovery from a coastal flood event can prove difficult.</td>
</tr>
<tr>
<td>12.</td>
<td>P_OWN_GT30</td>
<td>% Owner-occupied households spending &gt; 30% on shelter</td>
<td>Low residual income beyond core housing needs. Opportunity to purchase flood insurance to cover loss and damage.</td>
</tr>
<tr>
<td>13.</td>
<td>A_RENT_TEN</td>
<td>Average Rent of tenant-occupied dwelling</td>
<td>No equity or agency in property A majority of renters in Canada are not insured for flood damage.</td>
</tr>
<tr>
<td>14.</td>
<td>P_VIZ_MIN</td>
<td>% Visible minority</td>
<td>Historical marginalization and structural inequality. Low connectivity to local planning institution and communication systems in evacuation.</td>
</tr>
<tr>
<td>Variable Number</td>
<td>Variable Label</td>
<td>Description</td>
<td>Justification</td>
</tr>
<tr>
<td>-----------------</td>
<td>----------------</td>
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<td>---------------</td>
</tr>
<tr>
<td>15.</td>
<td>P_LANG_N</td>
<td>% population without knowledge of official language</td>
<td>Lack of access to social support systems, communications and greater community. Isolation in flood hazard planning information. Language barrier in evacuation. Difficulty in receiving risk and emergency communications. Exclusion from numerous relief and recovery services.</td>
</tr>
<tr>
<td>16.</td>
<td>P_BSER_CCC</td>
<td>% employed in basic service industries</td>
<td>High sector dependence makes for livelihood volatility. Lack of economic diversity can lead to difficult livelihood recovery.</td>
</tr>
<tr>
<td>17.</td>
<td>P_IMMIGRANT</td>
<td>% recent immigrant (within 5 years)</td>
<td>Low connectivity and trust to other residents and livelihoods. Low connectivity to local planning institution and communication systems in evacuation. Difficulty in receiving risk and emergency communications. Exclusion from numerous relief and recovery services.</td>
</tr>
<tr>
<td>18.</td>
<td>P_SEC_N</td>
<td>% population with no post-secondary education.</td>
<td>Lower levels of education have been found to directly influence risk perception, skills and knowledge and indirectly reduce poverty. Educated individuals are reported to have better preparedness and response to the disasters, suffered lower negative impacts, and are able to recover faster. However, contextual, traditional and non-formal education must be considered in weighting this variable.</td>
</tr>
<tr>
<td>Variable Number</td>
<td>Variable Label</td>
<td>Description</td>
<td>Justification</td>
</tr>
<tr>
<td>----------------</td>
<td>---------------</td>
<td>-------------</td>
<td>---------------</td>
</tr>
<tr>
<td>19.</td>
<td>P_SOC_OC_N</td>
<td>% population not participating in social service occupations</td>
<td>Low connectivity to health care, education community development services. Difficulty interacting with emergency management, warning systems and recovery efforts.</td>
</tr>
<tr>
<td>20.</td>
<td>P_SERVICE</td>
<td>% employed in service industries</td>
<td>High sector dependence makes for livelihood volatility. Lack of economic diversity can lead to difficult livelihood recovery.</td>
</tr>
<tr>
<td>21.</td>
<td>P_AGE_LT6</td>
<td>% population under 6 years of age</td>
<td>A locally determined prioritized vulnerable population. Young children lack mobility in evacuation, require caregivers and may undergo unique psychological trauma.</td>
</tr>
<tr>
<td>22.</td>
<td>P_PARTIC_N</td>
<td>% population not participating in labor force</td>
<td>High unemployment is considered a social and economic disaster. Unemployment can reduce access to financial resources, and is experienced disproportionately by minority populations and those with lower education. Lack of access to risk mitigation resources and disaster unemployment assistance in recovery.</td>
</tr>
<tr>
<td>Variable Number</td>
<td>Variable Label</td>
<td>Description</td>
<td>Justification</td>
</tr>
<tr>
<td>-----------------</td>
<td>----------------</td>
<td>-------------</td>
<td>---------------</td>
</tr>
<tr>
<td>23.</td>
<td>P_TTA_NC</td>
<td>% employed in transport, communication and public utility</td>
<td>High sector dependence / lack of economic diversity can lead to difficult livelihood recovery. Increased knowledge of services, emergency communication and transportation in evacuation.</td>
</tr>
<tr>
<td>24.</td>
<td>P_CHD_GT30</td>
<td>% families spending &gt;30 hours of unpaid childcare</td>
<td>Caregivers, often women, shoulder the burden of unpaid childcare. And the gender-poverty gap. Often an indicator of large families. Women's opportunity for paid labor may be reduced by hazard events and increase in already unpaid work given tasks of recovery.</td>
</tr>
<tr>
<td>25.</td>
<td>P_DU_MAJOR</td>
<td>% housing units in need of major repairs</td>
<td>Low quality housing can exacerbate social and health inequities. Poor housing stock conditions and inadequate building codes leads to higher loss and damage to property and higher mortality in flood hazard events.</td>
</tr>
<tr>
<td>26.</td>
<td>P_IND_OCC</td>
<td>% employees working in industrial sector (construction etc.)</td>
<td>High sector dependence increases livelihood volatility. Lack of economic diversity can lead to difficult livelihood recovery.</td>
</tr>
<tr>
<td>27.</td>
<td>P_CON_LT85</td>
<td>% housing units constructed before 1985</td>
<td>Aging housing conditions can exacerbate social inequity and health outcomes. Older housing may not be constructed to adequate Flood Construction Levels and may be located closer to watercourses.</td>
</tr>
<tr>
<td>28.</td>
<td>P_RESO URCE</td>
<td>% population working in primary resource extraction industries</td>
<td>High sector dependence makes for livelihood volatility. Lack of economic diversity can lead to difficult livelihood recovery.</td>
</tr>
</tbody>
</table>
6.2.2 Coastal Flooding Scenarios

Planning long-term for coastal flood risk in Squamish coast deals with uncertainty and the reality of environmental change. Past data cannot inform planning comprehensively given projected changes in meteorological and hydrographic conditions. While a “feedback” approach to planning, or reviewing and adjusting is a traditional approach, “feed forward” or scenario planning is useful to prepare for future flood conditions. This approach is grounded in determining potential inundation and future desired conditions of human settlement. To offer scenarios of coastal flooding, two models were created in GIS using district LIDAR elevation data. The first is meant to offer the impact of a 200-year storm event and the second is to give a long-term scenario planning for sea level rise. These two exercises offer future “worst case” scenarios that the District and its partners can use to work backwards from – to identify key uncertainties, generate strategies and action plans to reduce vulnerabilities to people and lands.

AEP 200 Coastal Inundation and SoVI

Guided by the 2012 NOAA primer for modeling a 1/200 return rate for a storm surge event, a single value water surface approach was used. This approach is also referred to as the linear superposition or "bathtub" analysis. A flood depth grid was created using LIDAR elevation data and exported as a shape file in Arc GIS.

Parameters for the flood depth grid creation were based off of Kerr Wood Leidal background study and Canada Department of Fisheries and Oceans records at Point Atkinson Station. A NAVD 88 vertical tide datum was used. Parameters used in creation of the inundation raster included.

- **High Higher Water Level**: 2.07m (200 year storm event)
- **External Storm Surge**: 1.25m
- **Local Effects of Skwelwil'em Squamish Estuary**: 0.35m

Sea Level Rise Analysis

To understand the future extent of high tides and Skwelwil'em Squamish Estuary reach upland given IPCC and provincial projected 1 meter of Sea Level Rise a series of two raster files were created. The current High High Water Level of 1.03 meters was used to create a base raster layer. A secondary layer was created adding 1m of Sea level rise.

A flood depth grid for 1 meter of sea levels was created using the same methodology as AEP 200 coastal inundation modeling. To understand how much land on the river delta would be impacted by long-term inundation by the sea, a raster calculation function in GIS was used to calculate total hectares of land affected.

Limitations

There are major constraints to a single value water surface approach to inundation modeling used in AEP 200 event and 1 meter of SLR inundation surfaces used. Computer modeled and interpolated water surfaces are
preferred, namely for sophistication in subarea floodplain dynamics. However, this approach is pragmatic for local GIS study and is commonly used for mapping sea level rise for local areas such as Squamish where only basic tide gauge or water level gauge is available (NOAA, 2012).

6.3 Plan Evaluation

To evaluate current flood management and official community plans; two structured approaches were taken to ensure that the analysis was transparent and replicable. These two different approaches offer policy analysis of two planning documents to generate a gap analysis of where a DROP approach can be strengthened or adopted.

1994 Flood Plan

No national or international standard currently exists in the evaluation of flood plans. To evaluate the District’s existing flood plan, a series of social vulnerability and ecological resilience variables were used to structure document analysis. To offer pragmatic evaluation and policy actions for local planners, findings are presented in a Strengths Weakness and Opportunities (SWO) format. Variables of social vulnerability and ecological resilience used in 1994 Flood Hazard Management Plan evaluation are available in Table 3 of Section 8.0: Plan Evaluation.

2009 Official Community Plan

Evaluating the quality of Official Community Plans for flood risk management has not been widely completed in Province of British Columbia to date (Baynam, 2011)(Stevens, 2013). None have been completed for coastal flood hazard and social vulnerability alone. To illustrate current performance and areas for improvement plan content evaluation was used.

Plan content evaluation is based on a set of protocol, or questions, that are asked to the planning document to study the presence of content. The output of this type of research is meant to be highly relevant to local planners and policy-makers, who are able to derive a framework or glean important plan elements when developing their own high quality planning policy documents (Kaiser, E J. & Davies, 1999) (Baer, W C., 1997).

Protocol creation in evaluating risk in an era of climate change aims to be as exhaustive as possible. Protocols in this analyses drew off established criteria in flood management climate adaptation in Canadian municipalities (Baynam, 2011) (Stevens, 2013; Stevens & Hanschka, 2014), sustainable development (Berke & Manta Conroy, 2000) ecosystem management (Brody, 2003), and natural disaster mitigation (Nelson & French, 2002) and social vulnerability reduction (Cutter, 2003). Moving forward this set of protocol (offered in Appendix Item 12.8) can be used to evaluate other land use and flood management plans across watersheds of Howe Sound and other Straight of Georgia coastal communities. In doing so the performance of plans to address coastal flood risk can be evaluated and lessons in management shared across a shared coastline.
To adapt content evaluation to coastal hazards in Squamish the following methodology followed in the evaluation of the current Squamish Official Community Plan:

1. First, best practices in climate adaptation, coastal flood risk planning and prior plan evaluations were reviewed to establish elements of an official community plan that best integrates coastal flood risk reduction.

2. These elements were turned into a series of 64 protocols, or questions -- organized by 8 major plan elements (Evidence Base, Policy and so forth). These are offered in Appendix Item 12.8 with findings.

3. Then, the entirety of the 2009 Official Community Plan, its schedules including the Squamish Oceanfront Peninsula Sub Area Plan was coded using Atlas.Ti software. Evaluations were made from the coded plan using binary (0/1) scoring, creating a sub-score by variable.

4. A cumulative score was then calculated from these sub-scores. A second coder was then asked to re-evaluate the planning document to ensure that protocols produced similar and repeatable results.

Limitations

While this plan evaluation offers detailed insight into where upcoming OCP revisions can focus to direct land use policy towards disaster resilience to coastal flood risk, the method has its constraints. First this type of evaluation only assesses the presence and quantity of indicators selected -- not the quality of the policy language. While the indicators have made an attempt to be robust, comprehensive and informed by leading literature they are not guaranteed to be exhaustive. Lastly, as only one plan was evaluated with this customized protocol, there are no available comparisons to other plans to understand variance in variables. This means that the score given only determines the quality of the Squamish OCP independently based on protocol, not the quality of the protocol compared to a standard set by other similar plans in the region.
6.4 Public Participation & IFHMP Implementation

Findings

To evaluate the current performance of the District in creating opportunities for public participation and partnerships in plan creation this section drew from structured analyses completed in the evaluation of the 1994 Flood Hazard Management Plan and Current 2009 Official community plan and review of the IFHMP engagement strategy. To offer a metric and widely recognized definition of participation the International Association of Public Participation (IAP2) spectrum was used to evaluate planning efforts thus far. The IAP2 spectrum of public engagement is based on core values in the practice of public participation which establishes that:

1 Public participation is based on the belief that those who are affected by a decision have a right to be involved in the decision-making process.

2 Public participation includes the promise that the public’s contribution will influence the decision.

3 Public participation promotes sustainable decisions by recognizing and communicating the needs and interests of all participants, including decision makers.

4 Public participation seeks out and facilitates the involvement of those potentially affected by or interested in a decision.

5 Public participation seeks input from participants in designing how they participate.

6. Public participation provides participants with the information they need to participate in a meaningful way.

7. Public participation communicates to participants how their input affected the decision.

The IAP2 spectrum varies from “Inform” and “Consult” (Low sharing of power) to Collaboration and Empowerment (High sharing of power). The spectrum offers an internationally recognized reference for planning institutions to for goals, commitments and techniques in public engagement (International Association of Public Participation, 2009). This spectrum provides a conceptual frame and measurement for public participation findings and grounding in IFHMP implementation recommendations.
**Recommendations**

Drawing from multi-stakeholder governance, participatory and critical social theory a series of recommended engagement activities were generated. Further informed by literature in community-based action planning the aim of these recommendations were to fulfill both process and substantive outcomes of participation in flood risk planning – improving opportunities for meaningful social participation, plan implementation and measurable vulnerability reduction.

**Limitations**

Evaluating the quantity of public participation (amount of persons in attendance at open houses, newsletters sent, groups contacted etc.) can be straightforward, but capturing the quality of participatory process, outcome and human empowerment can be more difficult. A constant dialog with core stakeholders to gather feedback and feed-forward future participation is critical in defining the successful public participation in IFHMP.
Findings
7.0 Risk Assessment

Introduction

Taking a resilience of place approach puts the most vulnerable people at the center of Integrated Flood Hazard Management planning. This section will offer a spatial understanding of social conditions, the interaction with physical exposure to coastal flood inundation and ways to improve flood risk management through public participation.

Detailed and quantifiable assessments of vulnerability are increasingly used disaster risk reduction planning to better understand risk more comprehensively. Further, study of disaster planning performance suggest a “paradigm shift” in resources and research away from disaster relief and response to disaster risk and vulnerability reduction (Birkmann, 2006; Yodmani, 2001). However, a lack of formal provincial or federal guidance on assessing existing conditions which produce vulnerability, Hazard Risk Vulnerability Assessment toolkits and flood hazard management plans in British Columbia do not account for existing social and environmental conditions - focusing on the frequency and consequences of natural hazards rather than addressing the root causes of exposure in local populations.

Risk and vulnerability assessments provide baseline observations of community resilience and interactions with coastal flood risk -- both current and future. This can best be understood as accounting for all components of a base risk equation. This conceptual equation is offered in Figure 23 Planning documents and local legislation provides vision and legal instruments to effectively manage risk at the local level. Effective social participation in the creation and implementation of flood management plans has found to lead to more effective risk-reduction and flood risk planning globally (Oulahen & Doberstein, 2010; Wisner, 2006). Risk has been widely understood as a function of hazard and vulnerability (Ropeik, 2002).

Figure 23: Base Risk Equation

\[ R = H \times V \]

Where:

\[ R \text{ is Risk} \]
\[ H \text{ is Hazard frequency} \]
\[ V \text{ is Vulnerability of the population living in exposed area and socioeconomic condition} \]

Taking a DROP approach to risk assessment recognizes that local planning plats a major role in reducing the vulnerability portion of the risk equation. This begins with understanding current vulnerability and potential future hazard scenarios that will interact with vulnerability.

To inform risk-based planning a series of analyses were undertaken to illustrate current conditions of social and land use vulnerability, land use planning policy and the level of participation of local residents in flood
management. Under these major areas this section offers the following analyses:

**Mapping**
- Social Vulnerability Assessment using SoVI indicators
- 200 year coastal flood event interacting with Social Vulnerability
- 1 meter in Sea Level Rise

**Plan Evaluation**
- 1994 Flood Management Plan Document Analysis
- 2009 Official Community Plan Content Evaluation

**Public Participation and IFHMP Implementation**
- Evaluation of public participation
- Discussion of strategies and activities to improve plan creation and implementation.

Combined with coastal flood hazard impact risk can be calculated in quantitative and repeatable ways. However, combining qualitative and quantitative approaches are critical to create accurate and relevant flood risk assessment (Oliver-Smith & Hoffman, 2002). Risk assessment and management must also deal effectively with public perception and values of risk in the determine of what is tolerable in exposure and consequence. This is often expressed as mortal risk.

These three assessments with accompanying syntheses of recommendations inform efforts by the District to practice risk-based land use planning and community development policy – an approach best informed with an intimate understanding of existing vulnerability.
HRVA and Acceptable Risk in Squamish

Tolerable risks are risks within a range that society accepts to secure certain benefits. The evaluation criteria for individual and societal risk are different, but some common general principles can be applied (Leroi et al., 2005). These risks are tolerated in order to realize some benefit, and should be reduced if possible by the local government and geotechnical professionals, guided by a legal responsibility to identify hazard lands. It is the risk owner’s responsibility to define tolerable risk and the process that local governments and citizens must establish “ALARP” – As Low As Reasonably Practicable, a “sweet spot” based on community perception and values based on frequency and fatalities. Current provincial Hazard Risk and Vulnerability Assessment (HRVA) toolkits elicit these observations of likelihood and probability but not existing conditions that amplify risk.

The Squamish Emergency Management Planning process has begun and has elicited perceived impacts. These are offered in Figure 24 where Moderate and Severe flood events are at the High to Very High in likelihood and impact. As hazards are often experienced by many people at once, group risk equations that factor in time of the event and existing sensitivities (such as high social vulnerability) are useful in HRVA assessment and flood hazard scenario planning. These quantify hazards and vulnerabilities to better understand the severity of exposure to risk (to society, sectors and infrastructure) – or social consequence -- considering wide spectrum of disaster event scenarios in flood prone coastal communities. They also provide a repeatable approach as vulnerability changes over time.

Risk assessments offered in this report focus mainly on the existing conditions of vulnerability in Squamish -- one element in the total risk equation. However, quantitative measures of vulnerability, like the SoVI composite score can be integrated into HRVA and IFHMP social consequence mapping.

Figure 24: Emergency Planning Risk Matrix

(Squamish Emergency Program, 2015)
The following 3 analyses offer insight into current conditions of vulnerability, land use and community development policy instruments and ways to improve public participation to meet current and future coastal flood hazards. To keep recommendations concise and actionable and a synthesis of short, medium and long term policy recommendations with relevant stakeholders in implementation are offered at the end of each major analysis area.
7.1 Social Vulnerability Indicators (SOVI)

Vulnerability can be understood as both a biophysical risk and a social risk. This means that ‘vulnerability’ can be considered a geographical space where vulnerable people are located, or a social space that is vulnerable regardless of its location. Social vulnerability is a multidimensional concept that helps to identify those characteristics and experiences of communities (and individuals) that enable them to respond to and recover from environmental hazards. In order to mitigate or respond to coastal flooding hazard it is necessary to understand the complex spatial patterns of social vulnerability within Squamish and how they change over time.

Social structures, composition spatial pattern, and underlying dynamics of social vulnerability can change rapidly over the course time in response to growth pressures and urban development. While these patterns cannot necessarily be assumed on the basis of prevailing theories of social disadvantage and behavioral change, it is important for social vulnerability maps to use the most recent social data, often found in Federal censuses. A selected suite of indicators, tailored to Squamish and consistent with some previous social vulnerability assessment in the region is available in Figure 25. A more complete rationale behind indicator selection is offered in the Methodology section of this report.
Figure 25: Selected Social Vulnerability Indicators

<table>
<thead>
<tr>
<th>Indicator</th>
</tr>
</thead>
<tbody>
<tr>
<td>% of population that has migrated from elsewhere in Canada</td>
</tr>
<tr>
<td>% of population living alone</td>
</tr>
<tr>
<td>% of population without access to a vehicle</td>
</tr>
<tr>
<td>% of population greater than 65 y/o</td>
</tr>
<tr>
<td>% population that has moved within the last year</td>
</tr>
<tr>
<td>% population that has moved within the last 5 year</td>
</tr>
<tr>
<td>% lone female parent households</td>
</tr>
<tr>
<td>% Aboriginal identity</td>
</tr>
<tr>
<td>% low-income families</td>
</tr>
<tr>
<td>% population spending &gt; 10 hrs. care to seniors</td>
</tr>
<tr>
<td>% tenant occupied households spending &gt; 30% on shelter</td>
</tr>
<tr>
<td>% owner-occupied households spending &gt; 30% on shelter</td>
</tr>
<tr>
<td>% visible minority</td>
</tr>
<tr>
<td>% population without knowledge of official language</td>
</tr>
<tr>
<td>% employed in basic service industries</td>
</tr>
<tr>
<td>% recent immigrant(within 5 years)</td>
</tr>
<tr>
<td>% population with no post secondary degree</td>
</tr>
<tr>
<td>% population not participating in social service occupations</td>
</tr>
<tr>
<td>% employed in service industries</td>
</tr>
<tr>
<td>% population under 5 years of age</td>
</tr>
<tr>
<td>% population not participating in labor force over 15 y/o - unemployed</td>
</tr>
<tr>
<td>% employed in transport, communication and public utility</td>
</tr>
<tr>
<td>% families spending &gt;30 hours of unpaid childcare</td>
</tr>
<tr>
<td>% working in industrial sector(construction etc.)</td>
</tr>
<tr>
<td>% housing units constructed before 1985</td>
</tr>
<tr>
<td>% population working in natural resource industries</td>
</tr>
<tr>
<td>Average Rent of tenant-occupied dwelling</td>
</tr>
</tbody>
</table>
Social vulnerability indicators offer a quantitative spatial assessment of socio-economic and physical vulnerability and aims to offer a background analysis of social exposure to risk in HRVA, IFHMP and OCP creation. Observations here are offered at the smallest level of analysis available from Canadian Census Data (Dissemination Areas) of 500 to 1000 people and attempts to locate social groups with the greatest social vulnerability in the face of coastal flood hazard. Background of creating the SoVI composite score and maps can be found in the Methodology Section of this analysis.

The purpose of these maps is to inform the District Municipality of Squamish, a current view of social vulnerability so that planning and strategies can better address vulnerability. Further, spatial overlays of physical hazards (such as 200 year surge event and sea level rise) and emergency management planning in relation to social conditions is emerging as best practice in addressing vulnerability in disaster planning (Cutter, S. et al., 2003) (Cutter, Mitchell, & Scott, 2000).

As vulnerability assessment is offered at the Dissemination Area level which does not align exactly with sub-areas or place-based neighborhood names, Table 2 groups DAs by common neighborhood name. These are meant to guide the interpretation of SoVI findings throughout Squamish, which are offered in Figures 26 and 27. Higher scores (deeper colors of red) represent a higher total composite level of vulnerability.

Table 2: Neighborhood SoVI Key

<table>
<thead>
<tr>
<th>Neighborhood</th>
<th>Dissemination Areas</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brackendale (BR)</td>
<td>59310188, 59310189, 59310190, 59310191, 59310215, 59310217</td>
</tr>
<tr>
<td>Downtown Core (DC)</td>
<td>59310201, 59310202, 59310203,</td>
</tr>
<tr>
<td>Dentville (DE)</td>
<td>59310200</td>
</tr>
<tr>
<td>Eastern Squamish (ES)</td>
<td>59310211</td>
</tr>
<tr>
<td>Industrial park (IP)</td>
<td>59310200</td>
</tr>
<tr>
<td>Garibaldi Estates (GE)</td>
<td>59310216</td>
</tr>
<tr>
<td>Garibaldi Highlands (GH)</td>
<td>59310212, 59310213, 59310214</td>
</tr>
<tr>
<td>Loggers Lane (LL)</td>
<td>59310203, 59310204</td>
</tr>
<tr>
<td>North Squamish (NS)</td>
<td>59310187</td>
</tr>
<tr>
<td>North Yards (NY)</td>
<td>59310200</td>
</tr>
<tr>
<td>South Squamish (SS)</td>
<td>59310205</td>
</tr>
<tr>
<td>Valleycliffe (VC)</td>
<td>59310207, 59310209, 59310208, 5931010</td>
</tr>
<tr>
<td>West Bank (WB)</td>
<td>59310198</td>
</tr>
</tbody>
</table>
Figure 26: Social Vulnerability in Squamish Valley
Figure 27: Social Vulnerability on the Squamish River Delta
7.1.1 Discussion

**Strongest Influence on The SoVI Composite Score**

Across all areas of Squamish certain individual vulnerability variables influenced the total calculation of social vulnerability. These heavy influencing variables included:

1. Population Migrating From Elsewhere in Canada
2. Population Living Alone
3. Population with No Access to Vehicle
4. Percentage of Population greater than 85 years old

It is important to note that these vulnerability variables influenced scoring in all Dissemination Areas, with “Population Migrating From Elsewhere in Canada” and “Population Living Alone” influencing vulnerability nearly twice as much as other heavily influencing variables. While the final SoVI composite score was ultimately adjusted for these loadings, the level of social connectivity experienced in all of these heavy influencing variables is of concern when planning for all hazards across the disaster cycle in Squamish.

**Correlation**

There is an interactive nature to social vulnerability in Squamish households and neighborhood. Most notably, there is a high correlation across Dissemination Areas between 1) Populations without a secondary degree and 2) Visible minorities. This may illustrate a deeper structural societal inequality in access to education in Canadian society, demonstrated in this Canadian coastal community. Further, there is a strong correlation between 1) New international immigrants and 2) Populations that have arrived in the past 5 years. This may illustrate that while many of those who are new to Squamish in the past half decade are from other nations, they are also experiencing lower levels of social cohesiveness to the broader social structure of the community.

**Factor Analysis**

Not all social vulnerability variables have the same impact on major vulnerability factors, some are more dominant across the dataset and must be noted. Seventeen of the original twenty-eight variables made noticeable increases to total vulnerability scores. These are illustrated in Figure 29. Most notably residents new to Squamish in the last 5 years, low-income households and residents (tenants and home owners) who spend more than 30% of their income on housing all had significant impacts on vulnerability factors.

In statistical analysis across DAs in Squamish, certain variables clustered into “Factors” depending on how much they impacted the data set and how well they are correlated to each other. The highest scoring variables in these clusters offer insight into what variables impacts social vulnerability at the DA level in Squamish. A complete table of factor strength across dissemination areas is offered in Appendix Item 28. Factors are listed in their order of impact (1 being the highest).

---

7 Eigenvalues greater than 2
**Figure 28: Social Vulnerability Factors in Squamish**

<table>
<thead>
<tr>
<th>Factor 1</th>
<th>Social Connectivity and Homeowners</th>
</tr>
</thead>
<tbody>
<tr>
<td>Residents who have moved to Squamish in the last 5 years those who are not connected to social service sector and homeowners paying more than 30% on their mortgage have a positive impact on vulnerability.</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Factor 2</th>
<th>Housing Security</th>
</tr>
</thead>
<tbody>
<tr>
<td>Renters paying more than 30% of their income to rent, residents who are over sixty-five years old, residents who have been in Squamish less than 5 years and Low income households have a positive impact on housing security vulnerability.</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Factor 3</th>
<th>Family and Livelihood</th>
</tr>
</thead>
<tbody>
<tr>
<td>Families spending more than thirty hours on unpaid childcare, those unemployed and those employed in public services have a positive impact on this vulnerability factor.</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Factor 4</th>
<th>Employment and Mobility</th>
</tr>
</thead>
<tbody>
<tr>
<td>Those working basic service industry jobs, who do not speak official Canadian languages, have no vehicle access and do not have a secondary degree have a very positive impact on vulnerability. This interaction of factors leads to a condition of marginality in employment in the Squamish economy and a lack of equity to private transport in case of flood event evacuation.</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Factor 5</th>
<th>Regional Migrants</th>
</tr>
</thead>
<tbody>
<tr>
<td>New recent internal Canadian migrants, those who are low income and those without a vehicle positively impact area social vulnerability. While those who are newcomers to Squamish dominate this, these populations in neighborhoods may experience lower social connectivity making evacuation and recovery from flood events difficult.</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Factor 6</th>
<th>Work Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Those working in transport, communication and public utility had a moderately high positive effect on vulnerability while those working in the industrial sector have a strong negative influence.</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Factor 7</th>
<th>Housing Quality</th>
</tr>
</thead>
<tbody>
<tr>
<td>Those living in older housing stock and those working in the service sector positively impacted this factor. Those semi-recent immigrants to Squamish working in the service industry disproportionately experience further, poor housing quality.</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Factor 8</th>
<th>Newcomers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Those who moved to Squamish in the past five years and those who were international immigrants had a somewhat positive impact on vulnerability scoring.</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Factor 9</th>
<th>Renters and Caregivers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Those tenets paying high rents had a very high impact on vulnerability scoring while those spending more than 10 hours weekly with seniors had a moderately negative impact on vulnerability.</td>
<td></td>
</tr>
</tbody>
</table>
Figure 29: SoVI Scores of Squamish Dissemination Areas

SoVI Score

59310202
59310201
59310212
59310207
59310209
59310204
59310206
59310203
59310189
59310193
59310200
59310208
59310187
59310215
59310197
59310198
59310217
59310210
59310213
59310214
59310192
Areas of Interest In Vulnerability Reduction

Certain Dissemination Areas demonstrate a heightened vulnerability and considerably higher level of existing social vulnerability and are of considerable interest in flood risk reduction planning efforts.

In order of vulnerability scores (Highest to Lowest) with key quantitative observations:

59310201 (Downtown Core)
- Highest level (38%) of people living alone
- Highest amount of lone parent households (33%)
- Highest population without a secondary degree (31%)
- A moderate amount (10%) of the population does not have knowledge of an official Canadian language.
- High population of those without a secondary degree
- 72% of houses were constructed before 1989

59310202 (Downtown Core)
- Highest population without access to a vehicle
- Highest household poverty rate
- Highest amount of people employed in basic service industries
- Very low connectivity to social services

59310203 (Downtown Core)
- All (100% reported) have moved to the area in the past 5 years
- Highest concentration of those spending more than 30% of their income on rent
- 27% of the population is over 65 years old

59310189 (Upper Brackendale including IR Cheakamus 11 and Waiwakum 15)
- Highest population of aboriginal peoples
- Highest population of visible minorities
- High unemployment rate
- High level of lone parent households
- High level of caregiving to elders and unpaid childcare

59310206
- 100% of housing units were constructed before 1985

8 While prone to intertidal/riverine rather than coastal flood risk, this area is of concern in flood risk management due to considerable levels of social vulnerability
Social Vulnerability Trends in Squamish

The first application of the SoVI in Canada was in Squamish during a Natural Resources Canada research project and use 2006 census data (Journeay, M. J., 2011). As these updates analysis used the same indicators -- with 2011 Census NHS data however -- patterns of social vulnerability in Squamish valley can be identified. The Downtown Core of Squamish remains the highest concentration of people experiencing heightened vulnerability. In this area vulnerability has increased since 2006, most notably in Dissemination area 59310202 -- areas, which are most subject to coastal flood hazard [See Section SoVI and Physical Hazard]. Cumulatively, social vulnerability composite scores have increased in the majority of Dissemination Areas.
7.2 Social Vulnerability and AEP 200 Coastal Flooding

As of 2011 the areas of potential flood inundation encompassed 3,235 residential buildings, nearly 60% of the total building stock (Journeay, M. J., 2011) and it is estimated that 7,477 9 Squamish residents live in a designated floodplain area (Ebbwater, 2015).

The coastal floodplain of Squamish supports many services and businesses critical to the economy of the town. These are relied on by residents living both on and outside the floodplain.

Key community infrastructure include:

- Municipal Hall
- Municipal emergency response service.
- Squamish Elementary School
- Howe Sound Secondary School
- Squamish Public Library
- BC Hydro’s Squamish substation
- Commercial and industrial facilities
- Commercial services and small businesses

---

9 Analysis was conducted using 2011 Census Data
7.2.1 Discussion
This analysis examines the effects of a 200-year coastal flood, likely a combination of a strong surge interacting with a mountain freshet in the winter months, to offer a scenario of the extent of inundation and related loss and damage it may have on human settlement. A district wide perspective is offered in Figure 30. Further, the Social Vulnerability mapping completed in the previous section is overlaid to see where levels of 200-year floodwaters and social vulnerability interact to produce total risk. These are offered in Figure 31.

Coastal flood events have the highest impact on the most vulnerable populations in Squamish living in the coastal floodplain of the Downtown Core.
Modeled coastal inundation ranging from 0.54 to 2.52 m here impacts the most socially vulnerable people in Squamish with the highest flood depths and extent. Further, this area also retains a high concentration of homes built prior to 1985 and flood construction levels (FCLs) established in the 1994 flood plan. These homes, located in low-lying areas of a connected flood plain will experience the greatest impact, loss and damage in a coastal flood event. A more detailed map of the interaction between flood hazard and social vulnerability for the Squamish Downtown Core is offered in Figure 32.
As this flood model does not account for structural upgrades to dykes or proposed sea dyking in the downtown area, these maps offer insight into how current social conditions may interact with a dyke breach most notably in the highest levels of social vulnerability and in the downtown area.

Observations of water depth from coastal flood event across the river delta include:

- 0.48m to 0.95m in Dentville
- 0.50m in areas of Stawamus 24

Vulnerable neighborhoods include North Yards, Squamish Business Park, Dentville, and Downtown Squamish. In addition to Squamish Nation Stawamus I.R. No. 24, other areas at risk to coastal flooding hazard include Squamish Nation Yekwaupsum I.R. No. 18 and Squamish Nation Yekwaupsum I.R. No.19 (Largely Undeveloped).

Nearly all industrial and commercial lands are subject to flood hazards (District Municipality of Squamish, 2009), however coastal inundation may also impact major regional transit infrastructure along the Mamquam Blind Channel (Highway 99) and Squamish Estuary (CN Rail).
Figure 30: 200 Year Coastal Flood Event in the Squamish Valley

Figure 31: 200 Year Coastal Flood Event and Social Vulnerability in the Squamish Valley
Figure 32: 200 Year Coastal Flood Depths and Social Vulnerability on the Squamish River Delta
7.3 Sea Level Rise and New Natural Boundaries

Introduction

Long-term vulnerability reduction, sustainability and coastal adaptation planning in Squamish must account for risks associated with current and future climatic change (Fussel, 2007). Addressing global climate change in local flood hazard and land use planning is ground zero for human adaptation to climate change. Here planning policy must deal with uncertainty. However, to present a future “Worst Case” scenario of a 1 meter Sea Level Rise (SLR) inundation bathtub model was created for the Squamish River Delta using the nineteen years of Higher High Water Level (HHWLT) tide data in Howe sound -- with 1 meter of additional water added. This model does not account for current or future sea diking or small-scale tidal effects on the flood plain but rather offers preliminary analyses of sea level rise using district high-resolution elevation modeling.

This modeling and preliminary visualization offer an early adaptation assessment for sea level rise in Squamish and may assist in creating a prioritized policy and infrastructure strategy for meeting coastal flood risks given projected climate scenarios.

However, today there is opportunity to identify “no-regret” or “low regret” actions on behalf of the municipality today, considering the timeline of sea level and how adaptation options perform the most robust across expert and community generated evaluation criteria.

A DROP approach to integrated flood hazard management considers natural boundaries of waterways and coasts in efforts to maintain and enhance natural buffer areas and account for future extent of ecosystem services providing flood protection such as the Skwelwil’em Squamish Estuary. Further, understanding new natural boundaries may inform the designation of hazardous areas for habitation and other land uses in long range sustainability planning and revisions to climate change policy in the Official Community Plan.

Figure 33 illustrates the extent and depth of inundation given a 1-meter sea level rise and offers three spot depth measurements of standing water across current human settlement on the Squamish River delta. Figure 34 offers a more detailed map of the downtown core.
Figure 33: 1 Meter of Sea Level Rise in the District of Squamish
Figure 34: 1 Meter of Sea Level Rise on the Squamish River Delta
### 7.3.1 Discussion

A 1-meter rise in sea level without a storm surge will impact at least 2.88 km²/ 289 Hectares or 3% of the District’s land. A majority of this inundation will occur in the most socially vulnerable, densely populated and economically active downtown area.

The deepest inundation would occur in the downtown core (1.82m at 2nd and Main and 1m at Eaglewind Drive), the Ocean Front Peninsula (1.27m). Squamish Reserve Stawamus 24 may experience up to .35m Dentville while upland areas in Dentville will experience lesser but notable effects (0.15m at Madill and Britannia).

Recognizing existing vulnerabilities in these social, environmental and built systems assists in prioritizing coastal adaptation activities (Fussel, 2007). To successfully adapt to these new boundaries the complex interaction between social and ecological systems must be engaged in an elicitation of community values -- based on ecological and social memory -- to assist in successful reduction of vulnerability given current and expected coastal change (Adger et al., 2005).

Sea level rise has major land use planning implications. Taking a DROP approach to adaptation, there are three areas of opportunity to recognize new natural boundaries in coastlines and intertidal waterways that include:

1. Land Use Zoning
2. Waterway Setbacks and
3. Skwelwil’em Squamish Estuary Upland Migration

These are further illustrated with relevant areas identified in **Figure 35**.

Understanding where future high tides is valuable in addressing both short term flood risk and long term climate adaptation in this coastal setting. However, successful adaptation to SLR and planning policy will be through engaging citizens and local values.

Simple Sea Level Rise visualizations out in the landscape where residents can see the impacts on neighborhoods and built environment can assist in connecting community actions and flood risk with global climate change (Sheppard, 2012). Visualizations of existing community vulnerability, 200-year surge events and Sea Level Rise are valuable beyond planning reports in translating knowledge into action. Examples of “Resilience Activities” including SLR visualization can be found in **Section 9.0 on Public Participation and IFHMP implementation**.

---

10 A raster calculation using a single water surface and existing District of Squamish LIDAR Digital Elevation Model.
Figure 35: Sea Level Rise Planning Opportunities in Squamish

1. Land Use

**Areas Impacted:** Downtown Core, Stawamus IR 24, Oceanfront Peninsula,

**Rationale:** Creating a Sea Level Rise Development Permit Area (DPA) in areas identified beyond tolerable risk can clear guidelines for use and building form can ensure that areas of inundation do not subject residents to coastal flood risk. Flood Construction Levels for future development must reflect expected SLR. Areas with existing low FCL buildings (often built 1985) subject to SLR demand attention in vulnerability reduction and zoning efforts.

2. Waterway Setbacks

**Areas Impacted:** Dentville, Business and Industrial Parks, Stawamus IR 24, Yekwaupsum 18, North Yards

**Rationale:** Given higher stream flows, tides and flood events that are impacted from higher seas, revisiting current setbacks for future development will ensure that sensitive environmental areas that provide flood management services and resident exposure to flood waters at higher natural boundaries are addressed.

3. Skwelwil'em Squamish Estuary Upland Migration

**Areas Impacted:** Downtown Core (Village Green Way, Wilson Slough,) Business and Industrial Parks

**Rationale:** As tides move upland so do intertidal environments that estuarine forests systems need to thrive. Expanding current estuary management boundaries and designating future lands that will become intertidal zones can ensure continued ecosystem services for flood management.
7.4 Towards Risk-Based Planning in Squamish

Innovations in planning research offer guidance to coastal communities like Squamish to set protocols for risk-based decisions for human use of hazardous lands. The Risk-Based Land-use Guide, released by the Geological Survey of Canada in 2014, structures such an approach to land use planning. The guide defines risk as the probability of consequence which differs slightly from the Risk = Hazard x Vulnerability approach taken here. However, consequence is based in social and environmental vulnerability and the exposure to risk (Struik, L C et al., 2015). Understanding existing vulnerabilities feeds into Step 3 of the proposed approach illustrated in Appendix Item 12. 5. A risk-based approach can be mainstreamed into the planning at the municipal level across departments and plans. Some of these formal documents may include:

1. Regional Growth Strategies
2. Official Community Plans
3. Development Permit Areas
4. Design Guidelines
5. Subdivision Bylaws
6. Transportation Plans
7. Capital Plans
8. Emergency Plans
9. Flood hazard management plans

Informed by baseline DROP analyses in this report, IFHMP study and emerging best practices, the District can demonstrate leadership and innovation in risk-based planning in Howe Sound and the Strait of Georgia.

7.5 From Findings To Action: Risk Assessment

The highest concentrations of social vulnerability and greatest exposure to coastal flood hazard (surge and sea level rise) are located in the downtown area ——— most notably Dissemination Areas 59310202 and 59310201. • Waters during a 200-year coastal flood event may reach 0.5m to 3m across the flood plain in a current dike or future dike failure scenario.

Given a 1-meter rise in sea levels, at least 2% of the District’s lands are subject to 1 meter of sea level rise, which will also be accompanied by an upland migration of the Squamish estuary. These findings suggest that there is much work to be done to address vulnerability and future water levels in planning.

The following synthesis of recommendations offers more comprehensive, time sensitive and party specific insights.
## Risk Assessment
### Synthesis of Recommendations

<table>
<thead>
<tr>
<th>Short Term</th>
<th>Parties Involved</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Complete Emergency Evacuation plan for downtown area with heightened engagement for Squamish residents in downtown Dissemination Areas.</td>
<td>District of Squamish Engineering and Planning, Emergency Manager, Community Organizations</td>
</tr>
<tr>
<td>2. Integrate SOVI and SOVI + AEP 200 Coastal Flood mapping into current IFHMP social consequence mapping</td>
<td>KWL, Arlington Group, District of Squamish Engineering and Planning, Community Organizations</td>
</tr>
<tr>
<td>3. Identify community organizations representing the downtown area in IFHMP implementation</td>
<td>KWL, Arlington, District of Squamish Engineering and Planning, Community Organizations</td>
</tr>
<tr>
<td>4. Review indicator weights of social vulnerability indicators</td>
<td>IFHMP Implementation Committee, KWL, Arlington Group, District of Squamish Engineering and Planning, Community Organizations</td>
</tr>
<tr>
<td>5. Complete community emergency management plan including provisions for coastal flood evacuation.</td>
<td>District of Squamish Engineering and Planning, Emergency Manager, Community Organizations</td>
</tr>
<tr>
<td>6. Complete Proper Functioning Condition evaluation of Squamish waterways</td>
<td>IFHMP Implementation Committee, District of Squamish Engineering and Planning, Community Organizations</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Medium Term</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Integrate SOVI + Coastal Flood mapping and new natural boundary estimates in 2016 OCP updates</td>
<td>District of Squamish Engineering and Planning</td>
</tr>
<tr>
<td>2. Create a Sea Level Rise or Coastal Flood Zoning Bylaw Designation [LTA Chapter 323 –Section 903 ] with restrictive use, and design guidelines for any allowed structures</td>
<td>District of Squamish Engineering and Planning, Municipal Council</td>
</tr>
<tr>
<td>3. Create community hazard vulnerability and risk monitoring and evaluation program.</td>
<td>District of Squamish Engineering and Planning, Squamish Emergency Planning, Community Organizations</td>
</tr>
<tr>
<td>4. Designate lands subject to high coastal flood risk as restrictive use [LTA Chapter 250 Section 85, 86, 2019] .</td>
<td>District of Squamish Engineering and Planning, Mayor and Council, Approving Officers</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Long Term</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Make land use planning policy and decisions based on social consequence of exposing vulnerable populations. [LTA Chapter 250 Section 85, 86, 2019]</td>
<td>District of Squamish Engineering and Planning, Approving Officers</td>
</tr>
<tr>
<td>2. Monitor community resilience based on vulnerability indicators (See Appendix Item 12.17)</td>
<td>District of Squamish Engineering and Planning, Community Organizations</td>
</tr>
</tbody>
</table>
Image 2: Development Proposal in the Downtown Peninsula Area during a Summer Storm Surge, 2015

Photo: Christopher J. Carter (Lighthawk Conservation Flying | Resilient Coasts UBC), 2015
8.0 Plan Evaluation

To understand where Disaster Resilience of Place (DROP) to coastal flooding could be mainstreamed into land use and flood hazard management plans, this analyses identified the following planning documents as highly relevant for review:

2. Official Community Plan (2009) Including Peninsula Area appendix
4. Upper Mamquam Blind Channel Policy Statement

While all documents were read, the existing 1994 Flood Hazard Management Plan and Official Community Plans were chosen for a structured and in depth analysis. These two documents are the focus of this section. These analyses illustrate gaps and opportunities where a DROP approach can be taken to reduce vulnerability to coastal flooding through local land use and planning policy. Current land use regulation in Squamish is done using 12 zoning designations and development permits areas. Figure 36. Illustrates current zoning designations in relation to coasts, watercourses and the Skwelwil’em Squamish Estuary.
Figure 36: Land Use Zoning and Management Areas in 2015

(District of Squamish, 2014)
Urban development in Squamish is confined by water, steep topography and a multitude of hazards, this leads to hyper-focused urban development on the valley floor, much of which is subject to riverine and coastal flooding. The Squamish Valley floor contains acceptable, negotiable and non-negotiable growth management areas established by the District (Journeay, M. J., 2011). Given a two-fold increase in population over the next 30 years local planning policy can adopt a DROP approach to ensure a risk-based use of land. Areas such as of the Squamish Downtown Core that are noted as “acceptable” in current growth management must be given consideration.

Guided by the current land use bylaw (No. 1324) and 2009 Official Community Plan, future densities of human settlement are directed away from coastal areas (Journeay, M. J., 2011). In efforts of risk-based land use policy, tradeoffs in development placement in relation to current and future risk must be made. Coastal hazards being are noted of moderate-high concern in Squamish HRVA study (Squamish Emergency Program, 2015).
8.1 1994 Flood Hazard Management Plan
**Introduction**

Flood hazard management plans typically are updates every 15-20 years by municipalities. The 1994 Flood Hazard remains the most recent iteration of a flood hazard management plan and must be updated to meet new understandings of climate, coastal hazards and innovations in community disasters resilience planning.

A social vulnerability and ecological resilience framework was developed to structure the Strengths Weaknesses and Opportunities (SWO). This framework captures major themes in those two. Evaluation variables and results can be found in the Table 3 below.

Based on these core concepts strengths, weaknesses and opportunities are offered by section and can inform updates to flood planning in current IFHMP creation. As the plan was never formally institutionalized, it remains unclear if the policies, structural suggestions and legal tools set forth were put into action. However, lessons and successful policy can be drawn from in the creation of a revised IFHMP.

This SWO plan evaluation follows the original structure of the 1994 flood management plan, offering analyses by the plans major five sections. These include:

1. **Public Education and Engagement**
2. **Regulatory Requirements**
3. **Dyking and Structural Improvements**
4. **Implementation**
5. **Monitoring and Evaluation**
### Table 3: 1994 Flood Management Plan Evaluation Variables

**KEY:** Addressed in Plan (**Green**), Not Addressed in Plan (**Red**)

<table>
<thead>
<tr>
<th>Variables</th>
<th>Provision</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Address Climate Change and Sea Level Rise</td>
<td>Plans for 3m-flood event. No strategy for SLR or climate change impacts.</td>
<td>--</td>
</tr>
<tr>
<td>2. Takes a watershed approach</td>
<td>No mention of watershed level, multi-stakeholder governance or Squamish First Nation</td>
<td>Must consider institutional arrangements and regulation of ground and surface water under 2014 BC Water Sustainability Act</td>
</tr>
<tr>
<td>3. Non-structural approach considered</td>
<td>Section 215 Covenants and 969 zoning bylaws (not passed by council). 1994 plan influenced OCP land use designations and policy for landslide hazards but lacks a natural hazards Development Permit Area</td>
<td>Focus on dyke setbacks and limiting unfinished basements. FCLs are out of date</td>
</tr>
<tr>
<td>4. Promotes Ecological Buffers</td>
<td>Protection of Squamish estuary</td>
<td>Recognizing citizen connection to dyke trail system is a great start for engagement</td>
</tr>
<tr>
<td>5. Acknowledges social capital</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>6. Promotes Networks and Social Learning</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Variables</td>
<td>Provision</td>
<td>Notes</td>
</tr>
<tr>
<td>-----------</td>
<td>-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
<td>----------------------------</td>
</tr>
<tr>
<td>1. Mitigation</td>
<td>Housing quality, resources or provisions for upgrades and insurance are entirely absent.</td>
<td>--</td>
</tr>
<tr>
<td>2. Preparedness</td>
<td>Limited to emergency communications plan and identification of neighborhoods. No discussion of warning system. Limited to 8 Page community brochure with flood maps</td>
<td>No languages identified</td>
</tr>
<tr>
<td>3. Response</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>4. Recovery</td>
<td>Some discussion of finance schemes for dyke upgrades. No focus on housing, social deprivation or inequity, political will, resource sharing with fellow district, impacts of flooding event or post-disaster planning</td>
<td>--</td>
</tr>
</tbody>
</table>
Discussion

Public Education and Engagement

Assessment

From the outset the 1994 flood plan identifies “public education” as the linchpin of successful hazard management and risk reduction planning process and recognizes that this will be more effective than dyke infrastructure upgrades and land use regulation. The description of flood risks and location was communicated through three four-page brochures that described flood risk and areas of concern with a circulation of 5,000 (population of Squamish in 1994 was 13,779). This brochure was in addition to local public radio announcements and two public open houses. The plan also recognizes Section 215 covenants as an indirect form of flood risk education.

Weakness

From a participatory theory perspective this plan took an additive (participation when possible) rather than a subtractive (participation as a core objective) approach. The result is an “inform and consult” rather than “empower” approach. These two approaches are at opposite ends of the Internationally Recognized IAP2 spectrum of public participation.

It is unclear why a brochure was chosen as an effective risk communication medium and there are no references to other languages the 8-page brochure will be produced in. As a multitude of regulations and design suggestions are made there was no mention of public consultation in this drafting and this may cause conflict in implementation and ineffective enforcement. Further, public education and engagement aim to “solicit cooperation” rather than share decisions and joint plan with the Squamish Nation.

Opportunity

This area of the 1994 plan and participatory planning practice offers the largest opportunities in addressing social vulnerability by putting the most vulnerable people and businesses at the center of planning efforts and privileging indigenous knowledge. Given recent decisions such as Tsilhqot’in FN v. Province of British Columbia and Lil’Wat FN v. Resort Municipality of Whistler that have recognized indigenous lands beyond areas of intensive use, land or water use planning must engage indigenous governments as institutions in the name of reconciliation in good faith, this collaboration is also good planning practice for Districts (Province of British Columbia, 2012). Further, Site A. of the Squamish Estuary, three Indian Reserves and the co-managed Skwelwil’em Squamish Estuary are integral to IFHMP protection schemes (BC Ministry of Environment, 2007).

Drawing from traditional knowledge holders and elders with the Squamish First Nation can achieve intricate flood histories and place-based knowledge that can inform analyses, coastal and riverine assessment and policy translation. Further partnering in education and plan implementation with an effective cross-section of Squamish civil society, especially youth, migrant, historically marginalized populations, impoverished and
renters can grant a better sense of who may be impacted.

A stakeholder map of relevant civil society organizations in Squamish not identified in current IFHMP process is available in Appendix Item 12.10. Granted that the District is now home to a multitude of languages and cultural backgrounds, namely 1,195 Punjabi and 190 Tagalog speakers, there are opportunities to meet citizens on their own terms (Statistics Canada, 2015). Emphasizing flood risk planning at the neighborhood level through participatory planning events, flood visualization, interpretive signage and estuary vegetation programs can build social capital and discuss topics like flood memory, traditional knowledge and place attachment.

**Regulatory Requirements**

**Strength**

The plan makes many productive provisions for leaving the natural environment untouched, protecting river floodways and sensitive areas (i.e. wetlands and coastal estuaries), buying out hazardous areas that may be subdivided and a focus on urban densification in areas of low hazard. This is achieved through a proposed Official Community Plan category for conservation and protection alongside zoning bylaws to preserve conservation along river channels. A Development Permit Area 4 – District Watercourses with guidelines for two inland channels effectively identifies watercourse setbacks (19.69 feet), restoration of biological function after any development. These measures carry tangible impacts for resilience planning by protecting and expanding ecosystem buffers.

Flood hazard areas are also proposed through the creation of bylaws (751) under Section 989 of the Municipal Act. This plan created Flood Construction Levels of 2.5m and guidance for urban development within the reaches of the Squamish and Mamquam river floodplains. Managing future development away from high flood hazard areas is recommended under the Land Title Act Section 215 and 219 covenants. These covenants are effective at mandating Flood Construction Levels and if applied to a title, waive local government liability for flood loss and damages. A full table of regulatory provisions is illustrated in Appendix Item 4.

**Weakness**

Drafting, legislating and attempting to enforce land use regulation and Official Community Plan updates without early and often public participation can prove politically problematic and do not address existing social vulnerability. While ensuring conservation of buffers, a majority of these regulations focus on new building guidelines and structural upgrades rather than investing in the resilience of local businesses and people. Allowing covenants to serve as a form of public education is novel but does not actively reduce the risk of residences or businesses that cannot invest elsewhere.

**Opportunity**

A focus away from buildings to environmental buffer enhancement, people impacted and public agency in flood risk planning can ensure that natural and social capital is at the core of flood-risk planning. Actively engaging businesses and residents in the creation of regulation, other non-structural land use and “resilience
activities” can garner support and ensure the relevance of land use designation and covenants. Identifying opportunities to expand the extent of the Squamish estuary through zoning designations and land trusts can enhance a green infrastructure approach to flood hazard management and higher sea levels.

Fellow communities in the Strait of Georgia have begun to integrate 1m of sea level rise into land use zoning provisions. Namely in Parksville BC where vulnerabilities to Sea Level Rise have been addressed through a zoning designation for Estuary preservation to protect the 145 ha (358 acre) Englishman River estuary. Additional development permit areas and guidelines have been slated to meet the land use and social vulnerability realities as part of the municipality’s sustainability and climate adaptation plans. A zoning bylaw is currently being planned for designated inundation areas surrounding the popular Parksville Beach and Community Park. Further estuary and historic preservation designations may be of use in flood risk coastal adaptation planning efforts.

As densification and clustering remains an important activity in this urbanizing district, adopting a Green Density model in low hazard areas that effectively designs for flood waters, neutralizes impacts to wetlands and promotes social connectivity can garner co-benefits such as aging in place, poverty and homelessness reduction planning efforts.

*Dyking and Structural Improvements*

**Strength**
From the outset, the plan identifies that dykes are only a partial solution for flood protection. Further socio-ecological interactions are recognized as the plan makes provisions for “public appreciation” of wetlands and high interactions with dyke systems through running paths.

**Weakness**
Firstly this plan and section focuses heavily on flood proofing and Flood Construction Levels and does not address Proper Functioning Condition (PFC) of watersheds and riparian zones. Not only do these not address the upgrade of current properties but the dyke systems in this analyses are based on protection from flood events that occur 1 in 200 years, and is based on flood assessments from the 1970s, this does not represent a change in flood regimes and updated sea level rise and regional climate study. Ongoing analyses consider 1 in 200 years given new climate projections and a 1m rise in sea level. Further, hybrid varieties of dyking and non-structural soft armouring is often much less expensive and can reduce total water level by dissipating flood energy and retaining water if estuarine and riparian systems are in Proper Functioning Condition. These are not considered.

**Opportunity**
Ongoing diking options can focus on protecting critical infrastructure and identifying green infrastructure hybrids and wave break options and retaining the fiction of the Squamish Estuary. The ‘Green Shores’ program, which takes ecosystems, focused approach to reduce erosion. This approach to shoreline design, illustrated further in *Appendix Item 12.4*, aims to limit erosion, urban encroachment, conservation of estuaries and restore riparian vegetation. There is opportunity to prevent the erosion of wetlands, wave breaking green infrastructure and other ecosystem buffers for coastal
flooding. Current IFHMP planning identifies a suite of protection strategies and include few hybrid dyke options (District of Squamish, 2014).

**Implementation**

**Strength**

A simple implementation program schedule for implementing strategic actions of Flood Hazard Management plan is included in the plan. This included the OCP Amendment Bylaw, 969 bylaw, adoption of the flood hazard management plan and creation of maps and public education materials. The need for an implementation steering committee made up of agencies was identified to oversee public education and transfer of regulatory authority is also identified. Financing dyking, flood management activities is recommended through general taxation development cost charges improvement programs, Federal grants and Public to Public Partnerships with the Ministry of Environment Lands and Parks are proposed

**Weakness**

Implementation is the linchpin to disaster resilience planning. This plan falls short on many fronts. Clear responsibilities, timelines, earmarked funding and evaluation criteria and schedules are all missing. Interviews with staff note that land use designations were changed in the Official Community Plan following the 1994 flood management plan as well as policy recommendations for development in Cheekye Fan. Today, 20 years later and lacking documentation it is unclear how the plan was implemented.

**Opportunity**

It is widely recognized that engagement and participation of civil society as collaborative partners can assist in the effective implementation of disaster and risk reduction plans complex hazard interactions and a climate uncertainty (Oulahen & Doberstein, 2010)(Head & Alford, 2013). However, this must begin in early planning stages. Further opportunities are outlined in the Public Participation and IFHMP Implementation Section of this report.

Provincial guidelines for flood hazard management from 2004 call for 1m of Sea Level Rise. According to more recent downscaled relative sea levels in the Howe Sound area, any structural upgrades and flood construction levels can account for 38.5 to 51.6cm in relative sea level rise in Howe Sound by 2100, these estimates are based on a range of relative carbon emissions or Representative Concentration Pathways (James et al., 2014). There are opportunities to use downscaled climate modeling provided by Pacific Climate Impacts Consortium and the current district Flood Construction Levels of 4.59m + wave effects to guide non-structural planning initiatives. This can include the creation of sea level rise planning areas, setbacks, investment in environmental flood buffers and identifying where new maximum natural boundaries of the ocean and intertidal areas coincide with social deprivation and vulnerability.
**Monitoring and Evaluation**

**Opportunity**
As the 1994 Flood Hazard Plan made no provisions for monitoring the status of vulnerability of society in Squamish it is advised to adopt a disaster resilience of place (DROP) model. In this approach risk (an objective measure of the likelihood of a hazard event) interacts with mitigation (measures to lessen risks or reduce their impact) to produce the hazard potential. The hazard potential is either moderated or enhanced by a geographic filter (site and situation of the place, proximity) as well as the social fabric of the place. Indicators increase transparency and assist in monitoring vulnerability reduction efforts (Cutter et al. 2008). This can be readily be adapted to the unique context of Squamish, acknowledging that not all are equal in exposure and would include ecological, social, economic, institutional, infrastructure, and community competence indicators.
8.2 2009 Official Community Plan Evaluation
Introduction

The Official Community Plan of Squamish can provide a guiding land use bylaw, which mainstreams disaster risk reduction and community values around risk – providing a valuable opportunity to integrate a disaster resilience of place approach. The Local Government Act of Canada Section 323 – Sections 875, 876, 877 and 878 make previsions for local governments to integrate these core concepts in management of resources, restriction of land use in hazardous areas and by setting objectives and policies that guide planning and land use decisions.

Using plan evaluation methodology (see methodology section) the current Official Community Plan 2009 Bylaw 2011 was evaluated to assess gaps in planning policy and land use regulation for coastal flood risk - specifically in taking a disaster resilience of place approach. Protocols for evaluation and results are shared in Appendix Item 12.8.

An assessment of strengths and opportunities is offered by the 8 plan elements addressed:

1) Evidence Base
2) Participation
3) Governance and Coordination
4) Goals
5) Legal and Local Government Requirements
6) Policy
7) Implementation, Monitoring and Evaluation
8) Organization and Communication

Discussion

Overall the plan met 63% of the plan evaluation protocols. The major strength of the OCP was in its Plan Organization and Communication, meeting 100% of protocols. Legal and Local Government Requirements, Public Participation and Governance and Coordination were also string all met 80% of the plan protocols. A visual of plan performance by element offered is Figure 37.

An area of concern in the OCP were overarching goals for risk reduction to coastal flooding which met a mere 14% of plan protocols – providing opportunity for major improvements in 2016 OCP revisions. These goals represent leadership by the Municipality to reduce risk and allocate resources to do. This area deserves major work in 2015 OCP revisions. The following analysis offers a detailed description of where the current Official Community Plan and areas where it can be strengthened, organized by major plan element.
## Table 4: Overview of Plan Quality Variables and Element Performance

<table>
<thead>
<tr>
<th>Plan Element</th>
<th>Individual Variables</th>
<th>Mean Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Evidence Base</td>
<td>12</td>
<td>67%</td>
</tr>
<tr>
<td>Participation</td>
<td>5</td>
<td>80%</td>
</tr>
<tr>
<td>Governance and Coordination</td>
<td>5</td>
<td>80%</td>
</tr>
<tr>
<td>Goals</td>
<td>7</td>
<td>14%</td>
</tr>
<tr>
<td>Legal and Local Government Requirements</td>
<td>5</td>
<td>80%</td>
</tr>
<tr>
<td>Policy</td>
<td>14</td>
<td>64%</td>
</tr>
<tr>
<td>Implementation, M&amp;E</td>
<td>9</td>
<td>22%</td>
</tr>
<tr>
<td>Organization &amp; Communication</td>
<td>7</td>
<td>100%</td>
</tr>
</tbody>
</table>
Figure 37: 2009 Squamish Official Community Plan and Coastal Flood Risk Planning
**Plan Element 1: Evidence Base**

**Score: 67%**

**Strengths**

- Climate change is addressed in Energy & Air Quality and Hazard Lands sections.
- Sea level rise and coastal flood risk was addressed in Hazard Lands (Section 25), Background Oceanfront Peninsula Sub Area Plan.
- Acknowledges designated flood hazard areas as those existing in the 200-year floodplain for watercourses and the Howe Sound (Section 25).
- Current population size and composition was included in section 6 Community Profile.
- Describes adjacent watercourses and coastline characteristics.

**In BC, climate change is anticipated to result in increased temperatures, increased precipitation, more extreme precipitation events, sea level rise, glacial retreat, and changes in estuary salinity and ecology.**

*With Squamish being located at sea level, at the mouth of an estuary, and home to glaciers, Squamish may experience all of these manifestations of climate change.*

*Hazard Lands P. 112 OCP(2009)*

**Weaknesses**

- Policy and evidence in surrounding climate change and hazard lands is weak and does not define vulnerability as persons, areas, businesses etc.
- Coastal characteristic description is limited to the Oceanfront Peninsula Plan. No coastal depth description or map of coastal topography map is.
- Provincial Sea Level Rise estimates (2014) of 1m were not cited.
- Did not note the extent in hectares, change or inventory of vegetation or forests in the valley. This is especially relevant riparian areas and the estuarine forest as flood management services.
- Does not include future population composition forecast.
- Local downscaled climate modeling not referenced.
- Environmental and hydrological monitoring data was not cited or referenced in resource management.

**Opportunities**

There are many opportunities to strengthen policy linkages between Hazard Lands and Natural Resource management given the overlap in flood management activities. Further clear connections between sources of environmental monitoring data (notably water and PICS downscaled climate models) and local decision-making.
Plan Element 2: Participation

Score: 80%

Strengths

- Strong recognition of collaboration with the Squamish First Nation. Most notably in a stand-alone section on First Nations (Section 13) and citation of the 2008 Protocol Agreement.
- Strong recognition of community consultation and involvement in decision making integrated throughout the plan including Sustainability Commitment (Section 9), Area Planning (Section 11), Community Services and Facilities (Section 14), Residential Neighborhood (Section 17) and Implementation & Monitoring (Section 27)
- Moderate recognition of community involvement in decision-making. Namely in Guiding Principles (Section 8), Residential Neighborhoods (Section 17), Implementation & Monitoring (Section 27) however it is unclear as to the degree of deliberative practices or direct decision-making.

Weaknesses

- Traditional flood knowledge and ways of knowing are not recognized in resource management or hazards planning.
- Community NGOs related to social development, are not identified.
- Community environmental NGOs BC Federation of Naturalists and Squamish ecosystem-mapping project are referenced but not in relation to hazard lands collaboration.

Oppportunities

While the plan identified relevant partner NGO(s) in community development for Parks and Recreation, Natural Environment and Economic development there is an opportunity to identify relevant organizations in vulnerability reduction. This can begin at the IFHMP implementation committee level and relevant organizations are illustrated in Appendix Item 12.10 of this analysis.

Principle 10 - Citizen Engagement

The District is committed to providing opportunities for its citizens to engage in meaningful participation in the community decision-making process.

- Guiding Principles OCP(2009)
Plan Element 3: Governance and Coordination

Score: 80%

Strengths

- Extensive collaboration and formal 2008 Protocol Agreement with the Squamish First Nation are mentioned extensively throughout the document - appearing in ten of the fourteen policy and objective areas.
- The Squamish-Lilooet Regional District is identified as a key party in OCP review, regional governance and growth management.
- The document identifies the role of a watershed-based approach to natural environment policy planning.
- A regional growth strategy is recognized as a major coordinating factor in strategic direction and shared objective sin the SLRD.
- Clear policy statements noting that the District will consider undertaking the identification and assessment of disaster risk reduction strategies in conjunction with federal and provincial agencies (Section 25-10).

Weaknesses

- The plan does not reference the BC Water Act or multi-stakeholder approaches to managing risk or water resources.
- No clear strategy for engagement of non-governmental and business stakeholders.

Opportunities

New opportunities for multi-stakeholder approaches to watershed governance are set forth in the recently adopted BC Water Sustainability and there are opportunities to integrate watershed management and planning initiatives with integrated flood hazard management planning. This is especially relevant to joint planning with the Squamish First Nation.

16 - 23 When considering impacts on streams and riparian areas, the District encourages a watershed approach to riparian area protection, with the aim of preserving the health of the entire watershed.

16 - 25 In coastal areas that are identified as environmentally sensitive or adjacent to aquatic habitat areas, development shall occur in accordance with federal and provincial guidelines or regulations.

16 - 26 The District will consider ‘Green Shores’ principles in the planning and design of developments adjacent to coastal areas to recognize and address the ecological features and functions of coastal systems.

16 - 27 Priority will be given to the re-watering of the Mamquam Blind Channel and tributary systems to improve the flushing action along the waterway and enhance its environmental features.

-Natural Environment P. 60 OCP(2009)
Plan Element 4: Goals

Score: 14%

Strengths

- Three flood risk reduction statements are made in the Hazard Lands section of the OCP. Objectives in the are made to:
  1. Understand, assess and manage multiple natural hazards taking into account publicly acceptably levels of risk.
  2. Minimize and mitigate the risk of loss of life, property damage and economic impact of hazards (including flood) and
  3. Adapt to climate change present and future while minimizing adverse impacts and capturing its opportunities.

Weaknesses

- There is no mandatory language around vulnerability reduction or risk-based.
- No particular businesses, infrastructure, services, populations, neighborhoods are recognized as being more vulnerable than others.
- The value or retention of ecosystems that provide flood risk management services is not recognized.
- A long-term risk-based approach to land use decision-making is not referenced in the document.

Opportunities

Guiding policies set the major directions for local planning, indicating levels of tolerable risk and vulnerable populations at this level puts risk reduction at the center of flood risk planning. Based upon social consequence mapping conducted by KWL there is opportunity to base land use policy for coastal flood risk management based on observations of current socioeconomic and environmental conditions.
Plan Element 5: Legal and Local Government Requirements

Score: 80%

Strengths

- Recognizes environmentally sensitive and hazardous areas in growth management, Area Planning, Natural Environment. Areas are mapped in Appendix Schedule C and D1.
- Protection of estuaries is recognized by bylaw in the Squamish Industrial Park Development Permit Area.
- The document notes the value of affordable housing for all multiple occasions and the Squamish Affordable Housing Strategy and
- The OCP notes intent to prepare a Regional Context Statement for the SLRD once a Regional Growth Strategy, then in drafting stage, has been completed.

Weaknesses

- The document does not address low vacancy rates or
- An action plan for is referenced but not linked to social deprivation or vulnerability to hazard.

Opportunities

Given a very low vacancy rate, an increasing rate of those to spending more than 30% of their monthly income on shelter and projected growth, there is opportunity to strengthen guiding housing policy to improve housing system capacity. Communities with low vacancy rates fare much poorer in disaster recovery than their higher capacity peers.

17 - 13 Socio-economic diversity is acknowledged as central to community livability. In an effort to enhance livability, the District shall encourage development of a range of housing forms, tenure options, and affordability options.

-Residential Neighborhoods P. 65
OCP(2009)
Plan Element 6: Policy

Score: 64%

Strengths

- Hazard lands policy is offered in its own section and lands impacted are mapped in Appendix Schedule D1
- Land use planning policy in flood prone areas is made clear using mandatory language in sections 25-3 to 25-6.
- A Green Shores and Green Infrastructure approach is noted in the management of the natural environment and the sustainability section of the Oceanfront Peninsula Subarea Plan.
- The potential for coastal adaptation is mentioned in broad terms.
- This planning element hosts the largest use of mandatory language ("Will", “Shall”, “Require”) in policy provisions for Flood and Hazard Debris Areas in sections 25-11 to 25-16.
- Gravel/aggregate deposits are identified for use in flood management activities.
- Housing policy identifies aging, and flood prone rental housing stock noting that, “The market has not produced purpose-built rental housing for some time and most purpose-built rental housing is 25 years old or older.”

Weaknesses

- Policies surrounding risk and hazard lands do not recognize vulnerable populations
- Specific community water use and water based risk is missing from the hazard and resource management sections.
- The OCP does not recognize the connection between hazard and climate change, GHG emissions or energy.
- A future map of land use policy and hazardous lands is absent.
- A Natural Hazard or Sea Level Planning Permit Area is absent from planning policy
- Coastal flood risk is not considered in hazard lands
- OCP housing policy focuses on a “Downtown First” approach to increase resident population
- Adaptation strategies (Protect, Accommodate, Avoid or Retreat) for coastal areas are absent from this OCP.

Opportunities

The linchpin to a disaster resilience of place is placing vulnerability of populations at the forefront of risk-based land use and community development policy. Further there is opportunity to improve strong water resource policy and management in relation to hazard in OCP These could be the immediate policy updates to conservation zones/protected estuarine areas, watershed or ecosystem-based land use management policy and land cover monitoring.

There is opportunity to illustrate how the District of Squamish will adapt to climate change, specifically sea-level rise and future storm surge events. Current conditions of social vulnerability and coastal flood scenarios offered in Risk Assessment (Section 7.1) of this report offer guidance of policy and OCP updates.
Development Permit Area 11 is the strongest policy around riparian and intertidal ecosystems that provide flood risk mitigation. This DPA could be expanded to focus on flood mitigation. Riparian buffer decision matrix (P.167) must be updated to account for new coastal boundaries. These new extents are illustrated in SLR New Natural Boundary mapping in the **Vulnerability Section of this report**
Plan Element 7: Implementation, Monitoring and Evaluation

Score: 22%

Strengths

- The plan sets aside one section with a sole focus on plan implementation with a monitoring and evaluation plan to be completed every 2 years.

Weaknesses

- A supporting adaptation plan, risk mitigation, disaster or flood management plan is not reference in implementation or OCP policy
- Departments, organizations responsible, support, and a working timeframe are absent from the plan.
- Vulnerability mitigation options are not identified, prioritized or financed for
- Sections of the plan could not stand alone in implementation.

Opportunities

The creation of an OCP implementation plan should clearly designate resources, identify lead parties/departments responsible, necessary deliverables and set an actionable timeline. Further, performance indicators of plan performance and impact on vulnerability reduction (offered in Appendix Item 12.17) help ensure that plans move from paper into action.

27-2 Monitoring refers to two specific activities:

1. Monitoring demographic changes and development activities and other trends in the District and surrounding area, and

2. Tracking and assessing whether the policies of its Official Community Plan have been successful in helping achieve the community's vision and objectives.

-Implementation and Monitoring P. 121 OCP(2009)
Plan Element 8: Organization and Communication

Score: 100%

Strengths

- The document is well organized with major hierarchies, subsections and a table of contents.
- The main points of the plan are summarized in the opening Scope and Content section.
- Internal citation between sections is strong with twelve direct references to other sections.
- Development guidelines illustrations are offered for the Mamquam Blind Channel in Development Permit Area 4.
- The plan sets forth 5 mediums for communicating OCP creation to the public across the major phases.

Weaknesses

- Development guidelines for coastal areas are very underdeveloped, especially for existing areas. Does not clearly illustrate FCLs or coastal green infrastructure approaches to residential or business.

Opportunities

Communicating updated OCP zoning in relation to coastal flood risk and policies addressing vulnerability can build off the districts strengths in plan communication. Illustrations can be improved to illustrate new FCLs and higher residual water levels in coastal development areas.

Figure 38: Waterfront Development Guidelines for the Mamquam Blind Channel Area

(District Municipality of Squamish, 2009)
8.3 From Findings To Action: Plan Evaluation

Planning documents are foundational approaches to reduce coastal flood risk through local land use policy and legislation. The existing flood hazard management plan from 1994 was never legislated and it is unclear how much was implemented ad hoc in the past 20 years.

While the current Official Community Plan met 63% of the biggest area for improvement in OCP revision is goals---setting for coastal hazards risk---reduction, this suggests that leadership in addressing major coastal risk will be needed to set a vulnerability focused agenda.

The following synthesis of recommendations offers more comprehensive, time sensitive and party specific insights.
## Plan Quality

### Synthesis of Recommendations

<table>
<thead>
<tr>
<th><strong>Short Term</strong></th>
<th><strong>Parties Involved</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Address Weaknesses of 1994 Flood Management Plan in Current IFHMP Plan creation</td>
<td>KWL, Arlington, District of Squamish Engineering and Planning, Community Organizations</td>
</tr>
<tr>
<td>Engage core relevant community organizations in IFHMP implementation (See Appendix Item 12.10 )</td>
<td>KWL, Arlington, District of Squamish Engineering and Planning, Community Organizations</td>
</tr>
<tr>
<td>Create a strong monitoring and evaluation programme for IFHMP (See Indicators in Appendix Item 12.17)</td>
<td>KWL, Arlington, District of Squamish Engineering and Planning, Community Organizations</td>
</tr>
</tbody>
</table>

### Medium Term

| **Update Flood Construction Levels**, coastal setbacks and floodplain construction requirements in 2016 OCP revisions based on 200 year coastal flooding. [LGA Chapter 323- Section 910] | District of Squamish Planning, Mayor and Council |
| Create stronger linkages between hazard lands, social policy and resource management | District of Squamish Engineering and Planning |
| Create a sea-level rise Development Permit Area designation to protect existing coastal buffers and future upslope extents of estuary based on new natural boundaries. [LGA Chapter 323 Sections 919.1, 920, 922, 927] | District of Squamish Engineering and Planning |
| Create a vulnerability monitoring and evaluation program | District of Squamish Engineering and Planning, Community Organizations |

### Long Term

| **Make land use planning policy and decisions based on ALARP risk assessments** | District of Squamish Engineering and Planning |
| **Monitor social vulnerability based on indicators** | KWL, Arlington, District of Squamish Engineering and Planning, Community Organizations |
Image 3: Erosion and surge during high tide at Nexan beach -Squamish Downtown Peninsula

Photo: Christopher J. Carter (Lighthawk Conservation Flying | Resilient Coasts UBC), 2015
9.0 Public Participation in IFHMP implementation

Flood risk planning provides a unique opportunity to place people at the center of creating flood plans and resilient communities. As floods present hazards to all, albeit unequally, these shared potential human and material losses offer shared value and opportunity for high quality engagement and meaningful participation from citizens and civil society organizations.

Effective public participation and the application of participatory budgeting in this unique planning setting offers opportunity to put vulnerable persons first, build social capital, promote active citizenry and improve the implement of flood management plans.

The province of British Columbia does not have formal government guidance or consistent approach to public participation. According to a 2008 report on the state of public participation in BC by the auditor general, British Columbians was generally satisfied with their participation experiences in planning, but are disillusioned with the results (Auditor General Of British Columbia, 2008).

Aside from Regional Context Statements, Official Community Plan updates and more formal agreements with First Nations, public participation through consultation is not mandatory and is at the discretion of local governments. As public participation is becoming viewed as an instrument of good governance making decisions more durable. Provincial and local governments see the value in aligning their decisions with the views of the electorate (Auditor General Of British Columbia, 2008).

With these considerations in mind this section offers an assessment of current public participation in IFHMP and presents a series of recommendations the District can follow to improve the level of public participation in IFHMP creation and implementation.
9.1 Findings

So far in the creation of an IFHMP, civil society in Squamish has meant to be “informed” of coastal flood hazard mitigation options. This has included sharing the findings of river modeling and coastal risk assessment as well as protection strategies on a project website and two open houses. The IFHMP public engagement plan seeks to incorporate public and stakeholder input on key coastal flood hazard mitigation options and river modeling assessment issues prior to significant technical modeling work. (District of Squamish, 2014b).

Using the IAP2 spectrum and participatory theory analysis, the 1994 and current IFHMP plan creation take an additive (participation when possible) rather than a subtractive (participation as a core objective) approach. The result is a low grade of public participation, an “inform and consult” rather than “empowerment” approach.

These two approaches are at opposite ends of the internationally recognized IAP2 spectrum of public participation (Figure 39). Current IFHMP planning is overseen by a technical steering committee that does not include a citizen seat (Figure 40). However, some community organizations have been identified Appendix Item 12.10

**Figure 39: The Spectrum of Public Participation**

<table>
<thead>
<tr>
<th>PUBLIC PARTICIPATION GOAL</th>
<th>INFORM</th>
<th>CONSULT</th>
<th>INVOLVE</th>
<th>COLLABORATE</th>
<th>EMPOWER</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>EXAMPLE TOOLS</strong></td>
<td></td>
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<td></td>
<td></td>
<td></td>
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<tr>
<td>Fast sheets</td>
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<tr>
<td>Websites</td>
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<td>Open houses</td>
<td></td>
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<tr>
<td>Public comment</td>
<td></td>
<td></td>
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<tr>
<td>Focus groups</td>
<td></td>
<td></td>
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<tr>
<td>Surveys</td>
<td></td>
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<td></td>
<td></td>
<td></td>
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<tr>
<td>Public meetings</td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Workshops</td>
<td></td>
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<td></td>
<td></td>
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<tr>
<td>Deliberate polling</td>
<td></td>
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<tr>
<td>Citizen Advisory</td>
<td></td>
<td></td>
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<tr>
<td>Committee</td>
<td></td>
<td></td>
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<td></td>
<td></td>
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<tr>
<td>Consensus-building</td>
<td></td>
<td></td>
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<tr>
<td>Participatory decision-making</td>
<td></td>
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</tr>
</tbody>
</table>

Source: Reprinted unaltered with permission of International Association of Public Participation on Community Engagement (IAP2, 2009)
Figure 40: Current IFHMP Technical Steering Committee

- District staff
- Fisheries and Oceans Canada
- Emergency Management BC
- Ministry of Transportation and Infrastructure
- Ministry of Community, Sport and Cultural Development
- Ministry of Forests, Lands and Natural Resource Operations (Inspector of Dikes and Ecosystems Branch)
- Squamish First Nation
The annual operating budget provides financial representation of the City's plans to deliver municipal services and programs while the capital budget is developed for the purpose of investing in the District's infrastructure, equipment and facilities. These budgets should not often interact often and the plan must also identify any proposed transfers to/or between funds. A financial plan may be amended by bylaw at any time and law in the province of British Columbia does not mandate public participation. The district engineer and planning & development services departments using class D construction and consultant estimates traditionally do the creation of flood activity budgets. To frame analysis and recommendations the current 5-year financial plan is offered in Figure 41.
**Figure 41: Flood Related Items 2015 – 2019 Special Projects, Operations and Capital Budgets**

<table>
<thead>
<tr>
<th></th>
<th>2014</th>
<th>2015</th>
<th>2016</th>
<th>2017</th>
<th>2018</th>
<th>All Years</th>
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<tr>
<td><strong>Special Projects</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Flood Hazard Protection Plan (IFRMP)</td>
<td></td>
<td>$205,000</td>
<td>$115,000</td>
<td></td>
<td></td>
<td>$320,000</td>
</tr>
<tr>
<td><strong>Operating</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Flood Protection</td>
<td>$169,306</td>
<td>$148,991</td>
<td>$151,971</td>
<td>$155,010</td>
<td>$158,110</td>
<td>$783,338</td>
</tr>
<tr>
<td><strong>Capital</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Raise Squamish River Dyke</td>
<td></td>
<td>$1,962,565</td>
<td></td>
<td></td>
<td></td>
<td>$1,962,565</td>
</tr>
<tr>
<td>Yearly Total</td>
<td>$158,110</td>
<td>$2,316,556</td>
<td>$266,971</td>
<td>$155,010</td>
<td>$158,110</td>
<td>$2,954,757</td>
</tr>
</tbody>
</table>

**Source:** District 5 Year Financial Plan (District of Squamish, 2014a)
Flood Risk Perception

From the outset the current 1994 flood hazard management plan “public education” is recognized as the linchpin of successful hazard management and risk reduction planning. It notes that a hazard informed public will be more effective than dyke infrastructure upgrades and land use regulation. The description of flood risks and location was communicated through three four-page brochures that described flood risk and areas of concern with a circulation of 5,000 (population of Squamish in 1994 was 13,779). This brochure was in addition to local public radio announcements and two public open houses. The plan also recognizes Section 215 covenants as an indirect form of flood risk education.

Planning efforts to date have not addressed the root causes of social vulnerability and exposure to hazards. Addressing poverty and inequity have co-benefits for community development planning. Working with vulnerable and historically marginalized populations can effectively address these existing conditions that exacerbate the loss and damages of flood impacts and natural disasters. A list of highly relevant organizations not included in current IFHMP engagement and their contacts are provided in Appendix Item 12.10. Effective implementation of an IFHMP, which will likely restrict land uses, new development and create zoning areas for flood inundation, will largely depend on robust public support.

Public participation in flood risk planning in Squamish must deal with social perceptions of risk. These perceptions frame people’s reality and ultimately actions around flood hazard, preparation and evacuation (Nascimento & Guimarães, 2008; Slovic et al., 2000). It has been note that there is an innate limitation in human tendency to use improved flood hazard information based solely on experience and a moving timeframe of memory. It has been stated that:

"Men on flood plains appear to be very much prisoners of their experience... Recently experienced floods appear to set an upward bound to the size of loss with which managers believe they ought to be concerned”

(Wapner, 2012)

Human memory is often biased to recent events or impressionable messages. Further, technical solutions and government programs to reduce flood risk is well documented and much of this can be attributed to how these provisions interact with decision-making. Decision makers and residents alike who are limited by perceptual and cognitive capabilities to objectively assess risk given subjectivity and uncertainties (Slovic, Kunreuther, & White, 2000). Data must be engaged to expand flood planning beyond what local risk managers have experienced. Sharing power in flood risk planning with civil society must be in relation to risk probabilities but also assess inherent values and social perceptions of risk.
When the focus is on flood hazard control alternatives, particularly in the case of non-structural measures, public perception of flood risk is critical to understand. Non-structural measures usually require public acceptance of living with floods and resistance in accepting this kind of solutions may emerge - particularly when structural alternatives are also under evaluation.

An excess of confidence in the performance of structural alternatives (i.e. sea dikes) in reducing coastal flood hazard frequency may also bias the decision-making process and eventually lead to an inadequate occupation of flood prone areas, increasing flooding potential impacts in case of structural failures. These outcomes point out the need of public involvement from the beginning of the decision-making process rather than as only a way of validating choices already made by experts (Oulahen & Doberstein, 2010).

It is also relevant to keep in mind that gaps usually exist between expert knowledge and lay understanding of flood risks. (Nascimento & Guimarães, 2008). Open houses to date have presented dyking options but have captured a sample of resident’s perception of risk and concern. The following questions from a poll in the October 23, 2014 open house reveal a level of high-level perceived risk to toward coastal and riverine flooding (District of Squamish, 2014d). However, it must be noted that while informative to eliciting risk and environmental perception at the community level, it is of small (n=22), non-representative, and likely engaged group of Squamish citizens. Results are presented in Figure 42. Questions posed in the survey included:

- **Question #1**: How concerned are you about the risk Squamish faces from flooding due to sea level rise and associated coastal storms over the next decade (10 years)?

- **Question #2**: How concerned are you about the risk Squamish faces from flooding due to sea level rise and associated coastal storms over the next century (100 years)?

- **Question #3**: How concerned are you about the risk Squamish faces from flooding due to the 5 rivers in the District?
**Figure 41: Open House Survey Question Results**

<table>
<thead>
<tr>
<th>Question</th>
<th>Very Concerned</th>
<th>Somewhat Concerned</th>
<th>Not Concerned</th>
<th>Undecided or Not Sure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Question 1 - Coastal Flooding (5 years)</td>
<td>39</td>
<td></td>
<td>54</td>
<td>7</td>
</tr>
<tr>
<td>Question 2 - Coastal Flooding (100 years)</td>
<td>55</td>
<td></td>
<td>32</td>
<td>9 4</td>
</tr>
<tr>
<td>Question 3 - Riverine Flooding</td>
<td>85</td>
<td></td>
<td>15</td>
<td></td>
</tr>
</tbody>
</table>

**Source:** Assembled from 2014 IFHMP open house polling (District of Squamish, 2014).
From these participant polls there is recognition of the impacts of climate change on sea levels and increased storm surges. In both the near and long term, further it is noted that a majority (78%) of respondents noted that considering environmental impacts in any mitigation activity is “Very Important”. These observations indicate a high consciousness of environmental change, existing flood hazard and implied local risks. Further as many open house respondents agreed with current decisions to “protect” Squamish settlement, there is major support (75%) to consider land use planning that “avoids” or “retreats” from flood prone areas.
9.2 Recommendations

A suite of actions is recommended to the District of Squamish to improve public participation and the effectiveness of the IFHMP implementation post 2016. The aim is to provide meaningful and pragmatic opportunities for public participation and to engage key community champions and organizations. If IFHMP implementation and is to be grounded in improving how Squamish residents understand and interact with coastal flood risk, the following actions are recommended to be taken in IFHMP creation:

1. **Immediate Citizen Representative Seat in the IFHMP Steering Committee**
2. **Creation of a Core IFHMP Implementation Committee**
3. **Community-Based Risk Mapping**
4. **Allocation of Funding and Implementation of “Resilience Activities”**

**Recommendation 1**
*Citizen Representation in the Steering Committee*

A current lack of participation from citizens on the steering committee represents a failure in multi-stakeholder governance of natural hazards. As many risk management activities have been downloaded to local governments without adequate resources effective plan implementation must take into account business, civil society as equal party members. This representation could include three rotating volunteer positions. These could be sourced from civil society organization representatives noted in **Appendix Items 2 and 3**.

**Recommendation 2**
*Creation of a Core IFHMP Core Committee*

This is the basis of a string multi-stakeholder decision-making and implementation and can serve as the core group for participatory budgeting resilience activities. This committee could draw from current targeted and suggested organizations outlined in **Appendix Items 2 and 3**. Drafting a terms of reference will assist in establishing roles, responsibilities in engagement and participatory budgeting activities for parties involved and lead to successful implementation of IFHMP regulatory provisions and the selected PB resilience activities funded by the district.
**Recommendation 3**

**Community-Based Risk Mapping and Vulnerability Assessment**

The purpose of participatory risk mapping is to allow citizens to participate in the identification of vulnerability and hazard and to generate opportunities, rather than a planning institution labeling areas as “vulnerable” solely on census data or flood models alone. This can be done in a public setting during community farmers markets or open houses and offers an opportunity for community members to get familiar with flood reaches and share place-based knowledge. A complete activity including instructions and a map of Squamish is available in **Appendix Item 12.11**.

A 2005 intensive study of resilience planning in Squamish conducted by Natural Resources Canada using the HAZUS flood model illustrated areas of social vulnerability to riverine flood risk and surveyed a working group of Squamish community members (n=35) about risk-reduction priorities. This was based on community assessments of vulnerable persons and locations (Journeay, M. J., 2011). This was the first application of Social Vulnerability Indicators (SoVI) in Canada. These vulnerability hotspot maps assist in identifying where the most vulnerable populations reside based on community indicators. Areas of concern for coastal flooding in Squamish include an east-west tract of the downtown Mamquam Blind Channel area and extending northward along the boundary between Loggers Lane and the industrial park into southern Garibaldi Estates (Natural Resources Canada, 2014).

Updated maps of social vulnerability and coastal flood risk using 2011 census data are found in **Section 7.1 : Risk Assessment**. As illustrated in **Figure 32** those who are exposed to the highest levels of natural hazard threat are also the most vulnerable to negative impacts and consequences in terms of both social agency and coping capacity. By allowing citizens to identify where flood risk originates, who is most at risk and where they may go during a hazard event the District can elicit key information in creating effective and relevant flood and emergency management plans.

Participatory approaches to risk assessment are powerful ways to raise consciousness to put the most vulnerable first in flood risk planning, based on the creation of a process that includes historically marginalized populations and builds social cohesion (Dias, 2014). The application of enhanced public participation and application of participatory budgeting games can make clear connections between citizen participation and taxation, risk reduction and IFHMP implementation based on particular groups and conditions identified as having differential exposure or vulnerability to extreme flood events.
**Recommendation 4**

Participatory Budgeting “Resilience Activities”

**Introduction**

Budgets represent institutional values and ultimately power in risk mitigation planning. The budget of focus for all participatory budgeting “resilience activities” for flood related is based from the existing 2015-2019 Financial Plan for the District of Squamish.

The application of Participatory Budgeting approaches in flood risk planning is largely unexplored but the approach offers opportunity to engage core democratic principles and social cohesion in the context of risk reduction and disaster resilience planning. These will be referred to as “Resilience Activities” in this illustration of a potential strategy in IFHMP implementations. The Participatory Budgeting Approach offers deliberative processes where values and technical assessment and traditional knowledge can interact to ensure that taxpayer dollars are spent in ways that the community sees best fit to reduce flood and disaster loss and damage. Piloting participatory budgeting in flood risk management planning offers a platform for such deliberative process and provides litmus test for further participatory budgeting. Lastly effective public participation draws on local observations of climate change, both indigenous and settler, and draws from local knowledge to frame relevant interventions.

**Rationale**

Grounded in the work of Paulo Freire in 1960s Brazil, popular education frames pedagogy as a practice of liberation towards critical consciousness, enabling marginalized or vulnerable people to understand their world and imagine change and better alternatives. Participatory Budgeting (PB), as a deliberative platform where citizens choose an allotted public budget to be spent, has spread around the world in the past 20 years in differing modes of actual power sharing. In its most idyllic form PB is both highly communicative and actively shares power (Baiocchi & Ganzuza, 2014).

Popular adult educators regularly use activities, especially puzzles, role-playing games, and physical and mental challenges and flood protection / drainage initiatives have made their way into participatory budgeting in Belo Horizonte Brazil and District 32 of New York City (Algava, 2006) (Dias, 2014). The application of PB in flood risk planning can be adapted around the PB budgeting cycle as illustrated in Figure 4. PB relies on finances being earmarked for spending based on PB deliberation and must be overseen by a PB council. In natural resource planning this may resemble a core stakeholder or implementation committee made up of community organizations.

An effective IFHMP will depend on community engagement and public support. Participatory Budgeting games have been observed to create shared value with citizens and get to having critical discussions and making real decisions (Lerner, 2013). Successes with PB games amidst urban redevelopment in Rosario Hábitat
illustrate that government programs can enhance democratic participation if they use games and game mechanics that engage the senses, legitimate rules, generate collaborative competition, and link participation with outcomes. Further the Porto Allegre model of PB promoted the creation of civil society organizations as for every 100 people organized 1 representative came to the table for budgeting activities. 20 years of PB illustrate the benefits and pitfalls of this approach a few winning conditions and offer insight into how the PB approach to Resilience Activities (Appendix Item 12.16) can be adapted to the unique socio-political environment of Squamish

Participatory and incentivized activities increase the agency and ownership of citizens, organizations and businesses in implementation and of IFMHP activities. Further, these activities broaden resilience planning beyond structural protections which are decades away from completion and meet other community development and emergency planning objectives. The Community Charter of British Columbia requires that a District’s five-year financial plan include proposed expenditures, including capital expenditures, and the proposed funding sources for expenditures.
The current 5 year financial plan makes provisions to spend $2,954,757 CAD on special projects, operating and capital expenditures related to flood hazard management. While a detailed line item budget is not available to the public, under special projects, the IFRMP budget has been largely spent on the IFHMP plan including 2D modeling of flood risk, analyses and engagement services from consulting firms. Flood protection largely is focused on maintaining tidal floodgates and dykes. Dike upgrades, first proposed over 20 years ago in the 1994 plan, are the sole item in the capital budget.

Around the world, participatory budgeting has engaged citizens and their organizations in deliberations in capital and program funding in larger cities up to $200 million per year. However, participatory budgeting is most successful at small scales when infrastructure and programs have direct and highly visible impacts on residents and local governments and their local partner organizations have enough capacity to run high quality public engagement programs (Dias, 2014). This approach has been found to be very effective at engaging the social capital of local organizations, most notably in meeting current and future climate adaptation and associated risks (Aylett, 2010).

**Next Steps**

A small provision, of $70,000 to $100,000 CAD (2% to 4% of earmarked funds) from the operating budget over 5 years can make major contributions to IFHMP implementation by engaging citizens in real decisions with real money (their tax dollars) to reduce vulnerability and improve disaster resilience in the community. Communicative and empowering approaches to put the most vulnerable people first in flood risk planning.
Drawing from deliberative decision-making experiences in public lands planning, a few lessons can guide resilience activities for flood management in Squamish.

1. **Acceptance that forums for social deliberation do not in itself ensure that decisions will be acceptable to all participants.**

2. **The importance of explicitly establishing rules of operation Clear scope and responsibilities ensure that expectations and contributions are clear and ensure the success of PB. This may include a terms of reference (Moote, 1997).**

3. **There is a need to assess local capacity in order to achieve both planning process and substantive outcomes** (Dorcey & McDaniels, 2001).

The first step in involving people with monetary decisions around flood risk planning and resilience is the development of a hypothetical budget matrix to explore existing priorities and themes. Working with the recommended $70,000 to $100,000 CAD it is meant this Budget Matrix might integrate with the IFHMP planning and district budget cycle processes. The purpose of this initial matrix is to incorporate a more participatory approach to budgeting for physical risk and social-vulnerability. The basic layout of the matrix and evaluation takes a Multi-Criteria Assessment approach, which broadens the performance of an option beyond simple cost and benefit. This approach can allow weighing of certain criteria more than others in the final stages of deliberative process. This matrix allows for each option and its implications to be examined by participants and matrix resilience activities are actively referenced in resilience literature but are not exhaustive. Community driven alternative activities are encouraged may prove highly effective in the context of Squamish coastal and riverine flood hazard. The performance of activities matrix has purposely been left blank and provides a visual tool for Participatory Budgeting games for flood risk in the IFHMP process. Activities such as neighborhood level emergency plans, flood level visualizations, coastal vegetation projects, bioswales and detention areas, interpretive signage and community-identified alternatives are described in **Appendix Item 12.14.**

For continuity, evaluation criteria actively used by the district in current IFHMP planning for structural upgrades can also evaluate non-structural “resilience activities”. The criteria consisted of natural, economic, social/cultural, political/planning, and technical material. The evaluation results were displayed through a colour scheme for each specific reach. They were rated as Most Preferable Alternative (Dark Green) to Least Preferable Alternative (Orange) and Show Stopper (Red). Each of the flood mitigation option posters contained a color scheme of dots related to the evaluation criteria. Costs and an evaluation matrix using the same Multi-Criteria approach used in IFHMP coastal flood protection option evaluation are offered in **Appendix Item 12.15.** A step-by-step development of resilience activities is offered in **Figure 42.**
Figure 42: Steps to Implementing Resilience Activities

1. Earmark
$70,000 to $100,000 CAD from operating budgets to resilience activities

2. Identify
Champions from IFHMP steering committee, organizations to participate

3. Deliberate
Create budget matrix, weight criteria and vote on resilience activities at open houses and IFHMP steering committee meetings.

4. Filter
What is duplicated or not feasible

5. Select
Top three activities and implement
9.3 Monitoring and Evaluation of IFHMP Implementation

While indicators are simplifications of complex social and ecological phenomena they provide a way to quantify, monitor and evaluate efforts over time. While these indicators contribute to the ‘where’ and ‘how much’ questions of vulnerability they seldom address the ‘why’ and ‘how’ of vulnerability. In resilience planning efforts, the social vulnerability approach and the use of indicators can start constructive dialogue and promote transparent and accountable governance of hazard. Further, the implementation of indicators can contribute to comparison and similarity study of coastal communities u the region, promoting a sharing of knowledge and resources regarding best practices in flood coastal zone management (Chang, Yip, van Zijll de Jong, Chaster, & Lowcock, 2015). Lastly a monitoring tool for monitoring vulnerability reduction goals including suggested socioeconomic and ecological indicators and sources can be found in Appendix item 12.17.

9.4 Expert Judgement and Public Participation

Participatory planning in flood management planning must interact with expert geotechnical and judgment. As people draw from personal values and perceptions of risk there may be a stage when appropriate weighting of criteria to evaluate activities. Any expert making judgments in flood risk planning or navigating uncertainty can (and should) use the consensus valuation of citizens. This keeps engineers and scientists from imposing their values on an unwitting public, and allows the public to have their say on how the judgments should be shaped. Achieving such consensus requires social practices that improve current anemic discourse about risk probability and values. (Douglas, 2009).
9.5 From Findings To Action: Public Participation and IFHMP Implementation

Participatory methodologies are powerful instruments to put the most vulnerable first in flood risk planning. This is based on engagement that acknowledges spatial vulnerability (See Findings in Section 10) and includes historically marginalized populations - building social cohesion and generating creative management alternatives based on local values (Dias, 2014). (RL Keeney, 1996) The application of enhanced public participation and application of participatory budgeting games can make clear connections between citizen participation disaster risk reduction and IFHMP implementation based engaging particular groups and conditions identified as having higher exposure or vulnerability to coastal flooding. Through heightened public participation Squamish can demonstrate innovation in IFHMP implementation and participatory planning in coastal Canada.
### Public Participation and IFHMP Implementation

**Synthesis of Recommendations**

<table>
<thead>
<tr>
<th>Short Term</th>
<th>Parties Involved</th>
</tr>
</thead>
<tbody>
<tr>
<td>Add a rotating civil society representative to the technical steering committee</td>
<td>District of Squamish Engineering and Planning, Community Organizations</td>
</tr>
<tr>
<td>Create citizen IFHMP implementation committee and begin implementation planning</td>
<td>KWL, Arlington Group, District of Squamish Engineering and Planning, Community Organizations</td>
</tr>
<tr>
<td>Complete participatory risk mapping during Fall 2015 IFHMP open house</td>
<td>Arlington Group, District of Squamish Engineering and Planning, Squamish Residents</td>
</tr>
<tr>
<td>Identify organizations to participate in resilience activities</td>
<td>District of Squamish Engineering and Planning, Community Organizations</td>
</tr>
<tr>
<td>Deliberate resilience activities for funding in IFHMP plan implementation</td>
<td>District of Squamish Engineering and Planning, Community Organizations, Mayor and Council</td>
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<table>
<thead>
<tr>
<th>Medium Term</th>
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<tbody>
<tr>
<td>Implement resilience activities</td>
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<table>
<thead>
<tr>
<th>Long Term</th>
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</thead>
<tbody>
<tr>
<td>Engage organizations in collecting data on social and ecological vulnerability in IFHMP monitoring programme</td>
</tr>
</tbody>
</table>
Image 4: Mamquam Blind Channel, Central Channel, the Squamish Estuary and Squamish River Delta

by Christopher J. Carter (LightHawk Conservation Flying | Resilient Coasts UBC), 2015
10. Future Work & Closing

Taking a DROP approach and having a baseline understanding of vulnerability can provide critical perspective in creating Integrated Flood Risk Management Plans that address the root causes of loss and create a more disaster resilient Squamish.

This analysis offered insight into where one coastal municipality in the Strait of Georgia can use a vulnerability, land use planning and participatory approach to improve the impact of IFHMP. However, there are a number of areas for further investigation where this coastal community planners and the academic research community can improve knowledge and action in the area of integrated flood hazard planning.

For the District Municipality of Squamish there are a multitude of areas that the can explore in additional work in disaster resilience planning:

1. **Integrate disaster resilience of place approach**, including SoVI analyses, in Hazard Vulnerability and Risk Assessments (HRVA). Current assessments and HRVA toolkits externalize vulnerability and do not account for preexisting social and ecological conditions.

2. **Monitor long term vulnerability** of flood hazard over time using quantitative indicators and community-based monitoring programs. This may offer insight into the effectiveness of IFHMP quality and implementation.

3. **Engage regional collaboration** in coastal hazard risk planning with similarly vulnerable coastal communities in the Strait of Georgia using the SEALINK’D resilient coasts planning tool (http://www.resilientcoasts.ubc.ca/indicators/). This may enable sharing of best practices, plans, resources and other network benefits.

4. **Elicit how Squamish valley citizens prefer receiving information** from the district. Then communicate core findings from IFHMP planning into preferred mediums (workshops, social media posts, short videos, resilience activities).

5. **Mainstream a Disaster Resilience of Place (DROP) approach** into community planning documents. Most notably addressing current social vulnerability and risk-based land use planning policy the 2015 OCP update.

6. **Connect with similarly vulnerable coastal communities in the Strait of Georgia** region. A set of Hazard Vulnerability Similarity Findings from the UBC Resilient Coasts research team is available in **Appendix Item 12.18**.
For academic researchers interested in understanding flood risk and vulnerability with Canadian coastal communities, there are opportunities to investigate the following areas:

1. **Investigate local planning institution capacity** for integrated approaches to watershed management and flood risk planning such as IFHMP. Identify gaps in funding for a vulnerability or ecosystem services approaches to flood hazard planning.

2. **Provide case studies and best practices** of how local governments and adjacent indigenous peoples can engage in joint planning for flood risk management.

3. **Establish indigenous indicators of coastal resilience** in partnership with Canadian First Nations planning institutions and alliances.

Since 1994 there have been major advancements in disaster resilience planning, coastal zone management and regional climate change study. Namely these have lead to the recognition vulnerability, non-structural and ecological and approaches to reduce loss and damages in disaster flooding events. As the current IFHMP planning continues a “protect” approach to flood hazard management this approach does not reduce the consequences of a dyke failure, total water levels given higher seas, more frequent surges mountain river freshets.

Revisiting initial hypotheses posed at the beginning of this analysis, a few observations are noted:

A. Certain people in Squamish BC are **disproportionately vulnerable** to coastal flooding events.

B. The District of Squamish **does not account for** current and future coastal flood hazards.

C. The District of Squamish **does not formally recognize ecosystem services** that provide coastal flood protection.

D. The District of Squamish partially **accounts for** current and future coastal induced hazards to their local populations and lands.

E. Given the current state of land use policy and public participation in plan creation and implementation, **it is unclear if the District of Squamish engages in evidence-based planning** to reduce exposure of vulnerable people and economies.

F. The District of Squamish has **not created inclusive and participative processes** to engage vulnerable populations and industries in flood hazard planning.
As the District has chosen to “hold the line” to “protect” human settlement from hazard, these structurally focused improvements do not address the existing conditions producing social vulnerability reproduce a dominant environmental and settler rhetoric of a “battle with the floods”. This externalizes risk rather than evaluating existing conditions and vulnerability. The consequences of dyke failure or long-term sea level rise.

Current IFHMP planning can create robust non-structural and social capital focused approaches to reduce vulnerability and inequity in exposure. The success of this is grounded in participation of Squamish society both settler and indigenous to plan creation and implementation. Putting ecosystems and the most vulnerable people first in planning and leveraging inherent community values for the environmental can ensure that the 2016 IFHMP makes major contributions to Squamish as a disaster resilient community.

A disaster resilience of place approach, while demanding more thought and resources initially, can introduce robust plans, policy and action to address inequity in exposure – reducing human, environmental and economic losses during expected increased coastal flood hazard events.

There are many opportunities in IFHMP to mainstream long-term vulnerability reduction to lower risks to all hazards in the Squamish Valley. As major wetland degradation and failures of dyke infrastructure during have illustrated interactivity of hazard, ecologies, society and institutions around the world, there are opportunities to innovate – creating flood plans that do not rely solely on protective structures but reduce risk by understanding existing vulnerabilities, social values and risk perceptions to build a more disaster resilient Squamish.
Image 6: Mamquam Blind Channel, Squamish Downtown Core and Highway 99

Photo: Christopher J. Carter (LightHawk Conservation Flying | Resilient Coasts UBC), 2015
11.0 Bibliography


District Municipality of Squamish. (2009). *Official Community Plan (Bylaw 2011).*


Dodds, K., Williams, B., & Bleck, N. (2013). *Picturing transformation: Nexw-áyantsut.* Vancouver: Figure 1 Publishing. Retrieved from
http://ubc.summon.serialssolutions.com/2.0.0/link
http://www.ebbwater.ca/wp/people-living-in-bc-floodplains/
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zwDuPHHb


http://doi.org/10.1016/j.ecss.2006.05.003


National Academies Press.


(pp. 3–22). School of American Research Press, Santa Fe.


Province of British Columbia. (2012). A resource guide to support Treaty First Nation, regional district and local government collaboration and planning (p. 82).


12.0 Appendix

Item 12.1: Terms of Reference

The School of Community and Regional Planning at the University of British Columbia
Student: Christopher J. Carter
Client: Planning and Engineering Department, District of Squamish, British Columbia

1) Introduction

Residents of Squamish Valley face serious coastal and upland flood hazard that must be considered in urban development and risk management. Currently the District, in coordination with the Squamish First Nation, Provincial Agencies and town citizens is creating an Integrated Flood Hazard Management Plan (IFHMP) that will analyze coastal and river flood risks and integrate them into structural upgrades and land use policy. As Squamish is expected to double its population in the next 20 years, they must find ways to accommodate growth while adapting to coastal risk.

2) Objectives

This project will provide the Municipality with analyses and recommendations to assist staff in the final translation steps IFHMP process. The analyses and recommendations will focus specifically on three planning objectives: reducing social vulnerability, practicing risk-based land use planning, and incorporating robust participatory planning processes. From an educational perspective, this project will enable SCARP Master’s student Christopher Carter to learn about the process of flood risk planning for coastal change at the local government level and provide professional experience as a planning consultant.

3) Scope

The study will examine current provisions for coastal flooding in Squamish using a social vulnerability and ecosystem buffering criteria and provide relevant best planning practices in social vulnerability, social participation in flood risk planning and non-structural resilience planning. The study will be limited to land use planning activities limited to coastal flooding in the Squamish Estuary, Downtown and adjacent areas subject to coastal flooding in preparation of 2016 IFHMP and OCP update planning activities. The study will not include landslide, pure riverine flooding or earthquake hazards.
4) Overall Responsibilities

a. Collect information through correspondence and/or from available publications on relevant aspects of the IFHMP planning process from the municipality and consulting firms
b. Assist in preparing relevant policy translation of coastal flood assessment.
c. Assess and advise participatory planning efforts in the IHRMP process using IAP2 and social planning and research council of British Columbia (SPARC) criteria
d. Provide policy recommendations to reduce risk to property and populations under the Municipality’s jurisdiction

5) Tasks

a. Evaluate current estuary and downtown area plans for the Municipality using plan evaluation methodology to evaluate land use policy provisions for coastal flood risk
b. Identify indicators for the monitoring and evaluation of social and economic vulnerability to flood hazard
c. Create updated social vulnerability “hot spot” mapping using 2011 NHS Census data
d. Introduce the Municipality to the UBC SEALINK’D platform for building coastal resilience networks

6) Deliverables

Prepare a policy memo or presentation on addressing social vulnerability in IFHMP to the technical committee and planning team, and a Draft Final Report within 4 months of commencement on all work carried out. The Final Report incorporating the comments of the staff and steering committee is to be submitted within one month of the receipt of such comments.
## Item 12.2: Overview of Applicable Land Use Regulations

<table>
<thead>
<tr>
<th>Land Title Act</th>
<th></th>
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</thead>
<tbody>
<tr>
<td><strong>Section 85, 86 and 219</strong></td>
<td>An Approving Officer may require a report certified by a professional engineer or geoscientist experienced in geotechnical engineering documenting the conditions required for the land to be used for the intended use.</td>
</tr>
<tr>
<td><strong>215 Covenants</strong></td>
<td>Can protect District of Squamish and the provincial government from damage claims in the event of flooding prior to rezoning and development permit approval in hazardous areas.</td>
</tr>
<tr>
<td><strong>219 Covenants</strong></td>
<td>The registration of a covenant on title can be required to regulate the subdivision of land or safety of development. Such covenant typically includes a geotechnical report specifying the conditions necessary to make the land safe for the intended use.</td>
</tr>
</tbody>
</table>

### Municipal Act *

<table>
<thead>
<tr>
<th>734 (Section 2, 3, 4)</th>
<th></th>
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</thead>
<tbody>
<tr>
<td>751</td>
<td></td>
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<tr>
<td>930</td>
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<tr>
<td>945</td>
<td></td>
</tr>
<tr>
<td>969</td>
<td></td>
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<tr>
<td>976 (Section 2 and 6)</td>
<td></td>
</tr>
<tr>
<td>989</td>
<td></td>
</tr>
</tbody>
</table>

### Local Government Act

<table>
<thead>
<tr>
<th>Section 903 and 910</th>
<th>A local government may designate land as a floodplain if it considers flooding may occur and authorizes a bylaw regulating flood construction levels, setbacks, and structural support (erosion protection from floodwaters) to elevate a floor system or mobile home pad above the flood construction level (FCL). Such bylaw must consider Provincial Guidelines.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sections 919.1, 920, 922, 927</td>
<td>A DPA designation can apply to the protection of development from hazardous conditions under section 919.1(1)(b). If so designated, section 920 prevents the subdivision of land, alteration of land or any construction unless the owner has first obtained a Development Permit issued by the local government.</td>
</tr>
</tbody>
</table>

* Renamed the Local Government Act
Item 12.3: Pressure and Release (PAR) model of Squamish British Columbia

The PAR model below (Read left to right) identifies current underlying conditions that produce vulnerability to flood risk in the District Municipality of Squamish. This qualitative model offers as a way of visualizing social vulnerability and places where flood risk hazard and emergency management planning can make major contributions to community disaster resilience and works in tandem with quantitative social vulnerability assessment and mapping offered in Section 7.1 Risk Assessments. By addressing the progression of vulnerability, -- root causes, dynamic pressures and unsafe conditions -- vulnerability can be reduced in District planning. A social vulnerability approach focuses on underlying social conditions that increase vulnerability, exposure and hazard to reduce lived impact.

**Progression of Vulnerability**

<table>
<thead>
<tr>
<th>ROOT CAUSES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Limited Access</td>
</tr>
<tr>
<td>Financial Resources to Municipality</td>
</tr>
<tr>
<td>Ideology</td>
</tr>
<tr>
<td>A historical “Battle to protect”</td>
</tr>
<tr>
<td>Inequality and Exclusion</td>
</tr>
<tr>
<td>Newcomers, Language and cultural groups</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>DYNAMIC PRESSURES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Institutional Capacity</td>
</tr>
<tr>
<td>(0.5 time position between two staff)</td>
</tr>
<tr>
<td>Macro-forces</td>
</tr>
<tr>
<td>Urban Development Pressure</td>
</tr>
<tr>
<td>Woodfibre LNG Proposal</td>
</tr>
<tr>
<td>UrbanizationPressure in hazard lands and estuary</td>
</tr>
<tr>
<td>Right of Way issues with utilities and higher levels of government</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>UNSAFE CONDITIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fragile Physical Environment</td>
</tr>
<tr>
<td>Encroachment on estuary</td>
</tr>
<tr>
<td>Downtown inundation</td>
</tr>
<tr>
<td>Location in a river estuary and flood prone valley</td>
</tr>
<tr>
<td>Local Economy</td>
</tr>
<tr>
<td>Vulnerable Society</td>
</tr>
<tr>
<td>Most socially vulnerable live in downtown area</td>
</tr>
<tr>
<td>Aging homes with low FCLs</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>FLOOD HAZARD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Riverine Flooding</td>
</tr>
<tr>
<td>Mountain rivers Freshet</td>
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<tr>
<td>Major precipitation events at watershed scale</td>
</tr>
<tr>
<td>Debris flows</td>
</tr>
<tr>
<td>Coastal Flooding</td>
</tr>
<tr>
<td>Major 1:50 and 1:200 Storm Surge impacts on downtown</td>
</tr>
<tr>
<td>Current and Future High Tides</td>
</tr>
<tr>
<td>Sea Level Rise</td>
</tr>
</tbody>
</table>

**DISASTER FLOOD EVENT**

Risk = Hazard x Vulnerability

(Adapted from Wisner, 2004)
Item 12.4 : A Green Shores Approach

<table>
<thead>
<tr>
<th>Green Shores Key Concepts</th>
</tr>
</thead>
<tbody>
<tr>
<td>Preserve the integrity or connectivity of coastal processes through land use planning, design and construction practice.</td>
</tr>
<tr>
<td>Maintain or enhance habitat diversity and function (on a local or regional scale).</td>
</tr>
<tr>
<td>Minimize or reduce pollutants to the marine environment.</td>
</tr>
<tr>
<td>Reduce cumulative impacts (namely erosion) to the coastal environment.</td>
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</table>

Considerations

- Larger footprint than conventional dyking
- Need to move earth and add gravel, rock, sand and replant vegetation from elsewhere
- Private property, right of way and easement constraints

Resources

A. **Green Shores Guidebook:**
   [http://www.stewardshipcentrebc.ca/PDF_docs/reports/Greening_Shorelines_to_Enhance_Resilience.pdf](http://www.stewardshipcentrebc.ca/PDF_docs/reports/Greening_Shorelines_to_Enhance_Resilience.pdf)

B. **Shoreline Policy and Bylaws:**

**The Green Shores Coastal Design Overview**

**Source:** Reprinted Unmodified With the Permission of the Stewardship Center of BC
Item 12.5: Risk-Based Land Use in Squamish

Innovations in planning research are offer guidance for coastal communities such as Squamish in creating a protocol for making transparent decisions. Specifically the Risk-based Land-use Guide released by the Geological Survey of Canada structures the risk-based approach to land use planning. In the guide they define risk as the probability of consequence. Consequence is based in social and environmental vulnerability and the exposure to risk. Understanding existing vulnerabilities feeds into step 3 of their proposed approach illustrated in Figure 43.

The guide identifies that a risk-based approach can be mainstreamed into the following planning documents and processes:

- Regional Growth Strategies
- Official Community Plans
- Development Permit Areas
- Design Guidelines
- Subdivision Bylaws
- Transportation Plans
- Capital Plans
- Emergency Plans

(Struik, L C et al., 2015)

Risk-based land use policy is best informed with an understanding of the existing conditions of vulnerability. Taking a DROP approach recognizes that local planning has a role in reducing the vulnerability portion of the risk equation. Full Copy: http://geoscan.nrcan.gc.ca/
### Item 12.6: Social Vulnerability Findings Across Dissemination Area

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<th>Variable</th>
<th>95%9310187</th>
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<th>95%9310190</th>
<th>95%9310191</th>
<th>95%9310192</th>
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<tr>
<td>% Population living alone</td>
<td>26 20 17 17 15 18 14 41 27 26 29 38 22 17 11 17 13 12 13 15 17 13 11 11 16 19</td>
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<tr>
<td>% Population without access to a vehicle</td>
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<td>% of Population greater than 65 y/o</td>
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<td>39 3 11 6 20 26 50 33 18 38 13 25 98 47 27 18 41 12 7 19 22 4 19 24 14 49 10</td>
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<tr>
<td>% Population that has moved within the last 5 years</td>
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<tr>
<td>% Lone female parent households</td>
<td>6 9 33 25 27 32 8 22 24 14 18 33 29 21 40 10 17 19 8 11 10 12 0 0 13 9 8</td>
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<tr>
<td>% Aboriginal community</td>
<td>5 4 95 4 5 4 3 3 7 0 5 8 3 3 3 90 0 0 3 0 3 4 9 3 6 2 2</td>
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<tr>
<td>% Low-income families (LICO - family of four in a community &lt; $30,000 making $27,329 after taxes)</td>
<td>4 3 0 5 7 3 1 5 4 10 9 5 13 10 0 3 4 0 0 3 5 3 3 1 0 1 2</td>
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</table>
### Mobilizing Resilience: A Disaster Resilience of Place Approach to IFHMP in Squamish British Columbia

#### Table: Demographic Indicators

<table>
<thead>
<tr>
<th>Category</th>
<th>Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>% Population spending &gt; 10 hrs. care to seniors</td>
<td>0</td>
</tr>
<tr>
<td>% Tenant occupied households spending &gt; 30% on shelter</td>
<td>15</td>
</tr>
<tr>
<td>% Owner-occupied households spending &gt; 30% on shelter</td>
<td>19</td>
</tr>
<tr>
<td>% Tenant-occupied households spending &gt; 30% on shelter</td>
<td>107</td>
</tr>
<tr>
<td>% Population without knowledge of official language</td>
<td>14</td>
</tr>
<tr>
<td>% Employed in basic service industries</td>
<td>25</td>
</tr>
<tr>
<td>% Recent immigrant (within 5 years)</td>
<td>40</td>
</tr>
<tr>
<td>% Population with no post secondary degree</td>
<td>8</td>
</tr>
<tr>
<td>% Population not participating in social service occupations</td>
<td>92</td>
</tr>
</tbody>
</table>

#### Table: Average Rent of Tenant-occupied Dwelling

<table>
<thead>
<tr>
<th>Average Rent</th>
<th>Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>107</td>
<td>2</td>
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</tbody>
</table>

#### Table: Other Indicators

<table>
<thead>
<tr>
<th>Category</th>
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</tr>
</thead>
<tbody>
<tr>
<td>% Visible minority</td>
<td>14</td>
</tr>
<tr>
<td>% Population with no post secondary degree</td>
<td>8</td>
</tr>
<tr>
<td>% Population not participating in social service occupations</td>
<td>92</td>
</tr>
</tbody>
</table>
### Mobilizing Resilience: A Disaster Resilience of Place Approach to IFHMP in Squamish British Columbia

| % Employed in Service Industries | 55 53 55 66 52 66 66 78 60 43 69 85 46 60 71 37 73 33 60 67 53 |
| % Population Under 5 Years of Age | 6 6 5 4 5 10 7 6 6 6 7 5 6 5 0 4 7 8 7 9 4 6 6 7 9 8 3 |
| % Population Not Participating in Labor Force over 15 y/o - Unemployed | 6 7 22 9 0 11 4 4 8 6 7 7 21 3 0 0 0 8 11 7 0 4 12 6 4 3 6 |
| % Employed in Transport, Communication and Public Utility | 56 57 8 5 7 57 33 25 20 32 27 35 31 33 43 35 71 28 17 28 12 19 27 28 33 27 18 |
| % Families Spending >30 Hours of Unpaid Childcare | 23 17 4 2 0 11 30 26 15 17 18 26 17 30 17 30 14 26 34 9 18 15 14 25 21 14 19 8 |
| % Working in Industrial Sector (Construction etc.) | 0 0 0 7 0 0 7 6 4 2 8 6 7 0 0 4 0 13 5 7 4 6 10 7 0 3 4 |
| % Housing Units Constructed Before 1985 | 43 60 3 7 6 74 40 53 3 49 59 69 73 39 57 40 85 100 92 96 55 77 34 83 45 68 53 42 |
| % Population Working in Natural Resource Industries (Mining, Forestry, Etc.) | 0 7 0 4 9 0 2 6 0 2 3 3 0 7 0 4 0 5 0 3 4 4 4 0 0 4 2 3 |
### Item 12.7: Factor Strength Across Dissemination Areas

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### Evidence Base

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<td>22 Energy &amp; Air Quality, 25 Hazard Lands</td>
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**Evidence Base Subscore**: 0.67

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**Mobilizing Resilience**: A Disaster Resilience of Place Approach to IFHMP in Squamish, British Columbia
## Participation

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| Participation Subscore | 0.80 | 14 |

*Mobilizing Resilience: A Disaster Resilience of Place Approach to IFHMP in Squamish British Columbia*
## Governance and Coordination

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<td>10 Growth Management, 11 Area Planning, 16 Natural Environment, Appendix Schedule C</td>
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<td>Does the plan identify protection of estuaries by bylaw?</td>
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<td>Does the plan include policies of the local government that address low vacancy rates?</td>
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**Legal and Local Government Requirements Subscore**

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<td>Does the plan contain at least one specific policy, action or zoning related to land use in hazardous areas?</td>
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<td>Does the plan reference a Vulnerability Assessment (HRVA or Other) that assesses coastal flooding in at least one section?</td>
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<td>Does the plan contain at least one specific policy or action related to land use planning in relation to flood risk or hazard reduction (i.e. location of development to reduce risk, alternative uses, land acquisition)?</td>
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<td>Does the plan contain at least one specific policy or action related to coastal green infrastructure or a 'Green Shores' Approach</td>
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<td>Does the plan contain at least one specific policy or action related to the creation of setbacks from waterways or environmental buffers?</td>
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<td>Is the connection between hazard and climate change, energy or GHG emissions made explicit in one descriptive statement?</td>
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<td>Is at least one land use policy written in mandatory language (&quot;will&quot;, &quot;shall&quot;, &quot;require&quot;)</td>
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<td>--</td>
</tr>
</tbody>
</table>

Mobilizing Resilience: A Disaster Resilience of Place Approach to IFHMP in Squamish British Columbia
areas, watershed or ecosystem-based land use management and land cover protection)?

| Policy Subscore | 0.64 | 23 |

### Implementation, Monitoring & Evaluation

<table>
<thead>
<tr>
<th>Variable</th>
<th>Description</th>
<th>Binary Score</th>
<th>Occurrence</th>
<th>Sections In OCP</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Does the plan include a separate section/subsection that addresses what needs to be done to implement the plan (designated resources, lead parties/departments responsible, deliverables and actionable timeline)?</td>
<td>1</td>
<td>2</td>
<td>27 Implementation &amp; Monitoring</td>
</tr>
<tr>
<td>2</td>
<td>Does plan identify partner organizations or governmental bodies in implementation in 3 or more policies/actions?</td>
<td>0</td>
<td>0</td>
<td>--</td>
</tr>
<tr>
<td>3</td>
<td>Does the plan identify a timeline for plan monitoring and evaluation?</td>
<td>1</td>
<td>1</td>
<td>27 Implementation &amp; Monitoring</td>
</tr>
<tr>
<td>4</td>
<td>Does the plan identify organizations with responsibility for monitoring?</td>
<td>0</td>
<td>0</td>
<td>--</td>
</tr>
<tr>
<td>5</td>
<td>Does the plan identify measures to monitor vulnerability(broadly defined)?</td>
<td>0</td>
<td>0</td>
<td>--</td>
</tr>
<tr>
<td>6</td>
<td>Could sections of the plan stand alone in plan implementation?</td>
<td>0</td>
<td>0</td>
<td>--</td>
</tr>
<tr>
<td>7</td>
<td>Are risk mitigation actions prioritized?</td>
<td>0</td>
<td>0</td>
<td>--</td>
</tr>
<tr>
<td>8</td>
<td>Does the plan reference a climate adaptation, risk mitigation plan or Integrated Flood Hazards Management Plan?</td>
<td>0</td>
<td>0</td>
<td>--</td>
</tr>
<tr>
<td>9</td>
<td>Are cost estimates given for prioritized actions or activities?</td>
<td>0</td>
<td>0</td>
<td>--</td>
</tr>
</tbody>
</table>

<p>| Implementation, Monitoring &amp; Evaluation Subscore | 0.22 | 3 |</p>
<table>
<thead>
<tr>
<th>Variable</th>
<th>Description</th>
<th>Binary Score</th>
<th>Occurrence</th>
<th>Sections In OCP</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Does the plan have a table of contents?</td>
<td>1</td>
<td>2</td>
<td>Table of Contents, Table of Contents Squamish Oceanfront Peninsula Sub Area Plan</td>
</tr>
<tr>
<td>2</td>
<td>Is the plan organized using typologies and subsections?</td>
<td>1</td>
<td>7</td>
<td>All sections</td>
</tr>
<tr>
<td>3</td>
<td>Is the plan synthesized in an executive summary?</td>
<td>1</td>
<td>1</td>
<td>1 Scope &amp; Content</td>
</tr>
<tr>
<td>4</td>
<td>Are sections and analyses cross referenced?</td>
<td>1</td>
<td>10</td>
<td>10 Growth Management, 11 Growth Management, 16 Natural Environment, 18 Downtown, 19 Commercial lands, 25 Hazard Lands</td>
</tr>
<tr>
<td>5</td>
<td>Do development guidelines offer at least one illustration related to flooding? (i.e. flood construction levels, existing or new natural boundaries)</td>
<td>1</td>
<td>1</td>
<td>DPA 4 Guidelines Mamquam Blind Channel</td>
</tr>
<tr>
<td>6</td>
<td>Is a flood hazard map included in the plan?</td>
<td>1</td>
<td>1</td>
<td>Schedule D1</td>
</tr>
<tr>
<td>7</td>
<td>Does the plan mention at least 3 mediums of communicating the OCP creation to the public (i.e. review, consultation, readings, hearing, phases)?</td>
<td>1</td>
<td>5</td>
<td>2 Official Community Plan Review Process</td>
</tr>
</tbody>
</table>

**Organization Subscore** | **1** | **27**

**Cumulative Plan Score** | **0.63**
Item 12.9: Identified Relevant Squamish Community Organizations

- Squamish Chamber of Commerce
- Squamish Historical Society
- Tourism Squamish
- Squamish Environment Society
- Squamish Downtown Neighborhood Association
- Brackendale Farmers Institute
- Squamish River Watershed Society
- Squamish Streamkeepers
- Squamish Downtown Business Improvement Association
- Brackendale Owners & Tenants Association
- Squamish Community Services Society
- School District No. 48 (Sea to Sky)
### Relevant Community Organizations in Squamish Flood Resilience Planning

<table>
<thead>
<tr>
<th>Organization</th>
<th>Description</th>
<th>Contact</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Rotary Club International</strong></td>
<td>To enhance health, empower youth, promote peace, and improve the community.</td>
<td>(604) 567-4816</td>
</tr>
<tr>
<td><strong>Canadian Red Cross Society-Squamish</strong></td>
<td>The Canadian Red Cross provides regional disaster preparedness resources and networks.</td>
<td>(604) 892 5318</td>
</tr>
<tr>
<td><strong>Safe N’ Sound Squamish</strong></td>
<td>Local branch should be involved in emergency and flood risk planning.</td>
<td>CONTACT: 604-849-0889 <a href="mailto:safensoundsquamish@gmail.com">safensoundsquamish@gmail.com</a></td>
</tr>
<tr>
<td><strong>Climate Action Network</strong></td>
<td>Educate, support, and empower the community of Squamish by developing, promoting, and implementing sustainable strategies to mitigate climate change.</td>
<td>(604) 815-4984</td>
</tr>
<tr>
<td><strong>Helping Hands Squamish</strong></td>
<td>An end to homelessness and hunger in our community.</td>
<td>CONTACT: 604-892-0305 <a href="mailto:ana.santos@telus.net">ana.santos@telus.net</a></td>
</tr>
<tr>
<td><strong>Squamish HotSpot Community Center</strong></td>
<td>A group of local immigrants and other interested community members working together to create a welcoming place for immigrants and newcomers.</td>
<td>CONTACT: (604) 815-4142</td>
</tr>
<tr>
<td><strong>Sikh Temple</strong></td>
<td>The Sikh religion recognizes the equality of all human beings, and is marked by rejection of idolatry, ritualism, caste and asceticism.</td>
<td>CONTACT: (604) 892-5016</td>
</tr>
</tbody>
</table>

| **Item 12.10 : Community Organizations Missing in IFHMP – Contact Sheet** |
**Item 12.11 : Community-Based Risk Mapping Tool**

<table>
<thead>
<tr>
<th>Description</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>To better understand how residents perceive risk in the landscape this mapping exercise can be used at open houses as a participatory activity to elicit valuable information in local level flood hazard, risk management and emergency response planning Each participant will be given a pin with a different color/shape that represents a different aspect of flood risk planning to place on the provided aerial map of Squamish.</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Resources Needed</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Printed sample map</td>
</tr>
<tr>
<td></td>
<td>Colored pins or sticky dots (Orange, Brown, Green, Pink and Blue)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Instructions</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Step 1:</strong></td>
<td>Allow people to get familiar with the map. Introduce the pins and what they mean.</td>
</tr>
<tr>
<td><strong>Step 2:</strong></td>
<td>Invite each participant to place each one of the five pins onto the map.</td>
</tr>
<tr>
<td><strong>Step 3:</strong></td>
<td>Review the placements and record explanations of why they placed the pins where they did.</td>
</tr>
<tr>
<td><strong>Step 4:</strong></td>
<td>Geocode placements in ArcGIS and include map in public outreach materials and 2016 IFHMP.</td>
</tr>
</tbody>
</table>
## Pin Color Introduction

<table>
<thead>
<tr>
<th>Pin Color</th>
<th>Description</th>
<th>Rationale</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Where do you live?</td>
<td>This is a gauge of which flood prone areas participate in the mapping exercise</td>
</tr>
<tr>
<td></td>
<td>Where does the flooding come from?</td>
<td>Understanding where flood waters to come from is the first step in understanding physical flood proofing measures. Granted that this may not align with technical assessments and 2D flood models, this also grants an opportunity to talk about perceived risk in relation to actual flood risk. These observations can be broad (eg. Squamish River or Howe Sound).</td>
</tr>
<tr>
<td></td>
<td>Where would you go your “Safe Spot” in a flood?</td>
<td>Few people actively plan for floods. Evacuation routes and locations are often related to connection and strength of social networks.</td>
</tr>
<tr>
<td></td>
<td>What is your favorite place or “Sweet Spot”?</td>
<td>This aspect illustrates place attachment and areas that may be of high environmental. Many of these may align with environmental buffers or flood prone areas such as the Squamish estuary.</td>
</tr>
<tr>
<td></td>
<td>Who should we protect?</td>
<td>This is all about identifying vulnerability and inequities in flood risk. Here is where citizens express their concern for others.</td>
</tr>
</tbody>
</table>
Figure 12.12: Community Based Risk Assessment – Sample Map
Figure 12.3: Community Based Risk Assessment - Blank Map

Source: Satellite Imagery Province of British Columbia, 2009
### Item 12.14 : Participatory Resilience Activity Descriptions

| Activity                                                        | Description                                                                                                                                                                                                 |
|                                                               |                                                                                                                                                                                                          |
| Neighborhood Emergency Planning Small Grants Program          | Creation of a neighborhood level funding for plan creation. This would include a 3-hour training, plan and map creation and a BBQ.                                                                                       |
| “Our Flood” Photovoice Photography Project                     | With roots in health policy research Photovoice is a process by which people can identify, represent, and enhance their community through a specific photographic technique to 1) enable people to record and reflect their community’s strengths and concerns for flood risk and (2) to promote critical dialogue and knowledge about important issues through large and small group discussion of photographs |
| Coastal Flooding Visualization                                 | Visualizations in the form of art installations or activities give people a glimpse of what their future world will look and feel like in their own backyards. They help community members understand how their quality of life can be affected by climate change, and by the decisions they make to deal with climate impacts. Visualization can help inform these kinds of tough decisions that many low-lying communities will have to make over the next 20, 50 and 100 years |
| Estuary Vegetation Activities                                  | Reconstruction of spawning channels, rearrange piles of dredged soil and reestablish the natural grade of the estuary and replant riparian vegetation. These activities are meant to increase the extent and functional of the estuary as an environmental buffer for riverine and coastal wave action. |
### Activity Description

<table>
<thead>
<tr>
<th>Activity</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Grey To Green: Bioswales and Detention basins and Permeable Pavement Upgrades</strong></td>
<td>Bioswales are vegetated, mulched, or xeriscaped channels that provide treatment and retention as they move storm water from one place to another. Vegetated swales slow, infiltrate, and filter storm water flows. Permeable pavements are paved surfaces that infiltrate, treat, and/or store rainwater where it falls. Permeable pavements may be constructed from pervious concrete, porous asphalt, permeable interlocking pavers, and several other materials. These pavements are particularly cost effective where land values are high and where flooding or icing is a problem.</td>
</tr>
<tr>
<td><strong>Interpretive signage for Estuary, Floodways and Grey to Green Works</strong></td>
<td>This is a form of public education in step with community organizations and tour operators that regularly give interpretive tours of the estuary. The function of the signs would be to give residents and visitors a sense of flood management activities, investments and community values of disaster flood resilience and climate adaptation.</td>
</tr>
<tr>
<td><strong>Land Conservation Purchase</strong></td>
<td>Purchasing or in-kind contribution to ecologically sensitive land or high-risk property for the purpose of land trusts, conservation and ecological buffering. This could include lands surrounding but not formally included in estuary management areas.</td>
</tr>
<tr>
<td><strong>Upgraded Flood Warning System and Plan</strong></td>
<td>Often an alternative to flood management flood warning systems can be tailored to the social networks, local emergency organizations and communication pathways of Squamish residents. Effective warning systems reduce property and human losses in emergency events.</td>
</tr>
</tbody>
</table>
## Item 12.15: Evaluation Matrix Tool for Resilience Activities

<table>
<thead>
<tr>
<th>Natural</th>
<th>Do Nothing</th>
<th>Neighborhood Emergency Planning</th>
<th>Photo voice</th>
<th>Flood Visualization</th>
<th>Vegetation Activities</th>
<th>Grey to Green Works</th>
<th>Land Conservation</th>
<th>Upgraded Flood Warning</th>
</tr>
</thead>
<tbody>
<tr>
<td>Natural</td>
<td></td>
<td></td>
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<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Economic</td>
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<td></td>
</tr>
<tr>
<td>Social</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Political</td>
<td></td>
<td></td>
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<td></td>
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<td></td>
</tr>
<tr>
<td>Technical</td>
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</tr>
<tr>
<td>Overall</td>
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</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Cost: Property Loss 11</th>
<th>Human Loss 12</th>
</tr>
</thead>
<tbody>
<tr>
<td>$10,000</td>
<td>7-11 deaths per 1,000</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Natural</th>
<th>Do Nothing</th>
<th>Neighborhood Emergency Planning</th>
<th>Photo voice</th>
<th>Flood Visualization</th>
<th>Vegetation Activities</th>
<th>Grey to Green Works</th>
<th>Land Conservation</th>
<th>Upgraded Flood Warning</th>
</tr>
</thead>
<tbody>
<tr>
<td>Natural</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Economic</td>
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<tr>
<td>Social</td>
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<td>Overall</td>
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</tr>
</tbody>
</table>

**KEY**

**Most Preferable Alternative**

**Show Stopper**

---

11 District Estimate
12 (Boyd, 2010)
**Item 12.16. Winning Conditions to Participatory Budgeting “Resilience Activities” in Squamish**

1. **Local governments support**
   - **Recommendation:** Kickoff meeting with the mayor and local organizations

2. **Strong civil society partners**
   - **Recommendation:** Allow rules and goals to be made by participants. A terms of reference will give clear purpose and responsibilities.

3. **A filtering phase for selected activities**
   - **Recommendation:** A 2 day retreat with mayor, council and staff helps build capacity

4. **One-time activities and capital projects**
   - **Recommendation:** Make quick starts, medium and long term projects/activities. Use local metrics and organizations to monitor the impact

5. **Visible implementation of projects**
   - **Recommendation:** Make quick starts, medium and long term projects/activities. Use local metrics and organizations to monitor the impact
### Item 12.17: Social and Environmental Vulnerability Indicators for Monitoring & Evaluation

#### Ecological

<table>
<thead>
<tr>
<th>Variable</th>
<th>Rationale</th>
<th>Source</th>
<th>Goal</th>
<th>Observed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Area of Estuary and Wetlands (in Ha)</td>
<td>A retained or expanded estuary will increase the buffer from the Squamish River and Coastal Flooding.</td>
<td>District GIS Officer/Ministry of Environment, Lands Parks</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Land cover as pavement (% or in Ha)</td>
<td>Impervious surfaces increases flood runoff quantity, velocity and can introduce pollutants into nearby wetlands.</td>
<td>District GIS Officer</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Amount of known pollutants (ppm)</td>
<td>Reclamation efforts of from industrial activities in Site A can degrade estuary function and habitat.</td>
<td>Estuary Reclamation and Mercury Cleanup Project</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Proportion of land dedicated to the protection of diversity and resources (% or in Ha)</td>
<td>Maximizing ecological buffers by protecting sensitive wetlands and respecting natural boundaries of watercourses can reduce exposure</td>
<td>District GIS Officer</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yearly Count of Migratory Birds</td>
<td>A proxy measure of biodiversity and estuary health. Diversity of bird species in yearly migration can provide a valuable proxy for the health of the Squamish Estuary its trophic system.</td>
<td>Squamish Environment Society</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Variable</td>
<td>Rationale</td>
<td>Source</td>
<td>Goal</td>
<td>Observed</td>
</tr>
<tr>
<td>----------</td>
<td>-----------</td>
<td>--------</td>
<td>------</td>
<td>----------</td>
</tr>
<tr>
<td>% Tenant occupied households spending &gt; 30% on shelter</td>
<td>Elderly populations face mobility challenges in flood risk. Situating care facilities away from hazard areas can reduce exposure.</td>
<td>Canadian Household Census</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vacancy Rate</td>
<td>Historically communities with low vacancy rates have a difficult time recovering from disaster events and long-term evacuations. Very low vacancy rates also can lead occupants into hazardous living arrangements.</td>
<td>Canada Mortgage and Housing Annual Report</td>
<td></td>
<td></td>
</tr>
<tr>
<td>% of pop that does not speak English or French</td>
<td>Populations without language connectivity may lack access to community support and emergency systems. Flood risk engagement materials must consider relevant second languages for publication, namely Punjabi.</td>
<td>Canadian Household Census</td>
<td></td>
<td></td>
</tr>
<tr>
<td>% of persons living with disabilities</td>
<td>Disabled populations face mobility and may be at higher exposure to flood risk.</td>
<td>Canadian Household Census</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>% pop low income for individuals after tax</td>
<td>Social deprivation and poverty exacerbates the impact of a flood event and recovery. For Squamish this is a family of 4 earning &lt;$27,000 after taxes.</td>
<td>Canadian Household Census</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>--------------------------</td>
<td>------------------------------------------------------------------</td>
<td>------------------------------------------------------------------</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Housing Vacancy/Homelessness Rate</strong> (head count or %)</td>
<td>Areas of low housing availability take much longer to recover after disasters / Homeless populations often take shelter in exposed riverine areas and represent a vulnerable population.</td>
<td>Canadian Household Census / Squamish Helping Hands</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>% pop who volunteer</strong></td>
<td>A proxy measure of social cohesion and community social capital.</td>
<td>Canadian Household Census</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>% pop that has moved to community within the last 5 years</strong></td>
<td>New immigrants may not be well connected to social organizations or emergency communication systems</td>
<td>2011 Household Census/Squamish Hot Spot Community Center</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
**Item 12.18 : Composite HVSI Findings for Squamish**

The Hazard Vulnerability Similarity Index (HVSI) is a tool developed by the Resilient Coasts Research Team at the University of British Columbia to connect coastal communities in the Straight of Georgia. The purpose is to create a network where information, resources and best practices can be shared to reduce vulnerability to coastal risks. The score is based on major capitals - social, economic, environmental, built environment and planning institutions. The tool matches data based on how similar coastal communities are. **Communities that score the most similar to the District Municipality of Squamish include Campbell River, Nanaimo and Maple Ridge.** The complete platform with full results and analysis tools will be available in late 2015.

**Website:** [www.resilientcoasts.ubc.ca](http://www.resilientcoasts.ubc.ca)
Item 12.19: Consultant Time Tracker

**Activity Type**

- Writing
- Editing
- Analysis and Mapping
- Project Management
- Coding and Plan Evaluation
- Layout

**Total Hours: 302**
13.0 Notes
Communities will always face natural hazards, but today’s disasters are often generated by, or at least exacerbated by, human activities. At no time in human history have so many people lived in cities clustered around coasts and seismically active areas.

Destitution and demographic pressure have led more people than ever before to live in flood plains or in areas prone to landslides. Poor land-use planning; environmental management; and a lack of regulatory mechanisms both increase the risk and exacerbate the effects of disasters.

-Kofi Annan